ANATOMY
OF
SCIENCE

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Anatomy of Science

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Dedicated to

my uncle, *Syed Mohammad Tonki*
who dedicated his life to school teaching, inspired and guided me and imbued me with a sense of idealism,

and

Dr. Syed Husain Zaheer, who gave me the opportunity to work on new areas, freedom of expression, encouragement and support to be creative.

PREFACE

I was invited towards the end of March, 1971 by the University of Sagar to deliver four U.G.C. Extension Lectures on the occasion of the birth centenary of the founder of the University, Hari Singh Gour. I took the opportunity to discuss in some detail the social basis of science and the attitude of scientists in the context of India.

Though the main framework has been retained the contents of the book represent a considerably modified version of the lectures delivered. Many additions were made to make the discussion of the theme a little more comprehensive. Despite the latter, many aspects could not be covered and it was not possible, for various reasons, to go into greater depth.

I nevertheless, hope that the analysis and the point of view presented would help in the appreciation of the social dimension of science and initiate a useful debate on the issues raised.

I am greatly indebted to Prof. S. N. Sharma, Head of the Department of Pharmaceutical Sciences, University of Sagar, for inviting me to the University for delivering the U.G.C. Extension Lectures on the occasion of the Founder's Birthday Centenary, Prof. S. C. Dube for his encouragement to revise and publish them, Professor S. Nurul Hasan for kindly going through the manuscript and making many useful suggestions, my colleagues in the Research Survey and Planning Division who have helped me in numerous ways, and Shri R.P. Thakral who has always borne the brunt of typing from my rather microscopic script.

—*A. RAHMAN*

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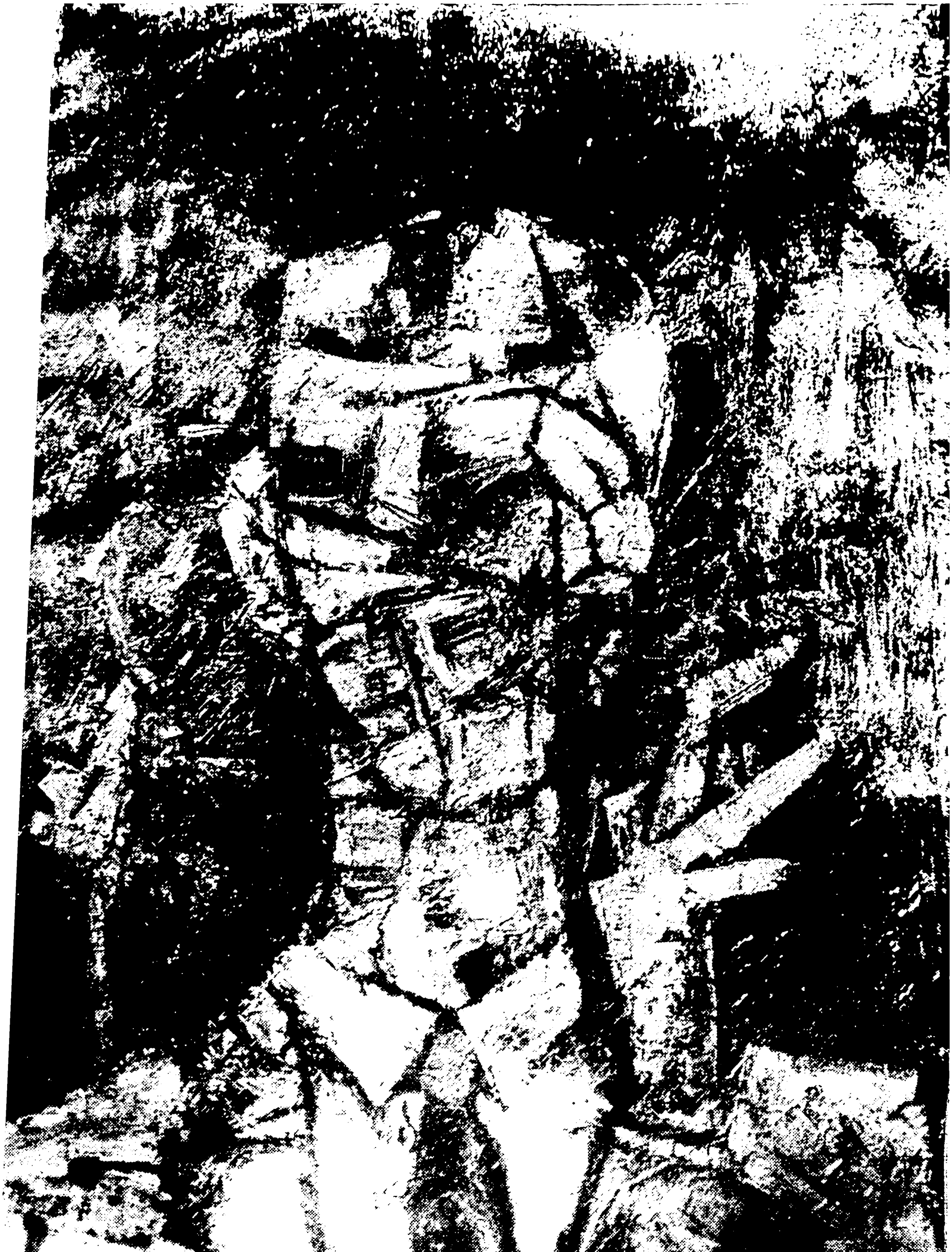

SCIENTIST M.F. Husain

INTRODUCTION

There is no doubt that science and technology are a powerful tool to help man overcome his natural and other limitations, a major instrument of intellectual and social transformation and in the evolution of a new culture. Their universality, however, lie in methods and techniques rather than specific solutions. The latter are a result of specific demands made on them, in a given social, cultural, economic and political situation and in the manner in which scientists of a country have reacted to these needs.

Many promoters and popularisers of science are busy with impressing the people with the now well demonstrated capabilities of science, and its twin technology, and building utopias of a prosperous and bright future. In doing so they, however, tend to portray science as apolitical, amoral, and without any social and cultural roots, specific to a culture-area.

While they are busy in projecting such a picture of science, the political leaderships of different countries are busy with using the demonstrated capabilities and potentialities of science to work out solutions of the existing problems. The latter, it is needless to say, are within the social and political framework of the shade of opinion they represent. The election manifestos of the different political parties for the mid-term poll, for instance, have suggested a programme for science and its efficient utilisation for the solution of many of the problems of India. A cursory glance at the manifestos would reveal the differences both in the approach to science as well as in its proposed utilisation for national development by the different political parties. Since one party thinks of using it primarily for the build-up of nuclear weapons, consequently its priorities in terms of areas of science and technology would naturally be different from the party which is proposing to use it for peaceful purposes. This politicalisation of science is likely to increase, with the growth of science and techno-goly, availability of a larger number of scientific and technological solutions to the existing social, political and other problems, and sharpening of political issues. There is, therefore, a need to critically study specific areas of science and the different technologies in relation to the specific social and political objectives, which a political party wants to attain, or a society wishes to achieve. In the absence of a critical study of these features we might be led to accept the present trends in science, existing technologies and possible technological solutions as the only road to development. Further, we could also be persuaded to overlook the ill-effects and evils as the necessary price for progress and to accept in the name of science and technology, social and political formulations and goals which would be otherwise unacceptable.

Little attention has so far been paid to the study of nature of science and its interaction with society in the context of India and developing a social consciousness amongst the scientists. The Indian scientists, in the name of internationalism of science, have tended to overlook the differences with regard to such features of science as its history, organisation and areas of emphasis in research, social consequences, philosophical outlook, and the manner of utilisation of results of research in different countries. Consequently, outlooks, attitudes and trends of development which are essentially the result of historical and social features of a different culture-area are freely advocated and uncritically accepted in the name of internationalism of science, despite their irrelevance to India.

Further, the Indian scientists generally accept the conclusions and implications of the social and cultural studies of science carried out in the advanced countries. This may be due either to the lack of their own effort in this area or the mistaken belief that such conclusions are also universally valid, since scientific and technical conclusions are so. This may lead to seriously impairing the generation of new social and political goals, particularly when they are different from those of the advanced countries.

A view of science which emphasises its social involvement and some of the specific features which it acquires as a result of the latter, would necessitate a discussion in a given framework of a country or a culture-area. It would further require the study, in some depth, of the motivation, attitudes and professional behaviour of the scientists. Since it is their activities and functioning, which to a large extent, give a definite shape to the science of a country. It would, therefore, be worthwhile to focus our attention to the Indian scene. Such a recourse has one drawback, there is paucity of literature on the subject, one has to be guided by the meagre published literature and more by personal impressions and knowledge and hampered by personal bias. Despite this major drawback it may be worthwhile to make a beginning to draw the attention of the concerned people and start a debate than be content with a vague and generalised discussion based on the problems of the advanced countries. Further, such an effort may lead to a better appreciation and critical understanding and be of considerable help in the organisation of science and a better utilisation of the scientists in the country.

NATURE OF SCIENTIFIC ACTIVITY

1. Nature of Scientific Activity

Science could be examined in many ways. One of the ways could be, for instance, to examine the techniques and methods of science and try to understand those features which distinguish it from other human activities. Another way could be to examine the end results, the pool of scientific knowledge, to understand nature and its processes. One could also study the evolution of science and the logical framework of scientific knowledge by concentrating on the successive pictures of the universe and the diverse processes of nature, and the elements of continuity or otherwise in our endeavour to arrive at them. Another method could be to study science as an activity.

Study of science as an activity has many advantages. Through such a study many features of science, which though significant but are obscured by the manner of presentation of new discoveries or new theories, would come to surface and help in understanding the role of science in a society. Further, it may also help to remove the confusion caused by diverse definitions of science, as are proposed, and the changing nature of scientific activity in different periods of history and culture areas. The purely epistemological approach or historical studies based on chronological record do not provide any clue to the appreciation of these problems.

Different scientists, for instance, in the same or different periods have defined science differently. The differences may have been due to the stages of its growth, or the particular aspect a scientist has chosen to emphasise. According to Dampier[1], for instance, science is an organised knowledge of nature, for Lord Kelvin anything not measurable was not a part of science, for others, like Crowther[2] it is a knowledge which man can utilise to master nature. A more recent effort by a committee—since committees now lay down laws—defines science as "an interlocking complex of attested facts and speculative theory, with the essential proviso that theories must be capable of being tested experimentally.[3]"

Looking at different phases of evolution of science we find a similar range of differences. According to Francis Bacon, (second half of 16th and early 17th century), science was a revolution against prejudice and superstition and within it everything was based on facts and hence irrefutable. This picture, however, changed by the 18th century. According to Pierre Duhem, every achievement of science was capable of being improved upon but not overthrown. However, in the present century, Karl Popper suggested a picture of perpetual revolution in science. According to him, a scientific theory was unscientific unless it was capable of being overthrown.[4]

Similarly, a study of science of different periods would also reveal wide differences in the nature and character of science in terms of questions asked, answers sought, as well as the overall objectives of science in a period.

It would, therefore, be desirable, to help create a better understanding of science and remove the confusion created by different approaches, to separate three aspects of science and examine them separately. The aspects are :

(i) Hard core of science based on observation and experimentation ;

(ii) The soft core consisting of hypothesis, theories and vision of science ;

(iii) Choice of research problems, in which the scientists institutions and organisations for research and the society of a period interact.

In the course of discussion, the involvement and impact of personal social and other features at various levels would be indicated, to stress that these are as much part of science as the procedures of enquiry and the knowledge acquired.

2. Hard Core of Science

The hard core of science could be described as the pool of observations and their experimental verifications. The observations are verifiable and the experiments repeatable. A single observation or experiment by an individual scientist is not considered sufficient to establish as fact the observed phenomena or the conclusions from an experiment, unless they are repeatable by a large number of scientists. The process is cumulative in so far each new observation and experiment has a basis in the earlier ones, which it may deny or confirm, modify or elaborate. The process becomes historical in view of its being spread over different generations and periods.

Three factors appear to play a dominant role in the process. The instruments of observation and experimentation, the conceptual framework and the language.

Observation may be with the naked eye or with sophisticated equipment, where it may be reduced to a mere pointer reading. Same applies to experimentation. However, as we know from the history of science, the techniques of observation and experimentation may change with the growth of science and with the development of technology. The latter, leading to an increase in sophistication of instruments and apparatus. With the latter, new discoveries are made, which modify and change the character of earlier observations. Eddington[5] has beautifully described the role of instruments in the acquisition of knowledge with his analogy ; the size of the fish caught would depend upon the size of the holes in the net and the area the net covers. With large size holes in the net the smaller fish is likely to get away. The history of discovery of different gases in the early phase of chemistry, new organic compounds or elementary particles suggest how significant changes in the techniques and the refinement of instruments could be in terms of their effect on scientific knowledge.

Observations and experiments, however, are not carried out in vacuum. They are carried out to seek answers to the questions raised by the scientist in the context of existing knowledge, within the framework of a theory and in a given cultural climate. It may not be possible to ask certain questions if the knowledge is not fairly advanced, when an accepted theory rules it out or when they are not relevant in a society. For instance, the experiment Galileo is said to have performed, from the leaning tower of Pisa to refute Aristotle, could have been performed at any time of history. Yet it was not done so earlier. The reason for not verifying the statement of Aristotle may be in excessive weight given to the word of the master or in the attitude of the Greeks, which applies to the Middle Ages also, towards working with hands, which prevented them from experimentation. Their social prejudices against working with hands, since their society was based on slavery, kept them away from experimentation and technology. Hence they could neither develop equipment nor the necessary instruments for experimental work. The geometrical thinking dominated their thought so much that even mathematical solutions which could not be geometrically applied had to be withdrawn[6]. On the other hand, the experiments on the position and velocity of electron were possible only when such questions could be asked on the basis of knowledge developed and the instruments for such measurement were available[7].

An example from India may further illustrate the point :

Raja Jai Singh II was asked by Mohammed Shah to reform the then current calender which was out of tune with the seasons. This he set out to do in, what we would call, a systematic and scientific manner. He sent emissaries to far off lands including Europe to collect information about the latest developments in astronomy, collected astronomers of diverse traditions at his court, reformed the apparatus of observation and its measurement and built a number of observatories to undertake observations. The calender he undertook to reform at considerable expense was, despite certain elements of novelty, by way of huge masonried instruments, not very different from the earlier ones. The range of observations and their measurement and the degree of accuracy was no better than the earlier efforts and the period for which the calender could effectively operate was, roughly, the same as before. What, however, is significant is the rejection of, by an acute and alive intellect as Jai Singh was, both the instruments and theories developed in contemporary Europe which had achieved the same purpose more adequately than Jai Singh's effort was to achieve. The available evidence suggests that this could not be due to his ignorance of the european tradition.

The question of the possible reasons for it naturally arises. Could it be due to Jai Singh's limited aim—of not reforming astronomy as a whole but only reforming the calender ; to meet the practical needs for the dates for agriculture and religious festivals, which did not require a high degree of accuracy ? Or was his limited endeavour due to the rejection of helio-centric theory, and the instruments and observations which went to support the theory ? Further, was the rejection of the helio-centric system and the latest instruments due to the influence of Jesuit missionaries, whom he utilised for gaining information and knowledge of european tradition, the belief of Indian astronomers or personal convictions ? Were the latter due to his upbringing and religious beliefs ; as a result of ideas formed by his education, or due to any other consideration ?

One could, of course, say that such a thing was possible in the early days of science, but not any longer, but the Aristotelian philosopher who refused to see through

Galileo's telescope was not unique. Was it not Rutherford who said : "Any one who looks for a source of power in the transformation of atoms is talking moon-shine"[8] ? In an effort to find an answer to the above mentioned questions, one has to analyse the scientific tradition in a different way. Leaving the end results aside, one has to study the background and motivation of scientists, the diverse influences on them and the climate of the period. Unfortunately, the scientific literature does not give any clue in this direction. The pattern of communication evolved over the years is highly stylised and depersonalised. It is limited to stating the observations made, experiments carried out and the inferences drawn. It depicts a picture of relative certainty and causal relations. Only a few selected observations and experiments are described, from amongst a large number performed, which are presented in an ordered form leaving out the uncertainties and imprecisions. In the early phases of the development of science, when the scientific communication was informal and descriptive, details, such as to why scientists chose a problem, why they followed a trend of thought and how they came to rigg up an experiment, or its interpretation, or a particular conclusion, could find a place in the literature published. Kekule's description of the process by which he arrived at the structural formula of benzene, is of course, a classical case. The manner of writing of scientific communication developed, since then, has become, however, more formal and selective. Such a manner of presentation, depersonalised and ordered, is useful for the process of accumulation of knowledge, its synthesis and propagation, but not very helpful in understanding the process of science and its characteristics.

3. Soft Core of Science

Observations and experiments have significance only when they are weaved into a theory, the latter leads to raising further questions and enquiry, otherwise it is a dead enquiry, and hence of no consequence. Jahangir, for example, was the first person to record, as far as I am aware from the written records, that rats cause plague. He records the story as related to him in the following words :

"One day, in the courtyard of my house, I happened to see a mouse in a distracted state. Like some one gone tipsy, it ran about in every direction rising and falling and did not know where to go. I asked one of my girls to take it by the tail and throw it to the cat. Fondly, the cat jumped up from its place, seized it in its mouth, but dropped it instantly and showed great disgust. By degrees an expression of trouble and distress showed itself on its face. The next day it was nearly dead when it occurred to me to give it a little *tiryaq-i-Faruq*. When its mouth was opened its palate and tongue appeared black. It passed three days in a state of misery, on the fourth day it came to its senses. After this, the grains of plague appeared on the body of the girl. From excess of inflamation and pain she had no rest. Her colour changed to blackish yellow, and temperature rose to burning pitch. Next day she passed loose motions and died".

"In the same manner about seven or eight persons died in the house......of those who had developed the grains called another person for water to drink or to wash the latter also caught the disease".[9]

Here is as complete a description as is possible to understand the causative agent, contagious character and the effects of plague. Yet this mine of observations remains untouched in history, till the modern times, to our understanding of plague. One remains at a loss as to why these observations did not lead to a study of the actual causes of the disease or suitable measures taken for checking its further spread. Was it the lack of inquisitiveness, asking proper questions or lack of proper theory ? Jahangir, like other medievalists, considers a wide range of epidemics being caused by the fouling of the air. The only remedy, when epidemics occurred, was to leave the towns and live in the country side, till the town was cleared of the fouled air* Why this sort of approach satisfied them, why the causal links were not seen and further investigations not carried out ? One possible reason could be the lack of proper theory. If the diseases are caused by god's wrath then one had to pray for the forgiveness and causal links were meaningless. If the epidemics were the result of 'foul air' then the study, if it were to be made, would rather concentrate on the nature of air than on the rats and the spread of contagion through them.

While the absence of a proper theory may hinder the correct appreciation of the observed phenomenon, the latter may also lead to development of two different theories. The classical case, of course, is the discovery of oxygen by Priestly and Lavoisier. The two take the same phenomenon but adhere to two different theories—Priestly to the theory of phlogiston and Lavoisier builds a new theory based on oxygen. The controversy continued for a time, generated much heat, as leading scientists were adherent of one or the other theory.[10] How could this phenomena be explained and what could be the possible reasons for such a situation? Are the latter, internal to science, in terms of conceptual outlook, interpretation of data or personal to the individual scientists?

The examples of similar observations or experimental results leading to two different theories are not limited to medieval or science in the early stages of its development only, they are numerous in modern period as well. This would be evident from a study of the scientific controversies in our period. An analysis of the controversies may reveal that they might range over the interpretation of data, relevance of certain observations and experiments, generalisations which could be made on the basis of the latter, conceptual framework of scientists, their concept of theory, philosophical ideas prevalent in a period and some personal factors. Some scientists may be found to continue to adhere to theories despite their rejection by most other scientists. The case of Priestly's adherence to the theory of phlogiston is of course a classical case. The case of Eienstein's advocacy of causality is a more recent one.

This raises the question of validation of scientific theories. What is the process by which they are validated, and accepted? The general picture which is painted is an idealised one—whereby every accepted theory is considered to be based on hard facts and accepted by every scientist.

The actual process is somewhat different[11]. A theory might be accepted, however, inadequate it might be, as there might not be another theory to correlate the data and explain the phenomena, e.g. Ptolemaic theory of geo-centric system. Another theory might be accepted as it turns out to be more simple, as the Copernican theory, or it might explain a few more known facts as the Newtonian theory. Two theories might be current at the same time, as each explains certain aspects of the phenomena, as the wave and particle theory of light.

A historical study of the literature suggests that the process of acceptance of a theory is both a social and historical process, and not merely a logical process. It is also not a depersonalised process as it is made out to be. If we look into the history of acceptance of scientific theories two things would be apparent. Firstly, the acceptance of a theory takes time and is established through a consensus. The latter may be developed through discussion over a period or through the adherence of younger scientists who become predominant in the course of time. Secondly, adherents of one theory or the other may remain its adherents, despite the claim of the partisans of a theory that the evidence is overwhelmingly in its favour.

The process of arriving at a consensus, to make a theory acceptable, is a complicated process. In the process climate of a period, personality of a scientist, his influence over the scientific community, the number of students he is able to attract and the manner of his presentation of the theme, i.e. factors, which are not internal to science and relevant to the merits or otherwise of a theory, appear to have considerable influence.

It would, therefore, be appropriate to draw the conclusion from the preceding discussion that the entire process of science, i. e. from observation, experimentation to the formulation of theories, is a social and histroical process. It is worthwhile to emphasise this aspect since this fact is often overlooked in the wake of abstract nature of knowledge, its universality and the technique of communication developed in science. This should not be taken to mean that scientific knowledge is subjective. What, however, it means is that there are significant personal, social and historical features which are part of scientific development and have to be taken into account to understand certain features of science.

4. Choice of Research Problems

Having discussed at some length the influence of personal, social and historical factors in scientific activity, even at the lowest level, it may be worthwhile to briefly discuss another aspect, the choice of problems for research, where these factors have a direct impact.

It is generally believed that the state of development of science, inner logic of development and the personal preference of a scientist dictate the choice. The work of Derek Price has suggested a net work of papers, based on references cited by a paper, whereby every paper is linked up with 10-12 papers published earlier. According to him :

"It is quite obvious, in fact, if you look at a scientific paper, it is full of foot-notes that are citations back to other peoples' papers—also to textbooks and to papers not yet published, but on the whole it is to previous papers. When one analyses the citation patterns one sees that there is a very close-knit structure here. Scientific papers are assembled together by a process rather like knitting or the way in which pieces of jigsaw puzzle are held together by interlocking with their neighbours. Each scientific paper seems to build on to about a dozen previous papers. Another way of looking at it is to say that roughly speaking like a human family except that instead of it taking two parents to make a child it takes about a dozen assorted parents—and they move around like a very free society enjoying such a deliciously complicated set up as a dozen for a quorum and each combination then produces about a child a year".[12]

One would generally accept the ideas put forth by Derek Price that the progress of science is based on the ideas generated previously. A critical look, however, would reveal two process at work instead of one.

The direct linkages could be due to certain suggested directions, in the earlier work which may be picked up by the scientists and worked upon. This may represent a direct and logical development of the earlier work. In this process the educational system and the research machine has considerable role to play. This has been, rather sharply, pointed out by Synge :

"Students in our unprecedently 'efficient' universities tend to stick to safe subjects. They must complete their courses in the prescribed time and get honours of the prescribed class......when more successful ones get to be research students they often become cogs in the research machine of their supervisor......"[13]

An analysis of scientific research in the Indian universities[14], a similar process, as pointed out by Synge, seems to operate. The analysis brought out that the researches in each department of science were limited to a few specialised fields, and these fields are more or less common to nearly all the universities in the country. This fact, coupled with the inbreeding within the academic institutions, suggests that the much of the direct linkages may be due to the social features, rather than a meaningful extension of earlier work.

Besides this type of direct development of the earlier work there is another type of linkages with the previous work, i.e. the cross linkage. The cross linkage may be with the work within a field, or with the work in other branches of science, or technology. A recent study[15] brought out rather clearly in the case of applied work, that the process of innovation is accelerated by the interaction of non-mission work with mission oriented research through the agency, of specialised multi-disciplinary laboratories. The process represents a deliberate choice in cross linkages where social, economic, industrial and technological factors seem to be of considerable significance.

In other words, it is not linked up with only the earlier work within a field, i.e. it is not merely a logical development of earlier work, when it is linked up, either through information used or ideas utilised from a number of areas, it may reflect a deliberate choice which may be based on various considerations. These considerations, it is suggested, could be philosophical, social, economic, cultural or even personal. Both the processes of linking strongly suggest that the choice of research problems and the pursuit of ideas in a particular direction involve a large number of factors in which internal factors of science may not have a major role. Further, this linking seems to operate effectively within a phase of development of science and has national barriers as well.[16]

The impact of social and cultural factors would be evident from a comparative study of science in different periods of history. The emphasis on logical analysis and geometry in Greek science, for instance, took them away from developing and extending the observational base of science developed in Babylonia and Egypt. Similarly, the comparative study would also reveal the importance of certain subjects in different periods of history. During the early stages of development of science there was emphasis on surveys of natural resources, geology and biology, study of problems arising out of mining, like the study of gases, engines for pumping out water, and problems connected with power. The area of study later on shifted to making of various types of natural and synthetic products to meet the problems of consumer industries as well as war requirements, primarily centred around chemistry.

Coming to more recent times the same pattern seems to have been followed. For instance, the study of Shils[17] revealed that a large number of scientists in USA choose the problems in the area of cold war, since it was easier to get funds and other resources. Another fact, brought out by recent studies, is the emphasis and priority certain areas of research have received, through greater investment and mobilisation of manpower. This could only be explained on the basis of social and political links of these areas of research and not on the basis of logical necessity arising from the growth of science. If latter were the case a large number of areas in science should have developed much earlier or developed more than they have today. For instance, after the breakthrough in biology in the nineteenth century one would have expected a greater growth in this area of research. This, however, was not so. Chemistry and later physics got greater attention in view of their social significance to the society of the period. The present push to biology is again due to similar links.

The links of science with the economic and social factors is also evident from the rise and fall in importance of different branches of science. If we look at the development of science we cannot help noticing periods of growth and significance attached to certain branches of sciences, such as geography, geology and inorganic chemistry, in the early phase of development of science. Similarly, during the first world war, it was chemistry ; during the second war, it was physics, which received considerable push and now the fashion seems to be moving towards biology. Could this shift in significance of a branch of science be explained by the internal features of science only—its life cycle so to say ? Or these have definite social reasons ? The question also arises as to whether this is accidental or there is a definite pattern ? The mapping of the areas of research, social needs, cultural climate, and a deeper study would certainly help us to know the inter-relationship between the two, for which there appears to be some basis as indicated above. The studies, so far carried out, suggest that a certain set of problems are generated in a period based on social needs and the cultural climate in a society. These problems when taken up generate further problems of their own. The investigation in the latter area may be far removed from the original problems, and may have only loose connection or seemingly no connection at all, with the social problems. In the latter case, the connections may develop later.

The social, economic, cultural and political links which affect the choice of research problems is also borne out by some recent studies. These studies have clearly shown the inter-connection of the so-called advanced areas of research with those of the social and political programmes of the countries concerned. For instance, as Derek Price has pointed out[18], that the total output in a subject varies from country to country. According to him, USA accounts for far more for papers in physics than any other country. It is not difficult to imagine that the emphasis in physics in USA is directly linked up with their nuclear programme and space research. Both are directly related to their defence problems and political goals.

The situation in India is not different, though it is complicated by the fact that many of the scientists are trained abroad and, on their return to the country, they generally continue to work on the problems in the areas where they had their training. The Indian scientists by doing so have strengthened the general belief in pseudo-internationalism of science, whereby the current areas of research in advanced countries are confused with the advanced areas as well as common areas for science for all the countries.

It is interesting to note here that while major developments in industry were taking place in Europe, Britishers, when they came to India, did not develop the then current areas in fashion in Britain. The area in which the British scientists in India, and later the Indian scientists also contributed, were survey of natural resources, agriculture and medical problems. The latter particularly those which dealt with tropical diseases, like cholera, plague, malaria, kala azar. The emphasis, which we find in India leads to the only conclusion that this was done to suit the economic and political requirements of the occupying power, and not to the often accepted notion, that the growth of science has a logical sequence in a country. The emphasis on surveys of natural resources and agriculture was to meet the needs and demands of raw materials for the British industry, and study of tropical diseases was to make the life of British colonisers more agreeable and safe. The development of science or the benefits to Indians were, if at all, secondary considerations.

Further, there has been, of late, considerable pressure on taking up problems which fall within the framework of the needs of the country. For instance, under the strain of foreign exchange shortage, after the war with China and Pakistan, a series of developments took place and the scientists of the country felt that research areas, where the resources should be concentrated, should be those which help in import substitution, export promotion, industrial development and meeting the defence needs. The research programmes at various institutions seem to conform to the pattern.

However, the factors operating in the choice of problems for research have been less direct than what they are now becoming. This change poses before us the inherent social, economic and cultural issues much more sharply than anything so far. As a result of continued increase in the knowledge of nature, powers of synthesis and creativity generated over the centuries and the tools developed and now at our disposal, man is in a position to fabricate anything he wants and attain any goals, or nearly any goal which he sets for himself, provided he is able to generate the necessary resources to attain the goal he sets for himself. The question necessarily arises as to how the available resources and built-in capacities should be utilised *i. e.* to what purpose and to what end ? How a choice is to be effected between two technologically feasible programmes ? What should be the criteria of selection ? Are there any intrinsic criteria, internal to science for a choice to be effected or the criteria are essentially social and political ?

Now that a stage has been reached when the scientific effort is being planned, and by virtue of its being directed in definite channels as a matter of deliberate choice, if for no other reason than paucity of resources and the scale of investment needed by science, the question of choice becomes a matter of social as well as national significance. The criteria of choice of research problems and the scale of investment are not dictated solely by technical possibilities but by their relevance and need in the context of social and political problems faced by a country or society. The shift from physics to the study of biological and environmental problems in the advanced countries and the emphasis on areas of research to meet the needs of the developing countries amply suggests the way the choices would be made and the criteria developed for such choices.

When Lenin gave the slogan for electrification of Soviet Union he made it obvious that the criteria were to be dictated by not merely the needs of science but by the needs of Soviet economy. Similarly, when Kennedy gave the slogan of man on the moon, he was not merely proposing a programme for the exciting development of science or realising of the exciting possibilities engendered by the development of science, but he was making it obvious that the choices are dictated by social and political considerations. This trend of taking a social or political decision and then mobilising the resources of science, technology included, is not only likely to increase but may become the dominant feature from now onwards. This is amply borne out from the recent cuts in the budgetary resources available to physics and the greater availability of resources to biology and social sciences in USA. It suggests that the process is not merely logical extension and utilisation of possibilities, but social and political considerations dictate the choice. The howl from the physicists to these cuts indicates that it could be painful both intellectually as well as financially. It is painful intellectually since it pricks the bubble of science being supra-national and makes the scientists face the stark social and political realities. It is painful financially since it takes away the bread of many, as is now happening in USA particularly for the physicists.

The impact and interaction of social factors on the development of science should not be taken to mean that science is not objective, positive and progressive. It is objective in so far as the method and techniques developed for obtaining are independent of men who operate, that the knowledge thus gained is repeatable and verifiable by any one who chooses to do so. It is positive in so far as it enhances the capacity to understand phenomena and nature and utilise this knowledge and understanding to control or change nature in a given direction. The latter could be done only by following the laws of nature as developed by science. It is progressive in terms of the methodology developed, procedures of enquiry evolved and total pool of information it creates. The former comprise language of science, procedures of investigation, instruments and equipments, theoretical constructs and the shared norms. While the latter helps us to spread net wider as well as to go deeper. The progress, however, is neither linear, in a logical sequence, at a uniform pace, nor limited to one geographical area. Its social characteristics are evident from the choice of research areas and problems, the manner in which the validity of scientific knowledge is established and the framework in which the scientists operate. By virtue of its social features, and in view of social and other differences operating in different countries, science in a country acquires very clear national characteristics.

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* Incidentally, when I first joined service in Hyderabad in 1950, I was rather amused by the existence of a plague camp, where people from the city, came to live during the outbreaks of epidemics in the city. Obviously the medieval theory held sway !

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PROFESSIONALIZATION OF SCIENCE AND MOTIVATION OF SCIENTISTS

1. General Consequences of Professionalization in Science

The picture of scientists which is generally painted is a romantic one. It is generally said that they are dedicated to science, their pursuit of truth is unmindful of any motivation and gains but the search itself. In fact, the image is often manichaen in character, which does not seem to admit that scientists have bodies, they eat and drink and have social life among fellow men, they share the beliefs and prejudices of fellow men, get influenced by the current fashions, personal ambitions and the problems facing society. Taken to extreme such a belief even denies a subconscious mind to the scientists.

As against this picture, a study of Lindemann and Tizard controversy[1], Oppenheimer story[2], and the many stories of scientists in India, often told but rarely written, reveal that scientists are like any other group of people. They have ambitions which may not have anything to do with the search for truth or academic attainments, and they may forge social and political links to better their prospects or to have power. Some people may even go to the extent of suggesting that scientists may not hesitate to write motivated reports to further the interests of the company they serve, or to suit the political ends of a nation or to meet the policy requirements of a government. In fact, those who have to deal with scientists at various levels, in the universities, research institutions or in the government departments, seem to think that scientists are more unscrupulous and venal as compared to other academics and professional people[3].

In the light of the popular myths about the scientists created by the journalists or the scientists themselves and the common experience and opinions of those who have to deal with the scientists, it will be desirable to discuss the background from which the scientists come from, their present conditions, their attitudes towards work and general outlook. However, before this is discussed, it would be worthwhile to indicate some of the features of modern science, which are a direct result of the professionalization of science.

In the earlier days scientists, incidentally called *men of science*, were either men of means like Robert Boyle or were supported by patrons, as Leonardo da Vinci was. As a man of means a scientist followed his own ideas and tried to satisfy his curiosity, otherwise he endeavoured to meet the demands of his patron. Today a scientist is very often called a *scientific worker*. He works mostly according to fixed hours in a laboratory, his job is generally laid out by his employers, which may be an industry or a quasi-government agency or a government department. His salary is fixed on the basis of his qualifications and experience. His freedom to choose an area of research, persue a line and to publish the results of research are circumscribed by his employer.

Unlike the earlier period, a scientist now need not do all his work; from literature search to planning of experiments, making of equipment and apparatus, performing of the experiments and deliberating upon results to construct a theory. He may either work in a team, where the work of each team member is laid out, or just as a technician doing a specified piece of work, which he is asked to do. In projects and programmes like those of atomic energy and space research a team may involve thousands of workers. In such programmes the work of a scientist covers only a very small fraction of the total effort. In such cases he may or may not even know the overall design, as is the case in work for defence purposes, or may not be concerned at all or bother himself, with the overall objectives. He may limit himself to doing his bit efficiently and successfully.

Each stage of research, library and documentation, laboratory-bench scale, developmental and pilot plant work has now become a specialized area with a cadre of competent specialized workers in each field. Further, carrying out of research on a project or a programme not only requires effective collaboration of research worker in each of these fields but also involves interaction with large number of specialists in different branches of science and persons specializing in the use of sophisticated equipment and engineers for design and fabrication of equipment. Further, to properly organize, efficiently use and direct the team effectively a different breed of scientists—the director of research—has developed. The directors are not only to be good scientists but also *creative organizers of research*. They have to be imaginative to appreciate scientific possibilities in a programme and resourceful enough to consider the capabilities of men and utilize them effectively for a common effort.

The institutional frameworks, where the scientists work, also vary considerably. Consequently, the motivation as well as the behaviour pattern of scientists varies according to the institutional frameworks under which they function. For instance, those who are working in the university departments or laboratories appear to have different motivation and value system from those who are working in government, commercial or laboratories supported by the industry or established within an industry,

A few studies of the pattern of behaviour of scientists show a wide divergence in the community in terms of their field of specialization. For instance, a current survey of scientists in USA showed that while biologists publish the most, chemists the least and in between the two were the physicists and mathematicians.[4] Does the publication pattern depend upon the institutional framework where the scientists work or is it a part of some historical pattern? The fact that most of the biologists work in universities and in unclassified area of research, as compared to physicists and chemists, could be one of the possible reasons for their publication pattern. Secondly, in the earlier phases of the development of science different pattern of publication activity in different fields of specialization would be evident. For instance, in the first half of the present century, the chemists and physicists were foremost in the publication activity. The latter could be due to the fact that most of the chemists and physicists worked at the universities and what is now known as classified science did not exist.

Besides the above, another significant question is with regard to the commitment of scientists. Are the scientists committed to narrow objectives or the larger goals of science? There appears to be a wide divergence amongst the scientists, based upon their field of specialization. Box and Cotgrove's survey[5] of chemists, for instance, suggests that chemists, by and large, have predominance of narrower loyalties. The latter could be defined in terms of serving the needs of a firm, furthering its interest, etc., rather than the larger questions of public good. How could the weaker commitments of the chemists to public knowledge and public good be explained? Could it be in terms of the philosophy of a branch or in terms of conditioning of the scientists by virtue of their association? Since the association of the chemists has been with industries and it is where their job opportunities lie, is it then a case of accepting of what they consider to be inevitable? Further; since the chemical industry in the western countries is, by and large, in private hands and works solely for profit motive, have the chemists tended to accept the value system of the industry as necessary and logical? Since, the rejection of the present philosophy of the industry and to undermine its current prosperity would mean turning upon their own future ?

Further, a sector by sector study of scientists, from different fields of specialization, may reveal a distinct pattern with regard to their attitude and outlook. For instance, the physicists tend to concern themselves more with wider philosophical questions as compared to chemists or engineers. Is it due to training they get and the general philosophy which prevails in a field of specialization or people with a certain bent of mind tend to opt for a particular area in science? There is a dearth of literature on the social, philosophical, political and other attitudes of scientists as a whole, as well as categorized under different fields of specialization. However, a general picture, which could be pieced together from such literature as exists suggests that a large number of scientists may be satisfied to work, given an opportunity, within a limited field and with limited objectives. They are unlikely to raise either general philosophical or social questions. Further, a scientist may show a certain ambivalence in his behaviour. The ambivalence may be reflected in adherence to contradictory philosophy, social attitude and general beliefs and professional life. A scientist, for instance, may believe in use of science for peaceful purposes or for social benefit, yet he may work in an area which may directly contribute to war or may cause social ill-effects. The instances of scientists opting out for reasons of belief, *i.e.*, refusing to wear different hats for different occasions, are few.

Secondly, the scientists, by and large, tend to accept the social philosophy of the country they live in. The scientists working in the western world tend to accept the western system of democracy and all that goes with it, while those working in socialist countries accept socialism and marxism as a part of their philosophy and tend to propagate it. These differences in attitudes would also be clear from the proceedings of international conferences, where scientists from different countries meet for negotiating and coming to agreement on specific issues, like nuclear disarmament or space work and other similar issues. Here, despite the common language of science, similar training in methods and procedures of science, etc., the scientists tend to represent more the social, economic and political commitment of the countries they come from rather than the common goals and objectives generated by science. In such situations their professional training makes them more competent and efficient negotiators for their countries than others would be.

Thirdly, in terms of rationalization and philosophy, scientists represent a wide spectrum. Their adherence to a philosophy, by and large, seems to depend upon the climate of the period and personal beliefs in which they have been born into. We may have, amongst the scientists, first-rate scientists, who are devout Catholics, Hindus or Muslims. They may not only believe in broad and general ideas of a religion, but may also participate in the ritualism of the religions, while some may even go beyond it, in trying to link the beliefs and practices of a religion with the latest discoveries and ideas of science. Such a belief is reinforced, for instance, by a cursory look at the Presidential addresses to the Indian Science Congress Sessions or other addresses given by leading scientists in India. According to Prof. Seshadri, for instance:

"A complete definition of science would include the idea of higher knowledge of Vedanta, and allow the scientists to move into more subtle and more difficult planes of study."[6]

Such attitudes and utterances led an observer of the Indian scene to conclude:

"The hold of traditional practices thus seem very firm... Many of them still feel a real attachment to these traditional practices but are unwilling to justify that attachment, particularly to a Westerner, who, they think disapproves of such practices...

"The religious indifference which is so widespread in the educated classes of the West has little counterpart among Indian intellectuals; even those without very intense religious sensibility speak the religious metaphors... It would not be an outlandish exaggeration to say that it is impossible for an Indian of Hindu descent to cease to be a Hindu."[7]

The same would apply to a large number of scientists of the advanced countries whose attachment to Christianity or Christian civilization and culture would become evident in more than one way when they are confronted with other religious cultures.[8]

Lastly, there is, however, a minority of rational scientists, which is growing in numbers with the increase in knowledge and scientific developments and the overall increase in the community. They reject ritualism, some of the old religious beliefs and are trying to develop a philosophical outlook which is consistent with developing knowledge and in conformity with the spirit of science and its broader goals. To this minority also belong those scientists who raise basic questions about the nature and character of science, the direction and trend of its development and the use to which it is put to. They are also trying to link the progress of science with the broad questions of ethics, morality, social progress and human objectives.

Two questions arise as to the role of such a minority. What is the connection of their belief with science? Is their conviction part of the scientific conclusions or their role and understanding of science a part of their wider social and political beliefs? And secondly, how effective they can be in a given framework? Would their effectiveness be a part of their scientific attainments or due to their social and political connections?

The literature, as is available, does not throw much light on these questions one way or the other. In fact, very little work has been done in this direction. Whatever little information is available, tends to suggest that acceptance of a philosophical view or involvement in problems of social or moral goals is not intrinsic to the development of science and ideas generated by this growth, though the latter may have much bearing on it. It may depend upon the commitment a scientist has to science as an outlook and philosophy as an instrument of social transformation.

The study of the literature, as is available, however, gives some broad indications. It suggests that an attitude of commitment to the ideas generated by scientific growth and the utilization of science in social transformation may depend upon the type of training given in science, the climate in which scientists have grown and the seriousness with which they take science and its conclusions. A compartmentalized education, lack of initiation into philosophical and social implication of science may make them masters of techniques, but limit their outlook and their discoveries to a specialized area. Unless, of course, they get interested in wider aspects of science and its problem through social contacts and interaction with other scientists so motivated. Their role, in influencing the climate and bringing about the necessary changes, would depend upon raising the science consciousness of people and the social and political links they are able to develop in a society.

Having described some of the broad features of the scientific community in general; it may be worthwhile to specifically discuss some of the features of the scientific community in India.

2. Some Features of the Scientific Community in India

2.1 Numbers and field of specialization—In terms of numbers, the Indian scientific community is rather large, the total being over a million. This would be evident from Table I. The rate of growth and annual out turn for certain years is given in Table II. The research enrolment is given in Table III, Employment pattern in Table IV.

2.2 Social backgrounds and other features—Having mentioned the number of scientists in the country it may be worthwhile to direct our attention to the questions as to who these people are, what is their social background, why they take up science as a profession and what they look for themselves in life through their profession? According to a survey,[9] most of the scientists come from families which do not have a scientific background, such as farmers, lawyers, businessmen, contractors, civil servants and property owners. Another interesting feature is that a large number of those who opt for science are those who come from low income family groups, *i.e.*, whose parents' salary is less than Rs. 600. This being so, would it be wrong to suggest that the needs and demands for scientists in the country and the avenues

TABLE I

Stock of Scientists, Engineers and Medical Personnel

Category	*Stock at the end of the year*					*Growth Factor(1)*	
	1950	*1955*	*1960*	*1965*	*1970**	*1950–60*	*1960–70*
Science Graduates	66,900	1,14,400	1,85,800	3,00,900	4,80,200	2·8	2·6
Science Post-grads.	17,000	30,000	51,400	93,400	1,52,700	3·0	3·0
Engrs. & Technologists (Deg.)	21,600	37,500	62,200	1,06,700	1,85,400	2·9	3·0
Engrs. & Technologists (Dip.)	31,500	46,800	75,000	1,38,900	2,44,400	2·4	3·3
Medical Graduates	18,000	29,000	41,600	60,600	97,800	2·3	2·4
Medical Licentiates	33,000	35,000	34,000	31,000	27,000	1·0	0·8
All Scientific & Technical Personnel :	1,88,000	2,92,700	4,50,000	7,31,500	11,87,500	2·4	2·6

*Estimates

Source : Technical Manpower, Vol. XII, No. 6, June, 1970, published by Directorate of Scientific & Technical Personnel, CSIR.

TABLE II

Out-turn of Scientists & Engineers by category

Category	*Out-turn during*					*Growth Factor (1)*	
	1950	*1955*	*1960*	*1965*	*1970**	*1950–60*	*1960–70*
Science							
Bachelor Deg.							
Gen. Science	9,628	15,964	22,693	38,150	60,000	2·4	2·6
Vet. Science	100	289	814	1,030	950	8·1	1·2
Ag. Science	1,000	905	1,990	5,560	4,700	2·0	2·4
Master Deg.							
Ag. Science	154	197	488	1,197	1,500	3·2	3·1
Mathematics	281	757	1,016	1,883	2,700	3·6	2·7
Statistics	30	100	258	358	380	8·6	1·5
Physics	222	454	736	1,388	2,000	3·3	2·7
Chemistry	346	582	1,081	1,943	2,900	3·1	2·7
Geo. Science	67	127	300	514	550	4·5	1·8
Geography	157	299	674	1,036	1,200	4·3	1·8
Zoology	128	252	429	760	1,200	3·4	2·8
Botany	97	251	414	702	1,250	4·3	3·0
Social Science	90	254	424	868	1,000	4·7	2·4
Others	7	22	50	74	175	7·1	3·5
Engineering							
Civil Deg.	712	1,310	1,964	2,515	3,250	2·8	1·7
,, Dip.	740	1,736	3,870	6,222	4,700	5·2	1·2
Elect. Deg	450	716	923	2,320	4,000	2·1	4·3
,, Dip.	430	674	1,403	4,279	5,900	3·3	4·2

Mech. Deg.	397	937	1,311	3,136	5,000	3·3	3·8
,, Dip.	399	620	1,835	5,931	8,800	4·6	4·8
Chem. Deg.	130	174	344	472	900	2·6	2·6
,, Dip.	45	32	10**	9	150	0·2	15·0
Mining Deg.	51	54	171	253	150	3·4	0·9
,, Dip.	44	14	188	199	100	4·3	0·5
Met. Deg.	47	51	139	329	575	3·0	4·1
,, Dip.	10	19	10**	9	100	1·0	10·0
Electron/Comm. Deg.	22	52	179	265	475	8·1	2·7
,, ,, Dip.	36**	86	81	129	250	2·3	3·1
Auto Deg.	24***	23	25	29	35	1·0	1·4
,, Dip.	75**	145	131	167	275	1·7	2·1
Aero. Deg.	24***	3	6	26	100	0·3	2·1
,, Dip.	10	40	—	—	—	—	—

* Estimates ** Out-turn in the next year *** Out-turn in 1952.

Source: Technical Manpower, Vol. XII, No. 6, June, 1970, published by the Directorate of Scientific & Technical Personnel, CSIR.

(1) Growth Factor is the ratios of the stocks of the out-turns as the case may be (1960 to 1950 and 1970 to 1960 respectively).

Notes : 1) Data on the Out-turn o f "other Engineers" and Technologists is not completely available.
2) No Out-turn of Diploma holders in Aeronautical Engineering since 1955.
3) Sources of data: Science Graduates: University Grants Commission.
Science Postgraduates: D.S.T.P. (CSIR)
Engineers: Ministry of Education.
4) The Out-turn of Engineers with combined Electrical Mechanical Engineering Course has been added half and half to Electrical Engineers and Mechanical Engineers for 1950 and 1955.

TABLE III
Distribution of Research Enrolment during 1957-58 and 1967-68

Fields	*1957-58*	*1967-68*
Science	1,085	3,703
Engineering/Technology	44	373
Medicine	62	115
Agriculture	50	669
Veterinary Science	—	72
Total	1,241	4,932

Source : Indian Pocket Book of University Education by UGC, 1969, p. 103.

The major area of employment and the number employed is clear from Table IV.

TABLE IV
Total Number of Scientific/Technical Personnel Employed in R&D establishments

	1958-59	*1968-69*
(a) Major Organizations under the Central Government:		
i) CSIR	3512	8848
ii) DAE	1067	7209
iii) DRDO	1500	4747
iv) ICAR	1500	7820
v) ICMR	1001	1221
	8580	29845
(b) Other Central Ministries	5663	15593
Total Central Govt.	14243	45438
(c) Universities	2600	7778
(d) State Governments	1000	6800
(e) Private Sector	200	2233
Grand Tetal	18043	62349

Source : Report on Science and Technology 1969. Prepared by CoST.

Notes : 1) Data relates to information so far received in the CoST Secretariat and in some cases the figures are incomplete.

2) The manpower for 1968-69 under universities, item (c) has been computed from UGC data on the assumption that entire number of university professors and readers and 50% of the lecturers in universities and 10% of the senior teachers and 5% of lecturers in the affiliated colleges are engaged in the R & D work. The manpower for 1958-59 has been computed, assuming the same rate of growth approximately, as under the Central Sector.

3) Manpower under the State Governments has been estimated at an annual expenditure of Rs. 10,000 per R & D worker, on ad hoc basis.

of employment and job opportunities which are available to them, tend to guide young people, particularly from low income group families, to take up science as a career ?

The scientists opting for one or the other field of specialization seem to depend upon the job opportunities available in a field, rather than interest of a student in a branch of science. This may be borne out, apart from others, from the data given in the tables. In the field of specialization in science the largest number is in chemistry, followed by mathematics and physics. Though data with regard to investment pattern is not available, the investment in broad areas covered by different agencies seem to suggest greater opportunities for employment in those areas where there is a large output. In other words, the needs in an area are generally related to the number of scientists produced in a field. Though this may not appear to be true in all cases and always. For instance in the field of geology there has been considerable unemployment, and a similar situation has now developed in engineering sciences. In both these areas it may be due to management problems rather than a case of over-production.

In terms of employment, as would be evident from Table IV, the majority of the scientists are employed by the Government, either directly or indirectly through the agencies. The number working for universities is small and for the industry it is negligible.

The imbalance between the three sectors of employment, *i.e.* the government, universities and the industry, has considerable impact on the scientific community. The latter is in terms of their conditioning to an environment and the effect of the dominant group over the other sectors. In terms of institutional affiliation and the terms and conditions under which they work, the large majority of Indian scientists are governed by the rules and regulations of the government.

These two features, *viz.*, the reason for which students take to science and the fact of their being employed by the government are reflected in other characteristics of the scientists of the country, their commitment to the broader values and goals of science and their reluctance to get involved in controversial issues or matters regarding organization of science or its policies as practised in the country.

2.3 Working Conditions—The working conditions of the scientists vary considerably. The available data suggests a definite social pattern and tends to reflect the overall values of society, rather than needs of science. Table V gives the salary range of most of the scientists, while Table VI suggests that the younger the worker is the less salary he is likely to get. Further, there is an additional difference between those who are trained in India and those who are trained abroad. A person of similar qualification who has had his training overseas is likely to get substantially higher emoluments (*see* Table VII).

TABLE V

Salaries of Scientists by Groups

Salary group (Rs. per month)	*Percentage of Scientists*
200-499	56·7
500-799	24·4
800-1099	10·1
1100-1399	4·0
1400-1699	2·1
1700-1999	0·6
2000-2499	0·3
2500 and above	0·1
Not reported*	1·7
	100·0

*Out of 2,143 covered in the sample, 37 scientists did not report their salaries.

Source: Aqueil Ahmad and S. P. Gupta: Opinion Survey of Scientists & Technologists, RSPO, CSIR, 1967 (Survey Report No. 9).

TABLE VI

Distribution of Scientists & Technologists in percentages by Age and Pay in CSIR in 1962

Salary Group (Rs. per month)	*Age Group*				*Total*
	Below 30	*30–40*	*40–50*	*Above 50*	
Below 300	32·39	9·54	2·17	0·32	44·52
300–500	15·29	15·14	2·12	0·24	32·79
500–1000	1·67	9·54	5·31	1·11	17·63
1000 and above	0·13	1·39	2·15	1·39	5·06
Total	49·48	35·61	11·85	3·06	100·00

Source : A. Rahman, *et. al.*
A Study of Expenditure in National Laboratories, RSPO, CSIR, New Delhi, 1964.

TABLE VII

Average Salaries for Indian & Foreign Trained Scientists according to Academic Qualifications

(Rs. per month)

Academic Qualifications	*Indian trained*	*Foreign trained*
Doctorate	650·0	852·2
Postgraduate	396·8	704·2
Graduate	389·3	716·7

Source : Aqueil Ahmad, and S. P. Gupta,
Opinion Survey of Scientists & Technologists, RSPO, CSIR, 1967 (Survey Report No. 9).

2.4 Some other characteristics—Scientific organizations in India employing scientists are : national laboratories, Government research institutes (other than national laboratories) ; private/Industrial Research Institutions and Universities/Teaching Institutions. Table VIII gives the commitment[10] indices of the scientists for each of these organizations. Each of the organization represents a social situation in which recognition, freedom to work and supervisor relationship on the one hand and manner of control, administrative structure and scientific tradition, on the other, play a major role.

TABLE VIII

Organizational Variables in Relation to Scientists Commitment

Institution	*Organizational commitment*	*Recognition*		*Freedom*		*Research Supervisor relation*	
		High	*Low*	*High*	*Low*	*High*	*Low*
National Labs.	High	93·9	87·0	98·3	94·6	96·6	81·7
	Low	6·1	13·0	10·7	8·2	5·4	18·3
	Sign. Diff.*	0·05		n.a.		0·0002	
Govt. Res. Instt.	High	95·7	86·88	89·4	90·8	93·5	81·2
	Low	4·3	13·2	10·6	9·2	6·5	18·8
	Sign. Diff.*	·002		n.a.		0·0001	
Private Industrial Res. Instt.	High	98·2	93·5	97·1	94·6	97·7	85·7
	Low	1·8	6·4	2·9	5·4	2·3	14·3
	Sign. Diff.*	n.a.		n.a.		0·02	
Univ./Teaching Institutes	High	96·2	82·3	92·4	90·8	92·5	78·5
	Low	3·8	17·7	7·6	9·2	7·5	21·5
	Sign. Diff.	0·0001		n.a.		0·0001	

* Significant difference

Source : Data collection by A. Ahmad & S. P. Gupta, for Opinion Survey of Scientists & Technologists, unpublished and kindly supplied by S. P. Gupta.

It is apparent that for scientists working in national laboratories, Government Research Institutes and Universities/ Teaching Institutions, recognition is a strong motivating force to commit them to organizational goals. However, in Private/ Industrial Institutions, the scientists have high commitment to organizational goals for reasons other than recognition. Professional freedom does not appear to have any significant bearing to commitment to organizational goals, under all forms of organizations. The researcher-supervisor relations, however, with regard to the organizational commitment turn out to be significant. More harmonious the researcher-supervisor relations are the greater is the commitment.

Secondly, it has been found that under Indian conditions, irrespective of the organizational form, salary is a direct indicator of the status of the scientist in the organizational hierarchy. This would be evident from data given in Table IX,

TABLE IX

Organizational Commitment as Related to Status, Age and Experience

	Commitment to organizational level				*P**
Status†	*High*	*Low*	*Total*	*N*	
High	98·7	1·5	100·0	149	·01
Middle	91·4	8·6	100·0	694	
Low	90 5	9·5	100·0	1068	
Age					
Over 45 years	95 5	4·5	100·0	156	·05
30-45 years	92·5	7·5	100·0	795	
Below 30 years	90·1	9·9	100 0	983	
Experience‡					
High	93·0	7·0	100·0	514	n.a.
Moderate	90·5	9·5	100 0	676	
Low	90·4	9·6	100·0	333	

* Chi-square test at 2 degree of freedom.

† Status : High : Income more than Rs. 1100 p.m.
Middle : Income between Rs. 500 p.m. to Rs 1100 p.m.
Low : Income less than Rs. 500 p.m.

‡ Experience : High : 12 years or more;
Moderate : 4–12 years;
Low : Less than 4 years.

Source : Same as for Table VIII.

Thirdly, age and commitment are also positively related. Survey indicates that mobility decreases with age. The scientists over 45 years of age are more or less committed to organizational goals than the scientists in lower age group. Older scientists are likely to be in part constrained to this commitment by their age, lesser mobility and imminent retirement. Secondly, it may be because they have remained so long in the group that they feel committed to it.[11] They are also probably committed to the organizations on individual grounds of their involvement in its informal group structure which gives them eminent position in the organizational hierarchy.

2.5 *Conclusions*—The features of the scientific community, as would be evident from the data and its brief discussion, suggests a picture which is far from what is generally made out. The scientists coming from non-scientific backgrounds and from low income family groups, take to science as a career, either because of the fact that other areas are saturated or because they think that this area affords greater possibilities and opportunities. Family of a prospective scientist, engineer, or a doctor invests in the education in the hope of better returns from it.[12] This could be confirmed in another way. If some sociologists were to carry out a study of the dowry offered to scientists, engineers and doctors, it may help us to get an idea of their market value. There is no data, but the general impression one gets is that, till the slump in engineer's employment, high dowry was demanded and received by engineering graduates. This probably is still true for medical graduates. Here also, there may be differences between those passing out from prestigious institutes like the All India Institute of Medical Sciences, and Indian Institutes of Technology, who may have more market value than those from ordinary medical and engineering colleges.

Since career appears to be a major motivation, as against commitment to values or objectives of science, certain other attitudes follow. Of the latter, some may be evident from the emphasis given to security of service, salary and status. Any reference to the memoranda submitted by an association of scientists, to the agencies or pay commissions, would have the necessary reference to security of service and promotion based on length of service in the organization. This is in sharp contrast to high mobility of scientists in advanced countries.

In a situation where scientists are working for security of service and having the objective of attaining better salary and status, they would tend to be conformists and more prone to follow the dictates of those who are in power. They, therefore, would be less likely to show independence of mind, follow the dictates of their convictions, raise controversial issues and involve themselves in matters of policy and broader issues of science. While the scientists in position of power are likely to be more authoritarian, imperceptive to the requirements of junior workers or the needs of science itself. In fact, such a situation prevails in the country at the moment, as would be evident from the published literature on the topic.[13] Any reference to the published literature in India would also show the lack of airing or participation by younger workers on controversial problems or on matters of policy and broad problems of science, and participation in public debates on such issues. Under these conditions, the public debates such as are generated are limited to administrative matters, appointments, and wastage of funds or such matters, or to personal controversies between different eminent scientists and their followers. Even where the broader issues are raised and matters of policy questioned the tendency is to identify it with personalities and reduce it to personal controversies.

Taking up of science as a career, without any commitment to values or goals of science is also reflected in the ambivalent attitude of many of the scientists, of being scientists in the laboratories, while outside the laboratories sharing in attitudes and behaviours which are anti-scientific in character. In the latter category belief in astrology, looking for auspicious hour for doing something or sharing in beliefs which go directly against such theories as evolution or existing biological knowledge are not uncommon.

The picture, which emerges, pertains to a large number of scientists, and should not be taken to apply to every scientist. There are some, a minority, at the moment, who may take to science for its intellectual, moral or social challenge and may be committed to its values and goals. It is these people who think of broader problems of science—moral and social—and try to harmonize the goals of science with those of humanity and utilize it for its transformation. However, till they come to dominate the community and become effective in a social situation, they do not set the tone for science.

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SCIENTISTS AND SCIENTIFIC AFFAIRS

1. Behaviour pattern of scientists

Scientists, in view of their rigorous training, are expected to apply scientific methods to the organisational problems of science and in arriving at decisions about policy and other matters. A study of how they function would reveal that there are large personal, group, social and political inputs. These inputs have also a direct relation to the social environment of the scientists, level of their maturity and the aims and objectives they set before themselves.

Scientists function at four levels : as individuals, groups of specialists, social groups and as a community. The scientists act as individuals in promoting their ideas, work and results of research as well as in looking after their personal interests. They may establish groups, new linkages in established groups, or new groups in support of new ideas and outlooks. Where they act as a community, their aspiration may be aimed at a place in the elite of the country—to be a part of the decision making groups. Their position may be circumscribed by the historical development of science in a country and the manner of their struggle for becoming a part of the establishment. Their functioning within the community may divide them in a number of groups. These may be built around age, field of specialization, institutional affiliations, philosophies or social attitudes. There appears to be sharp competition between these groups for greater resources for themselves, for promotion and utilization of science after the manner of their philosophies and outlooks and for coming into positions of power in the councils of science and those advising the government.

Such a pattern of functioning, as outlined, has been the feature of behaviour of scientists in different periods of its growth and in different countries and is likely to continue. Perhaps it may increase with the increase in the population of scientists and involvement of science with society. In the context of India, this 'politics' appears to operate generally at a personal level, aiming at achieving limited objectives. Many scientists are worried about the present situation and have suggested that remedies lie in going back to earlier values of science or through linking up of science with the values of religion. The transformation of this limited politics into an instrument of a community's struggle for broader goals, in our opinion, could only be affected through a proper understanding of the present involvements of scientists and a reorientation of attitudes and outlooks based on such an understanding. The understanding could only be developed through a systematic and scientific study of the factors involved, the motivation of scientists and their education. While it may explode many myths about scientists it may help us to understand and appreciate as to why scientists act socially in a particular manner and why their 'politics' shows certain characteristics.

The organized activities of the scientists are carried out roughly in three types of institutions; the research institutions, scientific societies and committees, appointed by the government or agencies. It would be worthwhile to examine in some detail the professional behaviour of scientists in each type of institutions.

2.1 Functioning of Scientists in Research Establishments—The research institutions could be roughly divided into three categories. Firstly, those where the scientists are supreme in organizing their work and choosing the area of research. These are the departments of the universities. Secondly, research laboratories of the government departments and quasi-government agencies, where scientist's freedom of choice and organization is circumscribed by government policies and rules and regulations of the administration, though within the framework they may have some freedom of work and operation. Thirdly, institutions of the industry, where the employer is in complete control of the situation both with regard to service conditions as well as the work to be done.

A cursory glance at the manner in which the scientists function in the three types of institutions brings to surface a few features which are worth mentioning.

Apart from personal contacts between the scientists working in different types of institutions, there appears to be some institutional loyalty amongst the scientists, which seems to lead to rivalry between the scientists working in different types of institutions. For instance, the universities and the research establishments, or the research establishments and the industry. The universities, for instance, do not appear to have taken kindly to the establishment of the national laboratories. The establishment of the numerous national laboratories. Was somehow taken to mean as minimizing the importance of the university science departments and of the university scientists. This was clearly reflected in the numerous statements which emphasized the depletion of universities, by university scientists going to the national laboratories, and as a reason for the lack of funds for research in the university science departments.* Such a point of view, which has often been repeated, is generally accepted as true and has been often echoed by other scientists as well. Dr. H. J. Bhabha, for instance, addressing the ICSU meeting at Bombay, commenting on this aspect said :

"It cannot be disputed that the cost of building national laboraroties on the lines followed by the Council of Scientific and Industrial Research has been a weakening of the universities by the drawing away of some of their good people, which is their most valuable asset."[1]

Similar views were expressed by another commentator, Dr. Kane :

"The scales of pay for scientific officers as well as the facilities for research in the National Laboratories were substantially better than those available in the universities...... Consequently, the National Laboratories had no option but to obtain their research staff predominantly from the universities .....

"The result has not been very happy for applied research in the country."[2]

As against this picture, a former Director-General of the CSIR, had a different view. According to him :

"However, it has not drawn a large number of scientists from universities to top positions in CSIR. When the laboratories were started, only director (one)........ came from a university .....of the 35 directors of laboratories, only four have been heads of departments in universities and that, obviously, does not constitute any significant depletion of university personnel."[3]

In addition, the establishment of national laboratories, contrary to general belief, lead to the strengthening of the universities. This was brought out by the Battelle Study :

"Most of the laboratories visited are located either adjacent or close to a university. Various laboratories have programmes in conjunction with the local universities in which staff members may participate...... The further tie of the laboratories to educational programmes is evidenced by the fact that the Director of the Laboratory and/or other top personnel, in most cases, are on the professional staff of the university."[4]

In the case of relation between laboratories and the industry, the picture is similar. The hostility of the industry towards the national laboratories was stated by a study in the following words :

"There is evidence that the scheme from the outset was opposed by private sector industry in the country as another example of government bureaucratic expansion."[5]

Further,

"Private sector industries are inclined to take the laboratories lightly and to be outspoken in their criticism, of laboratory research programmes and results they have produced.

"The Laboratories are further characterized as being refuges for technical misfits, who because of general incompetence, are unable to find satisfactory positions in industry."[6]

Similar views were also expressed in the Shri Ram Institute, Founder Memorial Lecture of 1968.[7]

As against this general belief the study states the conclusions of the investigators :

"All these rather harsh criticisms are believed by the study team to be generally unfounded. Many of them emanate from sources which have had little contact with the actual work of the laboratories and are, in all probability, simply giving hearsay evidence."[8]

We are thus confronted with two sets of opinions, held by leading scientists. These opinions, in spite of whatever else that may suggest, reflect an element of inpolitics of the scientific community. In a situation, where the base of science was being extended by the establishment of laboratories, through government initiative, one would have expected that scientists, both in the universities as well as in the industry, would welcome the step, as it opened greater opportunities for the scientists and a greater role for science. Further, it would have been natural to expect that the better conditions of work and salaries offered to those in the laboratories would motivate the universities to improve the conditions of the scientists under them. Similarly, the mobility from universities, one would have expected to be welcomed, since mobility as such is desirable, and also because it would have created opportunities for younger scientists to come up at the universities.

Further, one would have also expected the scientists to follow scientific method in the conduct of the controversy. While the controversy has gone on for decades, hardly any study, of the impact of establishment of laboratories on the conditions of the universities has been made. What applies to the attitude of scientists with regard to the relationship of laboratories to university also applies to the relationship of the former with the industry. In this context the remarks of the Battelle Report, quoted earlier, are very telling. This disregard of scientific method in the conduct of the controversy, and the conflicting view-points appear to be based on the inpolitics of scientists and reflect narrow loyalties rather than commitment to the broader goals of science.

Having discussed the relationship between one type of institutions and others, it would be worthwhile to briefly describe the relationship of institutions within one category, such as the science departments of the universities, or institutions under the control of one agency. The universities are free from constraints which apply to institutions of other category. Further, the scientists are apparently completely free to do what they think is in the interest of science and scientists. The picture which emerges is also not very happy.

The organization of science departments in the universities is hierarchical, there is little cooperation between members of staff in a department, and between one department and the other. According to a seminar report :

"The internal organization of universities everywhere is essentially paternalistic...... The academic staff has little impact on university administration; departments are organized in a manner that minimizes the influence of imaginative junior faculty......"[9]

Some of the consequences of the paternalistic attitude has been described by a university teacher in the following words :

"Practitioners of science in our country are divided into a certain number of *muths* or churches. Each *muth* has a powerful *mahant* who derives his 'temporal' power and sometimes even ecclesiastical power from one of the gods of Indian scientific pantheon. In the style of Indian *Puranas*, these gods are everywhere at loggerheads with one another and the jealousies of their 'spouses' do not in any way help to improve the relations."[10]

Consequently, lack of communication between scientists of the same department and between one department and another is not uncommon. This effectively hinders cooperative research programmes or collaborative effort on the one hand and comes in the way of building common facilities by way of documentation work, workshop, repair and maintenance of equipment, apparatus and facilities for analysis etc.[11] While each department could not have the resources for building up these facilities, lack of common facilities effectively hinders work.

The situation in research laboratories is no different. According to Battelle Report :

"Contact between the laboratories seems to be sporadic at best...... The Directors of Laboratories do convene one or two annual meetings, where mutual problems of administration are discussed, but it is understood that no technical subjects are reviewed...... There is little exchange of knowledge concerning current research programme... lack of communication and cooperation constitutes one of the more evident areas for improvement in the overall laboratory operation."[12]

The situation, in the context of what has been described before, may lead to personal factors becoming more significant than scientific criteria. According to Dr. Kothari :

"The allocation of slender available resources between the competing agencies depends more on the pulls and prestige of the leaders of the agencies......"[13]

The point of describing in some detail the situation in the organization where scientists work is neither to paint a depressing picture, nor to suggest that differences of opinion should not exist, but to stress that scientists amongst themselves are isolated and divided on the basis of their personal interests or group loyalties. Further, in the pursuit of such interests it does not appear that methods or criteria of science are utilized in coming to conclusions and advocating a point of view. The dearth of any serious scientific study on any of the points of controversy and differences, as mentioned before, is an indication of the fact that attitudes are formed not on the basis of data and its analysis but on other considerations. This situation, it may be stated, is not peculiar to India alone, but such controversies are common in advanced countries as well, where they are carried out in a similar manner though at a more sophisticated level.

2.2 Functioning of Scientists in Scientific Societies —Having examined the institutions where scientists work, it would be worthwhile to examine the way scien ists function in scientific societies.

Scientific societies, formed by the scientists, vary largely in character. There are mass organizations like the Indian Science Congress, professional associations like the Indian Medical Association or Institution of Engineers, specialized societies like the Physical or Chemical Societies etc., trade unions like the Association of Scientific Workers, special purpose groups like the Pugwash Group, and elite societies like the Indian National Science Academy.

Since these societies are formed by the scientists and run by them without any interference from outside, one would expect that at least these would be run on scientific lines and personal and other social factors would be reduced to the minimum. A cursory glance at the organization and functioning of these societies would reveal that they are beset with problems which are common to any social organization in the country, *i.e.* full of what one would call 'politics'.

A cursory glance at the list of office-bearers of these societies would indicate that the societies are generally dominated by a discrete group of scientists. The latter generally are heads of agencies and professors of the departments. An examination of the membership of the councils of the societies whether of the specialized societies, special groups like Pugwash, mass organizations like Indian Science Congress Association or the elite academies like the Indian National Science Academy would reveal a number of common names. This is neither accidental, nor could be explained on the basis of eminence in science. What a wit said about a controversial military leader ; some people are in the news because they are important while others manage to be in the news and thus become important, appears to apply to scientific eminence too.

In the earlier phases of the development of science, as has been pointed out by Merton,[14] values of science were set by scientists whose professional recognition was built by societies. Scientists met at the meeting of societies, reported their work, read their papers and discussed their ideas with colleagues and other fellow scientists. Around these formal and informal meetings the reputation of scientists were built and honours awarded to them. With the growth of science and greater investment in it, the situation has changed radically. Hubbert[15] has pointed out that with science becoming a large scale activity, scientific criticism is loosing much of its edge and hence professional recognition does not enjoy the same status as before. Money, prestige and power, according to Storer[16], have come to enjoy greater status than professional recognition. Consequently, those who command more resources and power have come to enjoy prestige and have greater chances of getting elected to the positions of the scientific societies.

How such societies function, and what role scientists play in their functioning would be evident from the study of a society. For this purpose, the choice of an elite society—the Indian National Science Academy (INSA), formerly known as the National Institute of Sciences of India, would be more appropriate.

The INSA is recognized by the Government of India as the premier scientific society. It claims for itself a status similar to that of the Royal Society of London, National Academy of Sciences, USA, and Academy of Sciences of USSR. Government of India has made it a corresponding body for International Council of Scientific Unions. It has entered into bilateral agreements, on behalf of India, with a number of countries. The Government of India has placed considerable resources by way of funds, to enable it to carry out such functions as delegated to it by the government, for its own programme of work, to support fundamental research, to support activities of other societies, and to promote publication activity. These resources made available to the Academy compare well with the allocations made to major research establishments or universities. Further, any grant which the government desires to give to any scientific society is generally referred to INSA and given only after the latter has recommended it. In other words, the Academy enjoys maximum power which a voluntary organization can hope to have.

In view of the above, two questions arise : Does it represent the cream of Indian scientists and by virtue of the concentration of merit it should enjoy such resources and power ? Secondly, what is the process by which it has acquired the status ?

At a recent conference of scientists and educationists, called to consider the implementation of Science Policy Resolution of the Indian Parliament, organized by the Cabinet Committee on Science & Technology (CoST) it was felt that there is no really representative society of the scientists and efforts should be made to constitute one. Even before this conclusion was arrived at the conference of scientists, serious doubts had been raised both with regard to the elitist character as well as the method of functioning of the Academy. Dr. Bhabha, for instance, when he was the President, in his presidential address to the Academy, had rejected its claim to represent the cream of Indian science and advised the government not to give it the status it was seeking from the government. Taking these factors into consideration, Scientific Advisory Committee to the Cabinet (SACC). incidentally the latter had many members of the Academy, had suggested that negotiations should be carried out between the Indian Academy of Sciences, Bangalore : Indian National Academy of Sciences, Allahabad ; and the National Institute of Sciences of India, Delhi to establish a truly National Academy of Sciences. No progress, however, was made in the above direction. In the meantime the name of the National Institute of Sciences of India was changed to Indian National Science Academy and the government recognized it as such and passed on to it the functions, as described above. The recognition of the Academy by the government could be ascribed to the pressures brought upon the government by its members, who were also heads of various agencies and had powerful positions in the government.

Its functioning has been severally criticized by many scientists. Some aspects of the criticism were reflected in the editorial comments of a leading daily. According to the Editorial of the National Herald, January 4, 1971 :

"The INSA, with only one Government representative on its council but with no representative for some years, is a closed society responsible to its own members. It has, however, secured representation on a number of government committees and other important organizations and associations, encroaching upon their work. There has been thus a concentration of activities and responsibilities. There is apprehension among many scientists, based on experience, that the Academy, with its resources and responsibilities, is not furthering the cause of science but has become a preserve of a small group with partisan purposes. This would be evident from the constitution of the various committees and the selection of persons for various responsibilities. The many important objectives of the original institute are not being served, and Dr. Atma Ram, has by his farewell address strengthened the impression."

The point which emerges from the preceding description is that even in the functioning of societies, organized by the scientists and run by them solely for the purpose of promotion of science, there are large personal, social and political inputs. These may be in the context of national policies or politics, as is evident from the participation in international and bilateral programmes, or in terms of the politics within the scientific community. The latter may be either due to domination of a group of scientists of one field of specialization, group politics based on personalities involved, due to generation gap between young and old scientists, or based on idealogical considerations.

2.3 Functioning of Scientists in Committees—Functioning of committees is essential to the functioning of science, particularly so in India. A committee is generally constituted to guide a programme, supervise the execution of work or to review, evaluate a project or select a scientist, in the hope that an objective scientific evaluation would be made. But once a committee is constituted one could safely predict the likely recommendations. The situation made a wit to remark :

"We call for a posse of scientific committee men and wonder which of our colleagues should be chosen."[17]

The committees which are formed in India are based on the philosophy that the working scientists in a department or a laboratory are not the best people, *i.e.*, not objective enough, to evaluate their own work or appoint a new colleague, though scientists from outside the institution could be so. The net result is that some of the old scientists are in considerable demand and seem to be continuously on the run from one committee to another, from selection committees to subject committees, special purpose committee, review or evaluation committees and committees formed to work out future programmes.

Plethora of committees and number one attends reminds one of the famous lines of Mayakovaky :

No sooner the night turns into dawn
then every one, whose job it is,
goes to the 'firm'
go to the 'CO'
to the 'INC', to the 'CORP',
They all disappear into offices
Paper business pours like a torrent,
No sooner than you get into offices.
Pick out from a hundred—
The most important !
Employees disappear into Conferences.
....
Twenty conferences we have to attend to
everyday—
And more to spare.
So we are forced to split ourselves in two !
Here to the waist,
And the rest—

over there.
Can't sleep for suspense.
I meet the dawn with frenzied senses.
Go for just
One more conference
Regarding the eradication of all conferences.

There is generally little information on the functioning of committees, their reports are rarely made public or discussed in an open forum. One occasionally comes to know from various channels as to what is happening and even then one does not know the full story; when there is serious dissension within the committee and some of the members choose to make the issues public, or those affected by the decisions of the committee take to airing their dissatisfaction. Much of the latter, is generally done by proxy.

A deep insight in the functioning of the scientists, in terms of their rivalries, their linkages with politicians and the methods of operation of committees, can be had from the study of the Report of Committee of Enquiry of the CSIR. The material made available to the Committee by the scientists, would indeed be a very rich source material for a sociological study of scientists. If it were to be made available for study, it would throw much light on the functioning of the scientific community in India. The first part of the Report, which is published, deals with the appointment of various scientists. Questions in Parliament and newspaper stories, no doubt fed by the interested, some of them 'eminent', scientists had made out that large-scale recruitment of incompetent people had taken place. It was alleged that some of those appointed were not even scientists. If the report is considered unbiased, then it would appear that the rumpus created was either based on hearsay, lack of information and understanding or due to exaggeration of minor lapses, which were blown out of proportion by interested scientists to achieve personal ends.

The report nevertheless suggests considerable infighting in the scientific community, lack of confidence by one group of scientists in the judgment of others. The questions which one needs ask oneself are : Does the community not have a common code of conduct or value system which it operates in practice? What is the cause of this lack of confidence in one another? Why marginal issues are exaggerated to further divide the scientists and dissipate their energies and efforts, while the latter ought to have been utilized for constructive purposes ? Is the situation in India peculiar ? Or the emphasis, which such issues receive, is due to the prevalent social conditions in the country ? Any study which seeks to throw light on these questions, may bring us face to face with features similar to those noticed in the functioning of scientists in the research establishments or societies.

A reference in some detail to the functioning of two committees of the CSIR, on the merger of INSDOC & PID, and Pilot Plant Committee,* would illustrate how decisions are taken, or reversed to suit the ideas of the head of the organization, or where clear cut political attitudes, based on certain philosophy of utilization of science, are asserted as a part of policy.

CSIR has two organizations at the monent, the Indian National Scientific Documentation Centre (INSDOC) and the Publications and Information Directorate (PID). A proposal was mooted by the Director of the INSDOC that the two be merged. This proposal was based on a recommendation or suggestion of some earlier committee. This proposal was examined by a committee and the Education Minister consulted some leading scientists in the field and submitted his conclusion to the Governlng Body of the CSIR that the functions of the two are different and that they should function separately. This was accepted by the Governing Body of the CSIR. One would have thought that that would be the end of the matter. It was not. Soon after there was a new Director General of the CSIR and the matter was re-opened, another committee was appointed and the committee recommended the merger of the two organizations as well as the technical directorates at the CSIR headquaters. It is alleged that the chairman of the committee was appointed after he had conveyed his opinion in favour of merger, and the committee was a mere formality to rubber stamp a foregone conclusion. The issues of the case were extensively discussed in booklet issued by two M.Ps. entitled "CSIR and its Affairs". It would be worthwhile to quote from the booklet to throw light on the functioning of the committees. According to them :

"The committee neither evaluated the functioning of the INSDOC and its efficiency, nor considered the material from the directorates. It, of course, considered the notes prepared by the administration in the headquarters but did not invite similar notes from the scientists working in the directorates. It arrived at the conclusion in a matter of an hour or so, revising the well-considered recommendations of the Third Reviewing Committee and the decisions of the Governing Body.

"The deliberations and the report of this committee was kept a closely guarded secret and it was hoped and expected that this would, in a routine manner, be placed before the Governing Body under the item of merger of the two organizations, aiming at saving a lot of infructuous expenditure, and passed. The report leaked out and created a furore. The issues involved were taken up by members of the Governing Body and the press. The attitude of the thinking people is well-reflected in the editorial of the Economic Times of 2 December, 1967.

"With the reversal of a well thought out basic policy of investing the CSIR with modern management techniques, such as independent survey of research, meaningful industrial liaison, and the development of appropriate scientific manpower resources, the cause of indigenous science and technology has suffered a grievous setback. It will be years before the damage done can be repaired. Notwithstanding the high-sounding phraseology used to scuttle the technical orientation of the CSIR, it is quite clear that a very wide gap exists between the professions and the practices of the top brass of the CSIR...... The bias against independent technical orientation and the strengthening of administration bureaucracy have now been exposed as the two sides of the coin now current in New Delhi.

"While in the name of economy, the directorates were to be disbanded and the INSDOC and the Publications

Directorate to be merged, the attitude to Science Reporter is significant. The natural place for it should be the Publications Directorate instead of the CSIR headquarters. This obvious point was neither raised nor discussed by the committee. It is alleged that the editor is a link of the CSIR officials with the press."[18]

The point here is not whether one decision was right and the other wrong. The main points which the controversy raises are: whether a systematic scientific analysis of the issues was ever made, and if it was so, why the need for repeatedly changing the decisions ? Why at no stage working scientists were not taken into confidence or involved in the decision making process, to decide about their future ? Do the committees function on pre-conceived ideas, at the behest of authority, on the basis of personal relations with those who form it or on objective lines following well-established procedures of science ?

It would be worthwhile to dilate a little bit on the last question, by giving another example, which strengthens the feeling that the committees and the choice of personnel is a process to further preconceived ideas.

A report in the CSIR made out that the current Pilot Plant work, which requires considerable investment, was a wastage of efforts as well as resources. A committee was appointed to go into the problems and report. The committee made a draft report, which was circulated to the directors of the laboratories. The directors strongly criticized the report. Some of the comments of the directors implied that many members of the committee had preconceived ideas, were opposed to generating know-how, had no experience of industrial research and some were heavily biased against some laboratories and their work. In view of the strong opposition to the report, and the heat generated by it, the report was not accepted. In the context of the discussion of the issues involved it would be worthwhile to quote from a booklet issued on "CSIR and its Affairs". According to the booklet :

"Another committee worth mentioning was constituted to review pilot plants. It is popularly known as Kane Committee. The chairman of the Committee, Dr. Kane, has been known for his support and bias for foreign know-how......

"Thus, those who were opposed to the spirit and functioning of the national laboratories came to dominate the policy making bodies of the CSIR. These people, with their philosophies and opposition to CSIR and its role in attaining self-reliance, were naturally to circumscribe its functioning, and effectively utilized the position in which they were placed by the CSIR management. Consequently, the pilot plant committee prepared a report contrary to national policies and objectives of industrialization .....

"As a result of the policies of the CSIR and the activities of the committee, there was a significant decline in the pilot plant work during the period of the present regime. This has obstructed the national drive to develop indigenous processes to industrial scale, and would thus allow greater import cf know-how and technology."[19]

The point, however, which need be emphasized again, is not one of the rightness or otherwise of one point of view, or about the undesirability of controversy, but about the nature of committees, its personnel and procedure of functioning. The two examples quoted would cleary show that the exclusion of the working scientists from decision making process does not necessarily make the committee objective and unbiased. On the contrary, there is evidence to suggest that committees, thus constituted, tend to become and are utilized as an instrument of group policies within the scientific community. Further, it does not support the view that committees consisting of scientists are necessarily objective and function in a manner which is consistent with scientific procedures to decide an issue.

There is another aspect of committees which need some mention. The committees at the highest level tend to lead to a high concentration of functions in a few men. The promoters of a particular programme also become the decision makers as well as evaluaters of the programmes. Dr. Kothari pointed out this limitation, when he said :

"The usual mechanism is to have a high level Science Advisory Committee. For such a committee to function properly, it is perhaps necessary that a major part of its membership belongs to persons who enjoy confidence of the scientific community but are themselves not in charge of big science agencies or science related departments. When the committee consists largely of people who themselves are in charge of science-using agencies, it becomes almost impossible for the committee to go into any critical discussion of problems and to reach objective and unbiased decision."[20]

Functioning of scientists in the research establishments, the scientific societies and committees consisting of scientists amply brings out that scientists in dealing with organizational problems of science tend to be guided by their personal opinions than by scientific methods which are so successful in the acquiring knowledge of nature. Further, scientific controversies and differences on organizational matters or on policies could not be taken as due to differences in the interpretation of data, but may be due to personal, social and political factors. It would be, therefore, worthwhile and rewarding to study the fuctioning of institutions and committees as social units to understand how and why scientists, who claim to be scientific, objective and unmotivated by mundane considerations, function in the manner they do.

To point out the functioning of the scientists in institutions, the manner in which it has been done, and the affects of personal, social and political factors in such a functioning, should not be misconstrued as an effort either to decry the scientists or minimize their social and political role. What, however, it suggests is that their role as a special group has to be seen in the context of the society in which they live, the goals they set for themselves and the level of their maturity as a community. The prevalent conditions, it is suggested, arise directly out of the limited objectives of the scientists, of personal career, instead of acting as a community to deepen the interaction of science and society to bring about economic and social development and cultural transformation. Consequently, the effort should be directed to take the scientists out of these limited preoccupation and to imbue them with broader goal of science and involve them as an instrument for social and cultural change.

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* See for instance Dr. D.S. Kothari's Shri Ram Institute, Founder Memorial Lecture, 1967 from amongst the many statements generally made by University Scientists about national laboratories.

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2. Shri Ram Institute, Founder Memorial Lecture, 1963, p. 7.
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4. A Study of Selected Laboratories and Departments of the Council of Scientific and Industrial Research, D. D. Evans et. al., Battelle Memorial Institute, 1965, p. 11.
5. *Ibid*, p. 35.
6. *Ibid*, p. 28.
7. loc. cit.
8. See Reference 4.
9. Chemistry, Design for Innovation, Bangalore, 1969, p. 2.
10. University News, VII(1), 1969, pp. 3-4.
11. This would be evident from the reports on Seminar on Physics & Chemistry by the UGC and N.C.S.E. held at Srinagar & Bangalore in 1970 and 1969 respectively.
12. loc. cit., pp. 26-27.
13. Shri Ram Institute, Founder Memorial Lecture, 1967, p. 8.
14. Merton, R. : American Sociological Review, *22*, 635, 1957.
15. Habbert, M.K. : Science, *139*, 884 (1963).
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17. N.W. Pirie, in Science of Science, Pelican, 1966, p. 213.

* The two cases are chosen in view of the fact that there was serious controversy on the issues and much was published in favour or against the recommendations of the Committees. These are not unique cases, nor is CSIR's functioning unique, if information were available on the functioning of other organisations, then one may notice the similarity in the functioning of committees.

18. CSIR and its Affairs : Arjun Arora and M.A. Khan, Mainstream Publications, 1970, pp 21-22.
19. *Ibid*, pp. 23-24.
20. Education, Science and Development, Shri Ram Institute, Founder Memorial Lecture, 1967.

SCIENTISTS AND INTERNATIONALISM OF SCIENCE

1. Role of Scientists in International Affairs

Facts of science are universal, so are methods and techniques. These do not have any national affiliations. Unless of course under political pressures some pseudo-scientists begin to distort facts, as it happened in Nazi-Germany, to suit the political exigencies of a period. Further, scientists share common techniques, methods and language, often cooperate with each other within a country and with those of other countries in a common endeavour to solve major problems of science. Besides the common goals of science, the spirit of rationalism and the broader objective to serve humanity tends to generate amongst the scientists a community spirit, which often overrides narrow national and other considerations.

The above mentioned facets of science have generated ideas of science being truly international, by its being supra-national. This is further strengthened by the lore of science.[1]

As against this picture of internationalism of science, and scientific cooperation ; as communion of spirit of truly dedicated searchers after truth, there are other facets which cannot be ignored. The latter suggest that both science as well as scientists are a part of government policies, to achieve well-defined political goals. Further, in being so, some scientists at least, contrary to their claims, could be far from being objective. This would be evident from a study of literature on scientifico-political controversies.[2] Further, we are faced not merely with an industrial-military complex against which Eisenhower had warned, but actually with a scientific-industrial-military complex. In this complex scientists are as much agents of the state as any other professional group. According to Jean Jacques Salomon, Head of the Science Policy Division of OECD :

"The adventure of the "Mahattan Project", which turned university laboratories into annexes of arsenals not only delivered scientists to the common fate of mobilised citizens, it also converted them into agents of state."[3]

How this scientific-industry-military complex works, has been pointed out by a number of scientists. According to Rose :

"D.O.D.'s impressively financed research into chemical and biological warfare, for example, now running at something over $300 million annually, is carried out not only 'in house' at such establishments as Fort Detrick and Edgewood Arsenal in Maryland, but has also recently been shown to involve a network of contracts, both secret and open, with many of the most distinguished universities of the country. Indeed the U.S. Army's highest civilian award was given in 1967 to a woman scientist from Detrick for her work in developing a more efficient rice-blast fungus."[4]

It is unlikely that these internal developments would remain isolated internal developments only without any ramifications in terms of international relations of science. The fact that they are not so was provided by what has come to be known as Project Camelot.[5] Project Camelot provided ample proof that the main aim of the project was not one of establishing scientific validity, but of collection of data and information which was relevant and vital to American global politics, or policies in a particular area, and it deeply involved scientific community as a part of these policies. Individually scientists may be involved as an instrument of state policies, or through institutions under whose aegis they work. These policies may have extra-scientific objectives, of which the scientists may be fully aware before they voluntarily undertake to further them. According to Salomon :

"Grants and subsidies made by governments to scientists to facilitate international exchanges are not without ulterior motives, and in what has been called "Scientific tourism", political or military espionage cannot always be ruled out. In the conquest of Asia, the missionaries supported the settlers and, more recently, the archaeologists the diplomats in the carving of the Middle East ; In the same way, the scientists are called upon to fulfil, officially or not, public functions which are connected with their technical or private preoccupation. There are also the roles which they are called upon to play in great international fairs where the conquests of science are entered into the account books as national achievements. In the framework of this 'cultural diplomacy', which has been defined as the "manipulation of cultural materials and personnel for propaganda purposes", men of science are exhibited like film stars or boxing champions."[6]

The reflection of the conflict between the policies followed by different states with regard to science and technology, as a part of their wider political aims, would be evident from the conflicting stands taken by different scientists representing their countries. An interesting example, given by Salomon, brings out the various political and other interfaces and would be worth reporting here :

"The International Geophysical Year, which was, in fact, organised by ICSU and which in 1957-58 coordinated the observations made by about sixty countries, escaped neither the pitfalls of national sensitivity nor the vicissitude of cold war. When the geophysicists wanted to create "World Data Centres" to store and distribute observations, it quickly became apparent that only the USA and USSR possessed the necessary financial resources and materials for the organisation of such a centre and for the full treatment of the data gathered. The choice, even if justified for reasons of economy, would have sanctioned the monopoly of power of the two Great Powers with respect to the International Scientific Community. As in any international assembly where the spirit of cooperation has to be forged through a wise compromise, it was decided to create a third World Centre made up of mini centres *situated in different countries which would collect data only on certain disciplines*. But no compromise could be found for the participation of two Chinas......For four years, Formosa had shown no interest; under American pressure, only two months before the observations were to begin, her official request for participation was presented and accepted, *with a little scientific programme improvised at great speed to justify her request*, and Communist China immediately withdrew."[7] (Italics mine)

The above quoted statement of Salomon clearly indicates the diverse aspects of international cooperation, even when carried out under the aegis of International Scientific Organisations. If one critically looks at the participation of smaller countries, with less resources, or less scientifically advanced countries, one would realise the onesidedness of many of such programmes, the control which the advanced countries exercise and political motivation of the latter. The advanced countries by using the slogans of internationalism of science and sharing of benefits by humanity etc. etc. are able to motivate the scientists as well as the governments of less developed countries to participate in programmes which are exclusively to the advantage of the advanced countries. In doing so the advanced countries are able to augment their resources by way of skilled personnel, many facilities, and get global data if nothing else. Further, in pursuing programmes which are a part of their scientific effort and their global strategies and whose benefit they alone are likely to reap, the advanced countries are also able to change the orientation of scientific effort of the developing countries and make it as a complement to their own.

2. Role of Indian Scientists

There is a common belief, particularly in India, that science is apolitical. Consequently, scientists consider that while industrial and economic aid could have political motivation and strings attached, scientific collaboration could not be but on the highest altruistic level. The latter, more so when scientists are responsible for the collaboration programmes. Further, international collaboration is generally considered as collaboration with advanced countries, and the manner it is conducted amply suggests that India is considered to be a recipient country. The latter would be evident from the neglect of collaboration with other developing countries. One would have expected that in view of lack of adequate resources, shortage of manpower and common problems in the developing countries, scientific and technical collaboration would be a major element of their policies. This, however, is not so despite the effort made by the Association of Scientific Workers of India. Each of the developing countries, including India look to the advanced countries. Visits by the Indian scientists to the advanced countries adds to their qualifications and testimonials from the scientists of these countries to their market value.

Indian scientists in many cases consider India to be backward country, have frequently been looking to experts, advisers from abroad as well as reacting to any development in the advanced countries. The latter both in the field of organisation of science as well as that of newer research areas. The attitude of dependence is unfortunately cloaked in the jargon of internationalism of science, learning from the experience of advanced countries and seeking their help for development. The extent and degree to which it happens, the uncritical manner in which this is accepted, the manner in which 'advice' is utilised, and how it becomes a substitute for making indigenous effort would be evident from a few examples.

2.1 Foreign Advisers and Indian Scientists—It is generally believed in India that an expertise of one country with regard to science and technology could be applied in another country, with slight modification, of course. As a corollary of this belief the experts of science are considered to be supranational. As a result India has been utilising the services of experts not only in specific technical jobs, such as teaching a branch of science, or supervising research in a highly specialised field of science, but also in formulating programmes and policies of the country. Take for example the field of agriculture. Since the Independence, three review teams had been appointed by the government, in 1954, 1959 and 1963, to review the organisation of institutions, facilities for education, research and extension. One would have expected in view of the long tradition of agricultural education and research in the country, the availability of competent experts within the country and the fact that national policies were involved, that such review teams would be constituted primarily from amongst the Indian scientists. One, however, finds that all the three were Indo-American teams, and the last one had Dr. Parker, Director, Crop Research Division, U.S. Department of Agriculture, as chairman. Such a dependence on the experience and experts of one country could have serious repercussions, in terms of orientation, and emphasis on programmes. In addition to the guidance received and the direction taken directly from experts, foreign agencies publish special documents, based on the information collected and experience gained by foreign experts in the country, which tend to assess development and suggest future lines of development. Ford Foundation, for instance, has published a series of documents under the general title of India in the Seventies, two of these documents cover the development of agriculture. Such documents, no doubt, tend to influence the organisational structure and policies in the country.

The field of agriculture is no exception; almost in every sphere of the activity, the presence of foreign experts guiding us with their experience and advice may be noticed. Take for example, the Education Commission appointed by the Government. The Commission had a plethora of foreign members, advisers, and consultants. Even the basic data collection and analysis was done by foreign scientists.

How all the data and the conclusions arrived at on the basis of its analysis would be helpful to the countries of participating scientists, in terms of their estimation of the trends in the country, the degree of developments and its efficiency and values, does not need much imagination. On the basis of such information, it would not be far wrong to say that they would be in a better position to evolve their tactics and strategies in a region, and make necessary adjustments to their own strategies of development as well as global objectives. Besides, the fact that it gives them more than adequate opportunities to influence policies, programmes and lines of growth. No other country in the world has such an open door policy and shown an inclination for dependence to such a degree. Such an attitude is understandable in a country which does not have a scientific community of a significant size, or tradition of science. Such a policy in a country with over a million scientists, a tradition of modern science for more than a century, and a vigorous national policy of independence with defined social and political objectives needs deep and critical study. It may either be due to the continuance of colonial attitudes of mind, which is responsible for lack of confidence in scientists of the country, lack of appreciation of social and political movements and their involvement for achieving them, or to the prevalent politics of the scientific community.

In addition to the advice through the membership of committees, there has not been any dearth of scientists, eminent or otherwise, from overseas offering India free advice as to how to plan its development and utilise its resources. This advice is probably given with all good intentions and a desire to help India, but when applied it has certain consequences in terms of fitting India, as a subsidiary to the development of advanced countries. When India embarked on a national policy of developing her natural resources and decided to invest resources in the exploration of oil, for which it was totally dependent upon Britain and America, it induced the former last Viceroy and first Governor-General of the country, Lord Mountbatten, to advise the late Prime Minister, Nehru, not to waste precious and critical resources on a wild goose chase and leave the job to the well established oil companies.[8] Fortunately the advice was not taken, in this case, and the country has been reaping rich dividends now.

Similar advice, of not going into an area of exploration or research, or aiming at limited development in view of the backwardness of the country or limitation of resources has been forthcoming from eminent scientists as well. Prof. Blackett, for instance, in his Nehru Memorial Lecture, suggested that India should go in for import of know-how and concentrate its research to the area of imported know-how. According to him :

"India must decide what production goods it intends to import, say, for the next few years, what it will manufacture under licence (so saving perhaps 90% of the foreign exchange), what it will copy, what it will get manufactured, by a foreign or jointly owned firm, what it will develop itself from scratch."[9]

And further, he goes on to say :

"the less the technological base or strength of the country, the more it should be dependent on the imported know-how by licencing etc. Thus the smaller the indigenous technological base of a country, the greater chance of the adverse balance of royalty payments. Far from such an adverse balance being a sign of inefficiency, it may well be an indication that the country's technical resources are wisely used in the latter stages of innovation chain and not frittered away, perhaps by sub-viable research groups engaged on unnecessary and unsuccessful redevelopment."[10]

Following the policy in practice, as suggested by Prof. Blackett, is likely to be beneficial to the advanced countries. Since they would be able to sell their know-how, maintain their R & D establishment as viable units, and keep the lead over developing countries. The developing countries, on the other hand, would be forced to follow continuously the technologies developed in the advanced countries and hence always trail behind them. Unless, of course, they develop their own technologies.

What, however, is interesting is the fact that no sooner such an advice is given, it is picked up by a number of Indian scientists as the solution to our problems and freely quoted and utilised, as confirmation of their ideas and to give their opinions added prestige. As if the opinions expressed and suggestions given by foreign scientists are the last word on the issue and the latter are made to appear as arbiters. Prof. Blackett's advice was widely quoted, as would be evident from the reflection of his ideas in the Presidential Address to the Science Congress[11], a couple of months later, or in the Shri Ram Institute Founder Memorial Lecture. It may be worthwhile to quote Dr. Kane, who gave the lecture, to illustrate as to how the process works. Commenting on Dr. Blackett's lecture, and its extension in Science Congress Presidential Lecture, he said :

"The accumulation of influential opinion described above is sufficient to indicate the direction in which efforts might be made......In the first place, as this method cannot compel an industrialist or government undertakings to invest funds on indigenous know-how, and in fact, may create a prejudice against those who claim to have developed such know-how. Rejection of requests for purchase of know-how from abroad for essential industries ought not to be done merely on the basis of claims of scientists that they have or can develop similar know-hows..."[12]

2.2 Motivation based on ideas generated abroad—Apart from the advice received from scientists from advanced countries, the climate in India appears to be very sensitive to the development overseas. The developments in newer areas of research, new emphasis given to research in a field of science, organisational changes in the institutional arrangements are also picked up. Such a sensitivity would be a good thing if it is followed by critical assessment in terms of our own needs and requirements. In the absence of the latter, the impression one gathers is that every development in science in the advanced countries is considered abstract and of universal applicability and is promoted accordingly.

There is much talk, for instance, in European countries and America, about the pollution of environment, as a consequence of the deterioration of the latter. There is, however, very little realisation, or at least the expression of it, that the uncontrolled exploitation of the natural resources and the discharge of effluvia is a result of the uncontrolled capitalism, wherein profit motive is the only criterion. There is nothing qualitatively new in our knowledge of the environment which has enabled us to see things which could not have been foreseen a century ago. The crisis, therefore, in the advanced countries is essentially the result of rejection of available knowledge in the interest of private industry and the profit motive. While the advanced countries are grappling with the problem of their own creation, they are posing the problem to the developing countries as a choice between industrial growth and saving the environment.[13] The moral of the story is to have zero economic growth and live in a serene environment!

The problem of pollution of environment was a major item of discussion at a recent meeting of Indian National Science Academy and a delegation of the Royal Society. Text of a paper released clearly indicates as to how the topic has been picked up in abstract and divorced from its social basis. Secondly, the emphasis which the problem is likely to be given, at the hands of interested scientists, is likely to divert attention from more urgent problems and those which are more relevant to development. In addition, since the problem is picked up, as posed by the advanced countries, we are less likely to direct our attention to the socio-economic basis and more to mere technological aspects.

Similar to our reaction to the current fashionable research problems of the advanced countries, we also react to their organisational changes. For instance, no sooner the government in U.K. undertook changes in the organisation of science, we also picked up the threads in India and suggested similar changes. The publication of the Trend Committee Report, for instance, became the occasion to suggest a series of changes in CSIR. Science and Culture, in a rather long editorial, commended the changes. After suggesting that a number of laboratories should be handed over to the user ministries, it said :

"The remaining Research Establishments under the CSIR could, with advantage, following the recommendations of the Trend Committee (U.K.)...divide its present responsibility between a newly to be formed Science Research Council and an autonomous agency for promoting industrial research and development."[15]

Dr. Kothari, in his Shri Ram Institute Founder Memorial Lecture, also drew attention to the same problem, with probably similar implications, when he said :

"In the context of what has been said above, it is relevant to recall that recently in U.K., the DSIR (which corresponds to our CSIR) has been abolished. The functions of DSIR relating to fundamental research have been transferred to new Science Research Council. Many of its functions concerned with applied science and industry have been taken over by the new Ministry of Technology."[16] The organisation of science is undergoing another change in U.K, and USA and we may have another spate of follow ups in India !

2.3 Foreign Aid and its consequences—In addition to the advice, India has also been receiving considerable amount of money for various programmes, to help develop its scientific and technological potential. The value and area of help is given in Tables I and II[17]. The impact this has on directing the research effort in a particular direction, or the cultural impact of the donor country has not been evaluated, though the advantages, might as well be considerable to the advanced countries. One thing, however, is apparent that the advanced countries get back a substantial portion of the aid they give through the export of experts, by getting trainees to their countries and by sale of equipment. In addition, they are also able to attract considerable highly trained manpower, through brain drain.

The manner in which the aid is utilised to penetrate and control the national research organisation would be evident

TABLE I

Statement Showing Field and Sourcewise Distribution of Total Assistance to Scientific Research (1959-60 to 1963-65)*

Fields Receving Assistance/ Source of Assistance	*Agriculture*	*Medical & Health*	*Scientific & Industrial Res.*	*Education & Social Sciences*	*Weather Science*	*TOTAL*
U N.S. FUND	(10.4) 6,834.41 (7.8)	(3.8) 2,499.00 (4 0)	(52 0) 33,925.47 (29.9)	(27.4) 17,865.71 (17.5)	(6 4) 4,157.86 (84.4)	(100.0) 65,282.45 (17.1)
U.N. EXPANDED PROGRAM	(14.1) 3,666.81 (4.2)	(24.7) 6,425.09 (10.4)	(2.4) 625.53 (0.6)	(57.1) 14,816.57 (14.5)	(1.7) 440.36 (9.0)	(100.0) 25,974.36 (17.1)
COLOMBO PLAN	(21.6) 41,079.901 (46.8)	(7.9) 4,906.61 (24,2)	(36.5) 69,413.17 (61.2)	(34.0) 64,586.51 (63.4)	—	(100.0) 189,986.19** (51.4)
ROCKEFELLER FOUNDATION	(42.7) 8,242.52 (9.4)	(34.3) 6,614.27 (10.7)	(3.4) 651.79 (0,6)	(18.0) 3,467.11 (3.4)	(1.6) 304.54 (6.2)	(100.0) 19,280.33 (5.2)
FORD FOUNDATION	(29.3) 6,909.19 (7.9)	(45.3) 10,672,55 (17.3)	(25.4] 5,997,60 (5.3)	—	—	(100.0) 23,579.34 (6.4)
PL 480	(46.1) 21,000.00 (23.9)	(45.2) 20,590.00 (33.4)	(5.9) 2,700.90 (2.4)	(2.9) 1,253.00 (1.2)	—	(100,0) 45,540.00 (12.3)
TOTAL	(23.7) 87,732.86 (23.9)	(16.7) 61,707.52 (100.0)	(30.7) 113,313.55 (100.0)	(27.6) 101,985.90 (100.0)	(1.3) 4,902.86 (100.0)	(100,0) 369,624.67 (100.0)

* The UNEPTA and the Rockefeller contributions are only for four years.

** This does not contain Rs. 75,306.47 thousands for equipment for which break-up is not available.

Source : Foreign Assistance to Scientific Research in India, An Analysis, Survey Report No. 7, RSPO, CSIR, New Delhi, 1966.

TABLE II

Distribution of Assistance in Terms of Experts, Trainees and Equipment (1959-60 to 1963-64)*

Source of Assistance	*Experts (Value)*	*Trainees (Value)*	*Equipment (Value)*	*Total (Value)*	*Experts (Nos.)*	*Trainees (Nos.)*
U.N.S. FUND	(32.8) 21,405.72 (14.1)	(2.9) 1,899.24 (2.4)	(64.3) 41,977.49 (28.5)	(100.0) 65,282.45 (14.8)	—	—
U.N. EXPANDED PROGRAM	(44,9) 11,630.32 (7.7)	(8.8) 2,283.41 (3.0)	(46.4) 12,065.63 (8.2)	(100.0) 25,974.36 (5.8)	242 (33.2)	111 (2.7)
COLOMBO PLAN	(44.7) 118,679.70 (78.2)	(26.9) 71,306.49 (93.1)	(28.4) 75,306.47 (51.0)	(100.0) 265,292.66 (59.6)	488 (66.8)	3,945 (94.9)
ROCKEFELLER FOUNDATION	—	(5.9) 1,133.21 (1.5)	(94.1) 18,147.12 (12.3)	(100.0) 19,284.33 (4.3)	—	102 (2.4)
FORD FOUNDATION	—	—	—	23,579.34** (5.3)	—	—
PL 480	—	—	—	45,540.00** (10.2)	—	—
TOTAL	(34.1) 151,715.74 (100.0)	(17.2) 76,622.35 (100.0)	(33.2) 147,491.71 (100.0)	444,949.14 (100.0)	730 (100.0)	4,158 (100.0)

* Contributions from the UNEPTA and the Rockefeller Foundation are only for four years.

** Break-up is not available.

Source : Foreign Assistance to Scientific Research in India, an Analysis. Survey Report No. 7, RSPO, CSIR, New Delhi, 1966.

from the Battelle Memorial Institute report on CSIR.[18] In the words of the report:

"During 1964, the United States AID Mission in New Delhi received requests from several laboratories of the Council of Scientific & Industrial Research, Government of India, for technical assistance in the form of equipment, fellowships for staff members, and experts from the U.S. Because these requests did not appear to be of uniform significance, and because all of the laboratories of the CSIR were not represented, it was AID's feeling that a direct review of the requests should be made with the cooperation of the central CSIR organisation."[19]

The AID Mission employed Battelle Memorial Institute for the task. The team of the Institute visited laboratories, held discussions and submitted its report and made a series of recommendations to improve the efficiency of CSIR. Few of these recommendations were:

"1. First, it is recommended that there be on-site participation of engineers and scientists from the United States. It is envisioned that these individuals would take an active role in conducting actual research projects in the Laboratories. In this manner, their particular backgrounds of experience could be brought to bear on the research problems involved, while at the same time a close working relationship could be established with the Indian technical personnel assigned. It should be stressed that the foreign expert should take an active role in the work of the project and would not serve strictly in an advisory capacity. It is also intended that any such outside personnel be well qualified in their technical fields in order to assure an optimum advantage to the Laboratory. It is also envisioned that the participation of such individuals would be on a sufficiently long term basis to facilitate using them to maximum advantage."

"2. A second suggestion is for the provision of technical information services from a broad-based technical organisation in the United States. Although the CSIR's liaison activities with foreign technical groups, both public and private are well developed there seems to be a need for a single source of specific technical information and opinion which could be tapped at the volition of the Laboratories."

"3. The fourth suggestion is that the CSIR and the Laboratories establish a relationship with a U.S. technical organisation which could provide contacts with all other U.S. technical sources for the purpose of placing CSIR scientists and engineers for training and collaborative technical work in the U.S. This is a reciprocal of the first suggestion made relating to the use of U.S. experts in India ; in this instance, engineers and scientists from the Indian Laboratories would be programmed in U.S. laboratories to work on projects which have direct relationship to their technical interests at home.

"This, of course, is not a new idea. The somewhat novel aspect is the suggestion that a single, qualified U.S. technical organisation serve as the coordinator and instrument by which such a programme is implemented."[20]

The implementation of such a report would have meant a complete domination of the research effort in India by U.S. agencies. Yet one finds praise for such a report, as was done at the recent meeting of the Governing Body of the CSIR.

3. Possible Reasons for Indian Scientists' Reactions

The question which necessarily arises is, why Indian scientists allow such a thing to happen, why do they show such a dependence upon foreign science and opinion of foreign scientists ? The simplest explanation would, of course, be that they still lack confidence, having not yet come out of the colonial period. Further, in this context it might also be asserted that those who dominate science in the country, are old guard scientists, who had had their training and lived through their creative periods under the colonial period and it might be too late for them in the day to discard their habits, of looking to U.K. and now to America. Such explanations are supported by such theories as advanced by George Basalla.[21] According to him, the development of science in a colonial country shows three distinct phases of development. In the first phase, the colonial country provides a search for European science, the second phase is marked by the development of colonial science, while in the third phase the process of transplantation is completed.

Such an explanation, however, apart from being too simple has the limitation of dealing with the problem in isolation from the social conditions under which scientists work. Looking at the problem from the point of view of the position of scientists, their aspirations and the manner in which they endeavour to attain the latter, it is suggested that the heavy dependence of many of the Indian scientists on those of overseas, is more an extension of internal situation than a desire for real collaboration. The Indian scientists, as has been indicated before, are not a cohesive group working for well defined social and cultural goals, but within the framework of bureaucracy for limited and personal gains. Consequently, we find that individual scientists, as well as groups, unable to generate a climate in favour of their programmes and gather support for themselves through interaction with the community and other social groups, rely heavily on testimonials from scientists overseas, as well as their support in favour of their programmes. Further, they use these recommendations and support for convincing those in authority in favour of their ideas and programmes. The foreign scientists, knowing the situation as they do, use it to their own advantage, by supporting those areas which do not clash with the interest of their countries or which complement their own efforts. The training overseas, foreign tours through invitation, short and long term assignments in universities and other research establishments, opinions and advice given in India and financial support given in selected areas are used, in the context of the functioning and behaviour of Indian scientists, to create an atmosphere, whereby anything in the name of internationalism could be sold. The Indian scientists, thus, become a part of the scientific community overseas but increase their social isolation at home.

Many countries who have embarked on a course of rapid development, have undergone a period of isolation either as a deliberate policy, as in the case of USSR and

China or through social circumstances, as in the case of Japan and possibly USA before world war I. What has been the result of such an isolation, on a national scientific community from those of the other countries, requires to be studied carefully. Does the lack of isolation lead to the continued dependence, trailing behind the development of the advanced countries, neglect of problems at home and suitable interaction of the scientific community with other social groups in the country ? Or would a deliberate policy of isolation of a national scientific community from those of the advanced countries lead to greater social interaction nationally, internalising the value and evaluation of science and scientists and emergence of the scientific community as a significant factor in the national scene ? These questions are important enough to be studied critically as a guide to formulation of policies.

It may be said that India is an open society and it may not be possible or desirable to cut her off from the international setting. What, however, could be done is to have a serious and critical appraisal of the pressures exerted by pseudo-internationalism to give direction to the research effort and organisation of science of the country. Such an effort is not only necessary but vital to give the scientific community a national identity, like that of any other country. While it will internalise the value system, help cohere the scientists into a community of men, working for desired social and political goals, it would also be of help in putting an end to careerism, supported by testimonials from abroad and support to those areas of research from overseas, which are not very relevant to national development.

The dependence on foreign scientific opinion and the social isolation of scientists at home are two sides of the same coin. To break the vicious circle the working conditions of scientists require to be improved, and they be given the necessary freedom to participate in debates on problems of organisation and policy. Such a policy would wean them away from their major pre-occupation, of advancing their career, to broader questions of science. In doing so they would develop internal criteria of evaluation and develop a national identity for the scientific community, like any other country. This is a vital need of the country, and to establish true scientific collaboration.

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18. In this context a reference to a booklet brought out by some Delhi University teachers is worth referring to for university problems. It throws some light on the penetration of academic institutions through exchange programmes and aid for purposes other than academic.
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STEPS FOR EFFECTIVE UTILISATION OF SCIENTISTS

The picture painted in the preceding chapters was to emphasise that science is not a self-contained system, isolated from and impervious to the social changes and pressures generated by the latter. The brief description of the social basis of science as a process, the motivation of those who opt for science as a career, the behaviour of scientists in discharging their functions in research establishments, scientific and professional societies and committees, and in their relation with the scientists of other countries, should more than amply justify the above contention.

A number of inferences could be drawn from the preceding description. It may be said, for instance, that the situation is peculiar to India, in view of the fact that science is not fully grafted in the country and is in a developing stage. This cannot be true, since a glance at the literature, now available, from the advanced countries, clearly shows that the situation as well as the problems in the developing and the developed countries are similar.

Another inference could be that the present condition of science and behaviour of scientists might be due to the commercialisation of science—its fall from the high pedestal of abstraction and idealism. While bemoaning the decline in science it is often suggested that the scientists are not devoted and dedicated any longer and are imbued now with mercenary motives.[1] Those who suggest such an explanation are generally old scientists, who either fail to see the realities of modern science as a consequence of its growth or cling to an idealised picture of science and scientists. The latter developed by some 'populisers' of science, either to attract the young people to science or to impress the community. Apart from the fact that 'heroic' science has never been a reality in any period of history, much less at present, those who peddle such a concept have never been guilty of practising what they have been preaching to others. Besides, such a treatment of scientific movement is remarkably similar to the treatment of religion by its followers; where the starting point represents the purity of concept and early initiatives as the purest, while any development, evolution and increase in complexity is treated as growth of impurity and debasement. The harking back to the good old days creates a climate where the farther we go back in history the rosier the earlier picture becomes. The nostalgic references to the past, could perhaps be taken to reflect an attitude of mind which shies away from the reality, shudders at the new complexity, in view of intellectual incapacity to deal with the problems, and shirking of the responsibilities arising out of the necessary development of science and its consequences.

The other inference which could be drawn is that science is following a pattern, in the course of its development and as a result of social interaction. Its development and present significance could then be taken as the necessary result of its becoming a powerful intellectual tool and a vital instrument in social transformation. Its interaction with society is then a necessary consequence of its vigour and capabilities and its impact on society could be visualised to grow as it develops further. Further some of its present features could then be understood and appreciated in the context of the links forged, relationships established with society at various levels and the way society has conditioned its utilisation. If there is something wrong in the present development of science, such as the over-emphasis in its utilisation for purposes of war, or the industrial development ignoring the well-being of environment and men, then the endeavour should be to study the sociological background and to remove those social features which are responsible for its debasement. Similarly, if the present day scientists are not considered unbiased, not imbued with the broader values and goals of science and are motivated by short term and personal gains, then it would require the study of social environment and those cultural features which are responsible for such a situation. It is the removal of the latter which is bound to change the situation, rather than emotional appeals or sermons.

The reaction of humanists, who, in their reaction against the misuse of science in present day society, wish to totally reject science and technology, is not of much use either. Science could neither be done away with nor the scientific endeavour reduced if the desire is to solve some of the present day problems of the contemporary societies. In order to achieve the latter a greater scientific effort may be necessary not only in various areas of research but also in the application of science and its social control. The latter could only be done through a greater and deeper study of science as a movement. Such a study would give the necessary insight and understanding and enable us to control and direct science into channels which are in consonance with human goals. Similarly, decrying the fall of the scientists from an idealistic pedestal is not likely to help. Scientists are like any other social group with their motivations and aspirations. An understanding and appreciation of their ambitions and channelling of those into social channels, along with educating them properly may develop them as a social group imbued with high ideals and persuade them to work for those goals which a society sets for them or they set for themselves.

Dependence of Scientists on the Government and its consequences

Modern science grew in India as a part of British occupation of the country and was utilised to serve the needs of the occupying power.[2] In doing so, it came to be closely associated with the establishment, to whom it looked for resources and support. The establishment, run by a well-trained and closely knit civil service, utilised the scientists as and when necessary, but kept the final decision making to itself. Consequently, even in the functioning of the science departments where a scientist was head of the department, the final decision making was in the hands of non-scientists. In the agencies, which were reorganised and galvanised after independence, a sort of a compromise was worked out when the heads of the agencies were also made secretaries to the government. The latter, however, does not apply to all the agencies.[3] This meant that while the power of administration was retained, the 'scientists' aspirations were directed in the channels of becoming members of the administrative elite, *i.e.* fitting into an existing framework and applying the service conditions and rules and regulations of that framework to science organisations.

Two consequences followed. Firstly, the scientists came to look to the government all the time. The latter was recently pointed out by the Prime Minister :

"It is rather disturbing to find that the leaders of this community, who should guide the government in identifying the imbalances to be corrected and initiatives taken, themselves seem to look towards the governmental bodies most of the time."[4]

Secondly, scientists instead of acting as a centre of well organised group, by rallying the community as a whole for the achievement of certain scientific, technological and social objectives, came to rely on government to give positions of powers to individual scientists. The struggle of the *elite* scientists was, therefore, directed towards being members of the decision making groups in the country. The latter was achieved through their being absorbed in the government administrative hierarchy. This was amply revealed, for instance, at the recent meeting organised by the CoST. In this context, a reference to the points raised in a review of this conference would be relevant :

"The scientists have been making a demand for participation in national policies, with a large content of science and technology, yet there is hardly any area of national policy which does not have such a content. The recommendations on the Science Policy stated : 'Though decision-making on important national policies involves technical, administrative and political components, at present only the politician and the administrator participate in the decision making.' The questions which necessarily arise here are : Do the scientists want to participate as mere technical people or as social changers and as a group of people in league with the future ? What are the policies which they would like to be adopted ? In what direction they would like society to move ? Have they any defined and clear-cut ideas, or would they like to participate merely for matters of prestige and status ?

"Scientists in the country so far have not given any significant indication of social thinking on a scale that could make them a social force for change. In the social sphere, they have shown a high degree of conformity to social practices, traditionalism, and conservatism, rather than a radical disposition. Some of the savants of science in the country have even advocated the cause of spiritualism, miraculous powers of religious heads, and have publicly advocated ritualism—ideas which are the very anti-thesis of science.

"In other words, the scientists' demand for participation in the framing of national policies and decision-making machinery is, at best, an advocacy for equal status in the *elite* group of the country, which they have been denied so far. Scientists in the country should be able to realise—particularly after the experience of the development and use of science and technology and its social consequences in advanced countries—that science and technology can become significant only in relation to particular social and political goals and objectives. A degree in science and specific technical competence is good and useful, but it does not necessarily lead to the position to which scientists aspire. Scientists and technologists in the advanced countries have over the centuries come to enjoy respect and prestige via their commitment to human values and the refinement of these through science and technology, and their advocacy of radical social changes in conformity with technological possibilities."[5]

In an effort to be part of the decision making elite, since only a few 'top' scientists could aspire to be thus absorbed, the major function of the scientific community, to work for specific goals in consonance with the knowledge and values generated by science was lost sight of. The problems, aspirations and the working conditions of the vast body of scientists were also ignored. Consequently, while the 'top' scientists aspired to be part of the decision making machinery, the conditions of work of the large body of working scientists became increasingly frustrating. The senior scientists tended to deny to their junior and younger colleagues what they aspired to achieve for themselves.[6] A cursory look, for instance, at the major recommendations arrived at, at the above mentioned conference, and the earlier conferences called to review the implementation of Science Policy Resolution, would reveal that a substantial proportion of the recommendations were not implemented, though they could have been by the scientists themselves. This could perhaps be explained by the fact that the scientific elite was preoccupied by its own limited objectives, at the expense of the conditions of a vast majority of scientists. Though it was the latter's number, effort and quality of work, which had given a new dimension to science and opened up opportunities for scientists in society.

The only way to improve the situation is, therefore, to bring about a change in terms of goals—from the limited aspirations of a few people to that of the community as a whole and for achieving broader social and human objectives. It is through the involvement of a large proportion of scientists that the scientific community can create the necessary impact on society. However, to motivate the scientists towards social goals and to create the necessary impact of the community on society would require a major change in their working conditions in terms of salary, freedom of expression and involvement in decision making at various levels.

Salary Structure of Scientists

The salary structure as it exists, unlike the civil service, is very broad at the base and very narrow at the top. Further, the multiplicity of grades adds to slow movement from the lower to higher levels. The number of people who could aspire to reach a decent level of salary, of say Rs. 1000/- or more, is extremely few. Besides, the time span in which it could be achieved is rather long.[7] Consequently, a large number have to be content at lower level, or make the problem of improving their salary and status, which goes along with it, their major preoccupation.

Low salaries, particularly for young scientists, when they are in their creative periods, generally cause considerable strain, particularly in view of the rising costs and difficulties of making the two ends meet. This forces the young scientists to divert their energies to have a better career, in terms of more salary. In the process they are exploited by the senior workers, who utilise their energies and work towards improving their own prospects. The cycle once started continues from one generation to another, in fact, gets intensified. As the young worker submits himself to the situation, the value system changes – from merit, creativity and independence of mind to subservience and utility to senior workers, thereby creating and increasing authoritarianism as well.[8] A young worker, therefore, tends to shy away from controversial issues and refrains from expressing himself on broad matters of policy and organisation and concerns himself more and more with his immediate work, or the work he is asked to do. This becomes a vicious circle, as more and more people allow themselves to be subjected.

It may not be a mere accident that the various revisions of salary structure of the scientists, even though they are even now not at par with those in administration or industry, have been beneficial mainly to those who are at the higher levels, while those working at lower levels, have only been marginally benefited, if at all.[9] The latter's position with the rise in the cost of living has become, if anything, much worse. This has increased those social features towards which a reference has been made earlier.

The only escape from the vicious circle is to move out to other countries, where there is a market at the moment. There has been, therefore, large scale migration of talented people from the country, which the country could ill-afford. The most interesting feature of this drain has been the reaction of some of the senior scientists. They don't seem to be perturbed about it and have often expressed that it is just as well that people should work elsewhere and contribute to 'world science'.[10] Nobody asks the questions as to why world science means advanced countries. Why India cannot provide them the necessary facilities, in terms of salaries and working conditions ? Why a decent standard of life in India, comparable to other professions in the country, and the necessary equipment and apparatus required for their work could not be made available to them ? These questions have not been asked, by those in power in scientific agencies and institutions, simply because to do so would initiate a process which would lead to breaking the control which senior scientists wish to perpetuate.

The change in basic emoluments and salary structure is likely to be crucial. Increase in the salary of scientists, to bring it at par with those in the administration and in industry, at least public sector industry, is essential, particularly at the lower level. Such a step is likely to result in a series of changes in the climate of science in the country. It would go a long way in removing the prevalent psychology of careerism, where the major effort of the scientists is spent on improving their salary and in order to achieve the purpose, they tend to please the superiors instead of achieving merit. A fairly good salary may ensure the generation of a climate, where a scientist would give greater attention to the problems in hand, to the field of science where he is working and those connected with policy and organisational matters. In doing so, the value system may also be affected in so far as the scientist would prefer to achieve distinction in science through merit and contribution rather than other means. Such an attitude will also cut through the prevalent authoritarianism and all which goes with it.

Freedom of Expression

Majority of the scientists work in laboratories of the agencies, where their conduct is guided by civil service rules. They are, therefore, unable to participate in public debates, discussions and debates on matters of policy, organisational problems and major decisions involving science. The freedom is enjoyed, if at all used, by senior scientists only, who in their capacity as office bearers of various societies occasionally touch on such controversial problems. The latter only in the context of their limited goals as indicated earlier. The younger scientists hardly have the freedom, and even where they could utilise the opportunity to express themselves, normally avoid for fear of contravening rules and wrath of senior scientists, particularly if their views are different from those of their superiors.[11] The freedom of expression, to younger scientists in particular, is essential for their development and maturity is also vital for the healthy growth of science. In the absence of such a freedom, apart from depriving the country of the benefit of opinion of young and creative workers, there is no feed back to the decision making machinery. It is difficult to know, for instance, the impact a particular decision has created on science and technology or on the scientists. Unless, of course, one is content to be guided by the personal impressions and opinions of those in command. Consequently, the mistakes committed continue and the required changes, to make science more effective, remain unrealised. Further, any effort on the latter direction has a tendency to get personalised.

The situation which prevails in the country, and the authoritarianism which has been the dominant feature of the organisation of science, would require considerable initiative and tact to encourage the workers to participate indiscussion on policy issues, organisational matters and controversial problems to persuade the younger workers to come out of their shells and express themselves freely. Only when such a policy is followed vigorously over a period that the desired results are likely to be achieved.

In following such a policy, the danger in the initial stages at least, is likely to be that before a proper orientation of scientists takes place, due to the pent up feelings and denial of such a freedom earlier, personal quarrels and petty issues may come to the fore. The extent to which that may happen would also depend upon the reaction of those in authority and how they handle the situation. Despite these risks, the chances have to be taken in the broader interest of science and scientists.

Democratisation

The increase in salaries and freedom of expression need be augmented further by democratisation of science. The latter, particularly in the area of decision making. At the present moment, the decision making is limited to a few 'eminent scientists', whether it is selection or review committees, expert groups, for new areas of science or national policy or organisation and investment. Consequently, the musical chairs and the phenomena whereby an eminent scientist in one field also becomes an expert in another field as well, in fact, in everything connected with science. This concentration of power has led to serious consequences, which have been pointed out earlier. In a population of over a million scientists, engineers and doctors, though all could not be involved in the decision making at all the levels, a fair proportion of them, however, could be involved at various levels, including the highest. In any case age should not be considered a bar against their participation, as is often suggested and invariably practised by the senior scientists.[12]

It is often stressed by some scientists that there is lack of talent in the country, particularly of eminent scientists to participate in the policy and decision making at various levels. The argument, to say the least, is denial of the merit of young scientists and their capacities, in order to keep the decision making limited to a few old scientists. To begin with, young workers are deliberately excluded from decision making machinery, either becase of their age or because of the assumption that if one is young and not experienced one is not likely to be wise. After excluding them, without testing their capabilities and abilities, the argument is further used to stress the lack of capable people. It is difficult to break the vicious circle unless one rejects the basic assumption of the argument and practice. Apart from the fact that science is the activity of the young, if one looks at the major achievements of science and technology, one cannot help noticing and admiring the role of the young scientists. If they could prove their capabilities and merit in their work and building up the infra-structure from the scratch there is no reason to believe that they will not be effective and wise in matters of policy at the highest level. And those who ignore them in decision making machinery, not only do injustice to them but incalculable harm to science in India. Such a step, of involving larger proportion of scientists in decision making, would not only put an end to the musical chairs, as is being played, but would also de-link issues with personalities, and put an end to the prevalent groupism.

The changes in the three directions, as briefly indicated, are essential for the further healthy growth of science and its effective utilisation for social and political goals. If science and technology is a powerful instrument of social change and scientists have to play an active and useful role in achieving those ends, if they have to act as a "group in league with the future", then an early and effective action in this direction is required. One could, of course, leave it to time and allow things to take their own course. That would mean allowing tensions to be developed to a breaking point, dissipation of energies of scientists and in-fighting to effect the necessary reform and changes in conditions of work.

Need for broadening the concept of science

The changes in the working conditions alone would not be sufficient unless they are accompanied by a major effort in promoting a perspective of science and creating social awareness amongst the scientists.

One of the major shortcomings in the education of scientists in the country is that it is limited to mere initiation into techniques and giving of information about knowledge of the different specialised branches of science. One is generally taught different and specialised subjects, told the theory, sometimes the latest, and is asked to carry out a few basic experiments. It is believed that a person, thus initiated into the individual theories and few experiments, would be able to appreciate science as a whole. It is like giving a few bricks to a person and leaving it to him to imagine the whole architecture. Consequently, the students who come out of the universities rarely have any idea of the historical development of science, its philosophy and general outlook. They are also generally unaware of the serious controversies raging in science, its social and political involvement, its role in modern society and the direction which science is taking or giving to society.

In the absence of any opportunity to know or discuss such problems a scientist remains indifferent to them and concentrates on the field of specialisation, for which he tries to obtain a degree. He, therefore, becomes a scientist only for a living, and never questions the current social outlooks, philosophies and attitudes, even though they might be directly opposed to science. Few amongst the scientists, who are more inquisitive, try to understand these aspects of science. In the absence of any literature in the country in the context of the growth of science, its interaction with society and philosophical problems, they read the European and American literature as is available to them. In the course of their studies, and if they are fortunate of being able to have contacts with the scientists overseas, they pick up information and concepts and attitudes which are relevant to the advanced countries. They, thus, seem to get an idea that these attitudes, philosophies and social attitudes are an intrinsic part of science and universal, since science is considered international. This would be evident from a cursory glance at the literature, such as is published in India. The articles and papers published by Indian scientists talk more about the development overseas, give examples and advocate conclusions arrived at in the advanced countries. The philosophical issues raised and the social problems discussed in the advanced countries appear to attract more attention of the scientists than more pressing problems and issues at home. These attitudes and outlooks have led to considerable alienation of scientists from their social milieu.

The alienation can be noticed in diverse ways. Take for example the field of history of science. It is rather surprising that despite the lip service by many leading scientists to our glorious past contributions to science, there is hardly any literature on the historical development of science in India, let alone school and college textbooks. What is available is generally unhistorical, uncritical and apologetic in character, and what is worse, based only on the secondary source material. The present situation can only be explained on the basis that either history of science is not considered essential to science or history of Indian science is not considered relevant. The latter opinion seems to dominate the thinking of Indian scientists, since the students at the universities are hardly ever referred to either historical or social problems of science in India. The historical and social problems of Europe and America are commonly described and discussed. This may be based either on the assumption that there is a sharp break in ancient and modern science in India, and there is no meeting ground between the two, or that the pattern of growth of science is universal and India may follow the stages of earlier developments of the European countries. In either case the study of the historical tradition of science in India becomes irrelevant. This attitude of mind is due to the fact that science is not considered as a movement, and no attempt is made to develop its overall perspective. Consequently, the nature of science in different periods of history, its interaction with society and the philosophical attitudes and outlooks are hardly understood and appreciated. We, therefore, bar ourselves from asking some basic questions and getting an answer or insight into them, such as : why science and technology did not evolve in India, after having reached a particular level of development ? Why the scientific and technological revolution did not take place in India, as it did in Europe ? Were the reasons inherent in science of the country, the then prevalent philosophical outlooks or structure of society ?

Similar to the neglect of history of science, there has been no appreciation of the need for *'generalists'*. A generalist in science, as opposed to the specialist, who is involved in discovering new facts, is to involve himself with the study of science as a process, its growth, trends, philosophy and interaction with other human activities and the dissemination of knowledge covering these areas. If science has come to play the role it has in contemporary society then an effort to create a synoptic understanding of science becomes necessary, both amongst the scientists as well as amongst the public. The generalists besides creating science consciousness amongst people can also be useful in forging links with other human activities. The effort can go a long way in making science as a part of culture of the country and in developing culture and social values in consonance with scientific knowledge. At the moment there is hardly any worthwhile effort in the country in this direction. Whatever attempt is being made is either to dazzle the people with the achievements of science and technology or merely to give them basic information about the latest discoveries and developments. The former creates a wrong image, and may even persuade people to accept things, in the name of science and technology, which would not be acceptable to them otherwise. The latter, however, does not generate much interest, either due to language, which remains esoteric despite the effort, or due to the fact that information is not relevant to immediate needs and problems of the people. The net result, of both the efforts, is either an uncritical attitude of accepting the currently fashionable ideas or indifference. In either case the result is the same, *i.e.* science, its values and outlook, do not become a part of the culture of the society. Lack of science consciousness and its proper appreciation effectively prevents people from exercising control over science, the area of its growth and the manner and degree of its utilisation. The scientists themselves, either consciously or unconsciously might be responsible for this limitation of science and the way it is being popularised. This might be due to their desire to have a special position and role in society like the priests in antiquity. Depriving science of its mystique and allowing people to participate in the decision making about science may end their importance. In any case they would no longer remain the promoters, decision makers and evaluaters, as they are today.

The conceptual approach to science, which reduces it to a sum of different fields of specialisations, prevents the generation of necessary capabilities in areas where multiple disciplines of science as well as economic, social and political and other fields are required to be integrated. One such field is called by various names as Science of Science, Science Policy Studies and Science Analysis etc. With science and technology becoming deeply involved, with economic, social, military and political issues, there is a need to study such problems in depth. There are large areas of the policies of the government which have to be analysed in the context of their consequences in terms of national as well as the international effects. Besides, the consequences of a major support to an area, in terms of investment, on other areas of science and economy as a whole requires to be understood before a commitment is made. For instance, it would be necessary to know, beforehand, the nature and degree of commitment if India is going for the nuclear programme as suggested in the 10-year programme of the AEC. The latter, in terms of total investment, the estimates as well as the expenditure, which is likely to be at the end of the programme, the requirements of ancilliary developments, the resources of technical personnel required in different fields, of specialisation, if the latter are not available the inducements and the period required to create them. Further, the effect of the scale of investment on other areas of science and industry and the likely returns in terms of technical objectives and social benefits. In the case of satellite hook up for radio and television, another dimension, of political interaction with other countries, with their divergent social goals and political objectives are also involved, besides a whole lot of economic industrial, technical and other problems. These problems are to be studied not only for themselves but also in relation to other objectives. New techniques such as systems analysis, have now been developed to facilitate a critical study of the problems, maximise the utilisation of available resources and help arrive at a decision. The information and knowledge thus gathered, would be of immense help, if disseminated, to debate the issues and induce the people to effectively participate in the social decisions. In the absence of the latter, only technical feasibility and the exciting prospects, promoted by the scientists are emphasised in the decision making process. Consequently, to undo this onesidedness, a major effort would be necessary to involve people from other fields of specialisation and activities and the public. Unless that is done the decision making would be the prerogative of the promoter and the administrator. Further, the creating of the necessary consciousness of the multiple issues involved cannot be left to either. This has to be done by an expert cadre in this field, of science analysts and critics. This is required to be developed both in the universities as well as in agencies to help the policy makers in decision making, and to make the people aware of what is involved.

The changes suggested in the working conditions, in the field of education and the realisation of giving attention to the new fields of science would go a long way in the transformation of science, role of scientists and the dimensions of science and its effectiveness in society. It is time that the scientists in India grow out of the romantic picture of science and its compartmentalised structure, to appreciate science as a movement and as an instrument of social transformation. In doing so they would also develop a national identity of their own.

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3. For example ICAR and ICMR.
4. Address to the Third Conference of Scientists & Educationists, organised by CoST, November 1970.
5. A contextual Role for Scientists & Technologists, Political & Economic Weekly, VI, No. 1, 1971, January 2.
6. This would be evident from the discussion of the two recent seminars : Management of Scientific Research, organised by CoST and Administrative Staff College, Hyderabad and the Third Conference of Scientists & Technologists, organised by CoST, as well as the seminar on Chemistry, organised by UGC, at Bangalore.
7. See—
   i) K. Ray, Policy on Scientific & Technical Manpower, Science in Parliament, 3(1), 1965, pp, 92-101.
   ii) Aqueil Ahmad & S.P. Gupta, Opinion Survey of Scientists & Technologists, RSPO, CSIR, 1967,
   iii) A Study of Expenditure in National Laboratories, RSPO, CSIR, 1964.
8. See for instance :
   Edward Shils : The Intellectual between Tradition & Modernity, Hague, 1961.
   J.D. Sethi : Seminar, 112, 1968, p. 36.
   A.D. Bhogle : University News, VII (1) 1969, Jan., pp. 3-5.
9. This would be evident from the reports on revision of salaries from time to time.
10. See for instance, the statements of leaders of science, one of whom is quoted in CSIR and its Affairs, Mainstream Publication, 1970.
11. See for detailed discussion : Scientists in India, International Sociological Science Journal, Vol. 22, No. 1, 1970.
12. See for instance the remarks of Prof. Seshadri at the CASTASIA conference organised by Unesco, where he said that scientists below a certain age should not be involved in decision making.

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