The Cultural Values of Science
Pontifical Academy of Sciences, *Scripta Varia* 105, Vatican City 2003
www.pas.va/content/dam/accademia/pdf/sv105/sv105-rao.pdf

SCIENCE AS A CULTURE: A CRITICAL APPRECIATION

CHINTAMANI N.R. RAO

Scientists have generally stood for certain principles that have provided traditions which go far beyond geographical boundaries. Scientists of the world do indeed constitute a supranational sub-culture and have evolved a value system of great relevance to society. Important qualities such as integrity, honesty and search for truth are taken as essential elements in the science sub-culture. Science also allows for aesthetics and has a place for beauty in science itself. What is not often understood, however, is the need for science in society or in one's life, other than for utilitarian purposes. Clearly, science also has a place in society just as poetry and philosophy.

In spite of the great virtues of science and the positive impact of science on human beings at large, it is important that we are conscious of how science is being practiced at the working level and how it may develop undesirable traits over a period of time. Such introspection and alertness are necessary to preserve the culture of science and science itself in the long run. The decreasing enthusiasm for science and the low priority it receives in the value system in many societies and amongst the younger generation makes it imperative to examine certain features that have emerged over the recent past. I shall attempt to examine some of these issues briefly.

The very rigour of science often results in parochialism and narrow loyalties, which can promote undesirable ways of communicating with one another even within the scientific community. It is not only divisions such as physics, chemistry and biology that dominate our functioning, but further subdivisions. For examples, in physics it is particle physics versus condensed matter physics. In chemistry, it is worse. It is just not organic, inorganic, physical etc., but people define themselves even more narrowly (e.g. molecular biophysical chemist). But, science is interdisciplinary, and science is one and universal. Such narrow sub-divisions have seriously affected the

teaching of science. This is specially true of chemistry. This has gone to the extent that many well-trained chemists find it difficult to teach a general chemistry course to beginning college students. They would rather teach specialized courses. We practice science in an interdisciplinary fashion. We carry out much of our research with an interdisciplinary approach, but we teach science on the basis of disciplines. We have to examine how this indisciplinary aspect comes into teaching. In many countries, curricula have become so rigid that a physics student has no way of learning biology or vice versa. A medical doctor does not learn basic science after high school.

'Fundamental' study is the general explanation or excuse given by most of us who carry out basic research. Under the façade of fundamental study, there is a tendency amongst many of us not to constructively scrutinize established styles of research. People find it convenient to classify science as basic (or fundamental) and applied. I find this to be counter productive. As far as I am concerned, there is science that has already been applied and science that is yet to be applied. Furthermore, the quality of mind required for applied work is by no means inferior to that required for basic research. Such distinctions may come in the way of creativity and encourage routine research. This may also render science less exciting.

There is a tendency amongst some scientists to claim that science can explain everything, including many of the human feelings and emotions such as love and faith. This has given rise to a new form of arrogance. Such arrogance may not be conducive to a meaningful way of life and to a purposeful practice of science.

Science has given birth to a language which tends to be antiseptic. Scholarly articles are accepted for publication only if a certain type of impersonal language is used. For example, one cannot write a paper where one states, 'I took the sample in a tube and heated it and then while cooling, I added x to it'. Instead one writes, 'the sample was taken in a tube and heated, and x added to it while cooling'. Is this necessary? Or, is this good? Is passive voice best for science? After all, much of the science is an expression of personal ideas, dreams and accomplishments.

While we use passive voice in writing, many of us have become much too selfish in the practice of science. Excessive industrial consultancy and commercial interests affect the way science is practiced. Rivalry, monetary benefits and the like have had a dominating influence on many scientists. Recognition and rewards (at all cost) become the priority and the pleasure of discovery is lost in this process. Such things change the value system in science.

Highly restrictive practices in the sharing of data and information go against the spirit of science. We have to carefully navigate in the present day scenario to ensure that knowledge is created basically for the benefit of humankind.

While promoting science culture, it is important to give due attention to the existing cultures in the world. These cultures have survived for centuries and have created languages, traditions and a variety of other important treasures of humankind. It is possible that as the science culture spreads, it may favour a common language which may slowly wipe out the importance of many important languages and cultures that exist today. Looking at the performance of human beings in the last century, we see that many important cultures, as exemplified by those of many tribes in Asia and Africa, have been wiped out. Many of the dialects and languages have been disappearing. I personally know of some of the languages and cultures in India wiped out in recent years. This may happen more during the next century even to some of the major languages and cultures of the world which may gradually lose their identity. This would be very unfortunate because the very diversity of this world is what makes it interesting and exciting. We have the responsibility to protect cultural diversity and traditional knowledge of various countries. At this juncture, I must point out that the cross-cultural effects play a role in teaching science in the villages of Asia or Africa. We have to examine the importance of cross-cultural effects in science education and in the spreading of the culture of science.

I cannot help feeling at this stage of my life that there is something called bad science as opposed to good science. A typical scenario that creates bad science is one where a scientist carries out a programme of research knowing fully that the results will be used to harm other human beings. The case of Haber is an example of a scientist who did great science (synthesis of ammonia) which saved humankind from hunger and also bad science (mustard gas) which killed many innocent lives. Cloning humans is, to me, an eminent example of bad science and yet it is being pursued. Bad science destroys the image of science and will contribute to the negative aspects of the science culture. Should we pursue any kind of science and at any cost? Some people may feel that cloning or making a killing chemical may be technology and not science, thus wash off the responsibility of science and scientists. I do not, however, subscribe to such puritanical views. As far as I am concerned, human cloning or synthesis of chemicals for warfare is also pursued by well-trained scientists.

When we think of science of the future, we have to be concerned as to how the culture of science will develop and influence the future of mankind. In order to protect and preserve the good features of the science culture, scientists would have to bear social and moral responsibility for situations arising from scientific pursuit. While scientists undoubtedly will continue to be interested in the discovery of new knowledge, it is important that science involves the minds and hearts of the peoples of the world and includes a component that leads to enlightenment. The culture of science could indeed help to make the practice of science a spiritual experience under favourable circumstances.

I believe that in this century, we should evolve practices that bring about major changes in our science culture which in turn would improve human condition and transform human society for the better. This would require a change in our attitudes to the poor, and those from the third world. The third world, consisting of a majority of the world's population is still suffering from illiteracy, poverty, disease and the absence of basic needs such as safe drinking water. The third world is yet to benefit from the scientific knowledge that has accrued in the world. We should do everything possible to spread scientific temper and knowledge amongst all the peoples of the world. In order to accomplish this, the main stream of science has to flow everywhere creating new channels and tributaries. Such a river of knowledge can only be created by the involvement of enlightened scientists in science education and human development. This will require humility, generosity and human concern on the part of all concerned scientists.

DISCUSSION ON THE PAPER BY RAO

VICUÑA: Before I comment on Dr. Rao's talk, I would like to say to Professor Zichichi that sometimes it's not so easy to differentiate between science and technology. I used to think the way you do, but now you see scientists that are in favour of doing research with embryos to manipulate them and to extract cells from them to do research, and they use words that don't mean exactly what they should mean, for example, they don't want to call it 'human cloning', they say 'nuclear transfer', and they say that the embryo is not a human being or a human entity just to be able to extract cells from them and do research that may have a very nice or useful purpose in the future, but the end doesn't justify the means, and that is research, it's not technology, that would be science. And when Dolly was cloned people were very concerned about cloning humans and I participated in so many debates in Chile and elsewhere saying: 'Don't worry, we scientists are pursuing the truth and we'll do what we have to do, but other people may use this knowledge in a bad way, but that is not our fault'. And you see now scientists that are doing research in a way that at least I don't approve and not everybody approves, and I would say that of scientific research. You may respond to that later, but I would like to comment on Dr. Rao's talk, and I think I share with him most of the concerns he has expressed about the way science is being conducted today, and I think that that's due to the fact that until recently science was a more idealistic activity, and was conducted by few people who followed a vocation, but science today for most people, especially for young people, is another way of making a living, you see, it has become a profession, a less idealistic activity perhaps than it used to be, so it is more competitive, there is more selfishness and it has become more massive than before, and I think that is the explanation.

IACCARINO: Professor Rao mentioned human cloning. I wish to make a comment. In UNESCO we prepared the Declaration on the Human Genome. It has been approved by the governments of all states, including

the Vatican. This declaration includes a paragraph on the prohibition of human cloning. I assume, and this is a question, that the Vatican approved the declaration after consulting the Pontifical Academy.

CABIBBO: No, we were not involved in that. I think it's important, however, to distinguish between ethical behaviour in research and the aim of the research. So, for example the use of embryos for purely scientific research is an ethical problem and it's certainly a serious problem, but there are other problems, such as mustard gas, which are completely different, maybe worse. Anyhow, they are two different problems, it's not that because you are only looking for truth you are automatically ethical. There may be bad things that you can do while looking for truth.

MENON: Mr. Chairman, I agree with my friend Professor Zichichi that science has first of all to be regarded as a creative activity through which one is trying to explore for the truth, to try to understand nature, to explain how nature behaves, and to do all of this on a quantitative experimental basis. But I would like to point out another angle to Professor Zichichi. He is a television star, and he interacts with governments at various levels. To some extent I've done the same, at least interacting with governments, and I know how politicians and administrators look at these things. I would like to read out to you from Professor Léna's talk this morning in which he says, quoting Jorge Allende, a very distinguished biologist from Chile, who said: 'For most people in Chile science is something magical, complex and expensive, that is done in the United States, Japan and Europe, that results in new gadgets or medicines that eventually appear in the stores of Santiago'. We must recognize that this is not the image of science that I just outlined. If you are a mathematician and do pure mathematics, number theory and the like, you can say it's the purest of all activities, and it is not harming anybody, but public perception is equally important, and nobody, no society today accepts a definition where science is looked at in this particular way. We all know of the interaction and the symbiotic and synergistic relationship between science, technology, applied science and what it has led to, and this is what society sees. You may say that science has nothing to do with the ozone hole, nothing to do with DDT, nothing to do with the thalidomide disaster and so on, but in the public image it has. CFCs are highly inert: they have a long lifetime; and therefore, as far as scientists were concerned, they were considered totally safe; that was the promise made. But when

they finally went into the stratosphere they interacted, and we found that they were capable of producing the ozone hole for reasons that we now understand. There are many instances like this. The fact is that public perception, how people look at all this, is even more important than our semantic definitions of what science is. This is the first point.

My second point is this. I remember Professor Singer said that the Manhattan Project was an engineering project, and so we should not regard it as science. One can say that it was purely a technology project because it was making an object, an object called the atomic bomb. But if you read the list of people who worked on the Manhattan Project they were the greatest scientists you had around, Robert Oppenheimer, Enrico Fermi, Louis Alvarez, John Cockcroft, Hans Bethe, Ernest Lawrence, Rudolph Peierls, Richard Feynman – a who's who of science. There were many unsolved questions which had to be dealt with before you could make something so completely new at that point in time. It needed knowledge then unknown and understanding of how Nature behaved. Therefore, we must accept that in many areas there is a significant overlap of science and technology, and we have to be very careful to understand how the public perceives it. We cannot escape responsibility by saying, 'Look, as far as we are concerned, this is science, this is what we are doing, therefore we are totally clear'. The American philosopher Herbert Marcuse has written, 'When the most abstract achievement of mathematics and physics satisfy so adequately the needs of IBM and the Atomic Energy Commission, it is time to ask whether such applicability is not inherent in the concepts of science itself'.

The other point that I want to make, if I may take a few minutes, Mr. Chairman, is on a completely different topic. It concerns the very important point that Professor C.N.R. Rao made about culture and language. We have to recognise that, in this particular meeting, we are talking about the cultural aspects of science. The title is 'The Cultural Values of Science'. Certainly science has a cultural value, since it is related to values such as creativity, curiosity, beauty and truth. If you ask how science flowered and grew exponentially over the last few hundred years, it is essentially because there were conditions in society which favoured it, and which allowed it to develop that way. Therefore we cannot separate science from society as a separate independent activity.

In society we are dealing with its culture, not with a monolithic culture but with diverse cultures. Professor Arber talked about biodiversity; similarly there is cultural diversity in the world which has also evolved over

time. And there is a strong relationship between language and culture. We are aware of the fact that what distinguishes human beings from the rest of the animal kingdom is their ability to communicate, their ability for social interaction, and with it of absorbing what is in the surroundings. And therefore we can ask ourselves, how did all these languages grow? We've heard the very brilliant lecture by Professor Werner Arber sitting in front, on the whole question of evolution from the Darwinian stage right up to molecular evolution through which we broadly understand, the horizontal spread, the vertical spread and so on. We still don't understand how languages developed. There are of course theories on how they grew from initial stages, but what is certain is that language has a great deal which relates to the surroundings. That is why words emerge which relate to what you see: relating to the desert, the tundra, the mountains, the icy continents, the forests, and so on and so forth, for those who live in these. Many languages and concepts have arisen from their surroundings, tradition and history, for which there are no corresponding expressions in any other language. This is all part of the diversity that humanity has inherited over a long time period: cultural diversity and linguistic diversity.

Now, if you look at the situation on the ground, you find that actually the total number of languages, and I have a list here, is about three thousand in the world, of which at least 38 are spoken by more than ten million people each. There are ten languages which are spoken by more than a hundred million people. Now we are in the age of information technology, and it is very young; the Internet and www in its present operational form with widespread IT ramifications in society, are just ten years old. What is happening is that the bulk of the knowledge base of the world, in the form in which it can be actually largely accessed is in English or a few other languages of the Western world, and that is where everybody searches. This is going to create a situation of tremendous imbalance, of Western, indeed English predominance, with everything in English; this will have a major impact if you take a longer time horizon. I know Dr. Lourdes Arizpe answered Professor Rao's question yesterday when she said: 'Look at the fact that you have America, the United States, you have Europe, France, and you have Japan, and they still, in spite of IT and so on, have preserved their cultural differences'. But I would like to state that this is only in a time period of a few years that the IT age in the form of the Internet and www has been in existence; if you take a much longer period its impact could be greater, as you focus entirely on accessing knowledge, and people will have to do that in the knowledge-based economy and society of the future. What

impact this will have on human psychology cannot be forecast as it involves brain development, cognitive and group psychology. Those who are out of it are totally left out. The digital divide could be the most defining divide of the future, if we are not careful, and we'll have to look into it.

If you look at English today, it relates to about 320 million people in the world. Just two languages that I can name in India and Bangladesh, Hindi and Bengali, have more related population than English, and yet nobody knows them here. Therefore this dominance and its impact on the cultural diversity of the world is something that should concern science. That's why Professor Léna referred to comments that I had made in the education study group last year about the need for scientific efforts and technological breakthroughs relating to a seamless transition from one language to another, which is now possible for a large part of the work involved in access to scientific knowledge.

So, I thought I should mention that we should not, when we only talk of the cultural value of science, forget the rest of cultural diversity that characterises the societies of the world; or what is going to happen to this in the future as we proceed along with scientific developments converted to technologies in the IT area, and their impact; this is similar to what is happening to biodiversity as a result of human greed, and that is again something we cannot afford to lose; as Professor Werner Arber has told us, that is something which we cannot reproduce, which has arisen out of a process of evolution over a long time period in ways which we are not competent or capable of generating; it is not that we can't make an individual transformation, but on the other hand to do that on the scale as nature has done is something which is unlikely to take place.

So we ought to be cautious of how we move in these areas, and ensure that what we do ensures that the ill effects don't take over.

ZICHICHI: Professor Rao has made an encyclopaedic review of the three basic achievements of the human intellect which are, and remain, indeed, language, logic and science. It is our duty to let people clearly understand what the implications are for each of these three pillars of our intellectual achievements. Let me give an example: a couple of years ago the President of the most powerful country in the world, the United States, signed a cheque for 20 billion dollars for a project which is technology but which was presented as science, and crossed out another project which was also presented as science and indeed was real science. The decision-making people need to have clear ideas. The image of science is due to us, not to any-

body else. If we go on confusing technology and science, then we'll suffer from this. Cloning is genetic engineering, it's technology, it's not science.

You mentioned Fermi, Oppenheimer, Wigner, the great scientists of the twentieth century involved in the Manhattan Project. Why? Because the moments were tragic, and therefore if you want to select people to implement the project you cannot use a poet, but if Dante was able not only to write the 'Divina Commedia' but also to invent an instrument, you cannot say that language and technology are the same thing, because the same person can play the violin and then engage himself in some other activity in science. So, the distinction between science and technology is absolutely profound, and I'm very grateful to this great Pope, who has made this distinction clear to everybody: the use of science is no longer science. We cannot confuse technology with science, because as a result true science will suffer. For example, you mentioned my public activity in Italy. Why do I do this? Because we live in a democratic country and if you want to have influence you must speak to people. It is not enough to speak to decision-makers. You must show that people follow you, and people in Italy follow me. They make this vital separation between science and technology. There was a sort of analysis made by a British group of people and they realised that Italy is the first country in the world where science and technology are clearly defined. People don't confuse science and technology. It is in our interest, in the interest of science, of true science, to make this distinction.

If we go on confusing bad science, good science, technology, language and logic, then how can a decision-maker, who hardly understands the difference between chemistry and physics, make a decision? So, it is our responsibility to make clear the distinction between pure science and technology. I invite my friend Professor Menon to help us in making a big step in India to make all Indian people clearly distinguish between science and technology.

RAO: Who cannot agree with Professor Zichichi? We all agree. Among scientists I think this is a very good argument, and I always defend science outside and say, 'Look, don't confuse science with technology'. I've been doing that all my life, and there is nothing new in what he says. The unfortunate thing is that there are cross terms. It is not that science is pure, technology is pure: there are not two compartments. There is a tremendous interaction. For example, discovering a new compound, which is a better nerve gas, is science, there is no technology in that. So,

you cannot say: 'Oh, it is pure technology'. Similarly, many things I talked about today deal with interaction of science and society. You cannot say scientists are not responsible because the destruction of a language has nothing to do with science. Yes, sure, except that the way we are practising science and bringing new technology – there is a responsibility to see that the societies we live in do not experience the disappearance of languages and cultures, because they are all trying to follow the science culture and the technology culture. So, we can't say sciences are so pure they have nothing to do with technology. In fact, where Zichichi is wrong is that some of the science I do today, in two months may become technology. There are certain areas for example in nanoscience that I do, some become technology within a year, within six months, so it is very difficult to say where science ends and technology begins. So much purity, I do not approve of.

LÉNA: I would simply like to point out that a distinction between science and technology may be looked at at a theoretical level, but has also to be looked at at a practical level. I have the good fortune to work in an area of science – astrophysics – which has little applications, but is critically dependant on technology to build new instruments, discover through new observations. Is this lack of immediate applications the reason of the great favour astronomy always enjoys with the public?

On a practical level, everybody understands who decides which science ought to be done: the scientist. But who decides for the technology? It is unclear for the public: the industry leaders? The politicians? While clearly a given technology is related to science, and scientists are always proud to show their discoveries have applications. In practice and to many, science appears hard to distinguish from its applications.

CABIBBO: I wanted to propose that we close at this point, because we still have two talks to hear. If I am allowed, however, to comment, I always remember the story of the mad cow disease, which was somehow counted as one of the bad effects of science, when it was due clearly to someone else. I mean scientists discovered the thing, warned against its danger but their warnings were not heard.

RAO: Professor Cabibbo, I don't know if you remember, but in the beginning of the talk I did say that these are the issues where the Academy should be really worried. We are in fact really not just scientists.

As Professor Zichichi said, our relations with society are intense. I think we should spend much more time on these issues, and come out with maybe our own guidelines and whatever we want to. I don't know if it helps anybody, but certainly it's not a bad thing to look at these issues. We really should have more discussion.