# QUALITY IN SCIENCE*

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IN this talk, I shall tell you about how quality of science can be improved, with special reference to the activities in our own country. First of all, I would like to dispel a common mistake made by many, that scientific research is an esoteric activity, and that it does not deal much with practical things. This is not at all true, for science is not a blind search for new facts, which may have no relevance to practical reality. It is, really a *search for utilizable knowledge*, and the development of this knowledge for the good of mankind. In that sense, what are commonly designated as "basic science" and "applied science", cannot be separated at all, and the two are closely intermingled. Therefore, they have to be considered together whenever programmes of research in science, particularly in countries like ours, are planned and executed.

Unfortunately, we have, in our country, far too many persons working in the so-called "pure" fields of science, so that the feeling has gained ground that only such researches should be encouraged in the name of science and that this is what constitutes real science. The practical worker, who only applies the known knowledge in science for designing a machine or a gadget required for a specific purpose, is often taken to belong only to the lower grade of scientists, and is given the name "technologist", rather than "scientist". This is not at all correct, and the first suggestion I would like to make is that this non-appreciative attitude towards applied research should be reversed, and the ability to solve an actual problem that one is presented with, should become the real measuring rod for evaluating the capability of a scientific investigator.

Coming back to quality in science, the most important criterion that contributes to this is the following :— Any research is of high quality if it requires considerable thinking, planning, design, and originality, on the part of the investigator, and if it has achieved the purpose for which it was started.

I may illustrate this by two particular examples that readily come to my mind. One is the discovery of penicillin by the famous British medical and biological scientist, Alexander Fleming, and the second is that of the "Raman Effect" by our revered Prof. Sir C. V. Raman. In the case of Fleming, the deduction which he made, namely, that a chemical produced by the mould penicillium notatum which had fallen on the medium in a petri dish containing bacteria, was the responsible agent for the disappearance of the bacteria in the neighbourhood of the spot of mould, was indeed a discovery of monumental importance. Hundreds of persons before him would have seen such dishes being spoiled by mould deposits; but only Fleming had the wonderful idea that the mould was producing *an anti-bacterial agent, which could be usefully employed* to kill the disease-producing bacteria in the human body. With the cooperation of several other British scientists, he isolated the chemical, which has since then come to be known as penicillin. In fact, Fleming's work has led to a *whole new age of antibiotics*.

In the same way, what Raman discovered was the occurrence of a small number of weak lines, other than those due to the incident light, in the spectrum of light scattered by a pure liquid medium. Many persons, who had seen such lines earlier, had attributed these to impurities, and rejected those data. Raman, on the other hand, had the perspicacity to study them in great detail, and to convince himself that they were really due to a new optical effect produced in the medium itself. This was a great discovery, for not only did it establish a new type of optical effect (the Raman Effect) as a part of science, but *it has become an extremely practical technique* in recent years for studying the spectra of molecules very very simply. However, unfortunately, the practical establishment of the Raman Effect as a powerful analytical tool had to be done by workers in Europe and USA, and not in India.

Having thus considered what high quality research is, let me examine what we should do in order to foster this type of work in our country. All that is needed, in my opinion, is that the right type of encouragement should be given to persons who are capable of doing high quality research. A beautifully and elaborately written report about a piece of work should not be the sole criterion for judging the quality of a piece of work. The quality can be judged much better by talking to the person concerned, and finding out what his ideas are—not only of what he has discovered and of what he is currently working upon, but particularly about what he expects to do five or ten years hence. I believe that *the poor quality of science*, which generally exists *in India* (with a few notable exceptions) *is due to the lack of such a plan or purpose* in the investigations. Very often, we find that a person studies a large number of compounds using a particular

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technique, and becomes a good specialist in that field. However, he neither makes a new improvement in the technique, nor does he have, as his ultimate aim, a systematic study of the chemical, or biological, or medical, aspects of the compounds he has studied. The compounds examined are often unrelated, and they were taken up for study only because they happened to be available. It is quite likely that such a person has hundreds of publications to his credit, but they make only for quantity, and not for quality.

On the other hand, even ten papers produced in five years, but each of which goes to the root of the problem, and involves an investigation of the essential features of the subject which he is studying, should, in my opinion, qualify a young worker for special consideration and support. Therefore, if we want to improve the quality of science in India, I would suggest that the following be especially taken into account :

1. A genuine feeling must come among the younger scientists in the country that *there are persons who will appreciate quality* and not quantity, *and who will encourage really good work*. Unfortunately, very often, quality works out to be rather a disqualification, than a qualification, for achieving success as a scientist, in our country. Consequently, many good and sincere workers have gone abroad and have obtained the right type of encouragement, and are producing high grade work there, and not in their homeland.

2. If it is found that a person has a clear aim in his researches, (particularly in relation to future application of his studies towards practical results), then he should be provided abundantly with the necessary equipment, facilities, and grants, to go ahead with it. This means that *it is the duty of the senior scientists* in our country to make a proper and correct appreciation of the quality of work of young workers in different places, and *to provide grants which are commensurate with the real and intrinsic worth* in each case. There should be no dilution in this process, and preferential benefits should be provided to the right persons, with the full confidence and support of all the scientific workers in the country.

3. Our Planning Commission should bring out short booklets dealing with different fields of science, which indicate the types of studies that will lead to really *useful consequences of a practical nature for the benefit of the Nation*. I may take as an example the energy crisis. Several suggestions have been made to take care of this, but the biological approach of fixing solar energy has not been pursued well enough in the advanced countries, for various reasons. We, in India, have plenty of sunshine, and plenty of land where grasses, or other fast-growing plants can be grown utilizing sunlight. Therefore, we should go about studying intensively the following, with special reference to Indian conditions : (*a*) The best method of getting energy-rich compounds from biological materials of plants; (*b*) the best way of storing such energy-rich materials; (*c*) the best way of utilizing them either for producing electricity in a central place, or for driving vehicles like automobiles and locomotives; (*d*) the best way of utilizing these chemicals not only for energy, but also for various other purposes; and so on. In fact, this one subject alone can employ as many as a hundred research establishments spread all over the country. Microbiologists, biochemists, chemical engineers, mechanical engineers, agricultural scientists, botanists, and even physicists and chemists, can play an important part in planning, designing, organizing and carrying out, the researches leading to the production of results of practical value, in this field.

4. This brings me, finally, to the question of organization. I always tell my friends that we, in India, are individualists, and can rarely get together to do something in an organized, cooperative, manner. This tendency must be overcome, and the leading scientists should particularly encourage inter-institutional, inter-departmental, and, more than that, inter-individual cooperation, in doing research of value to the whole of the country. If this can really be done, then I would feel that I have succeeded in the purpose of this talk. If such studies prosper and lead to practical results, the scientists themselves will feel that what they are doing is of high quality, and will achieve satisfaction in their endeavours. They will feel happy not only that they have learnt new things, and produced new results, but also that they have contributed to the development of the nation, and to the improvement of the lot of the common man.