

Mega science versus small science: remarks on scientific research in India*

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This note presents a critical appraisal on scientific research in India now, and delineates basic lacunae in the praxis of science in India today, with suggestions on how these may be overcome.

'Mega science' and 'small science' refer to two aspects of scientific research which are on the one hand, complementary to each other, while at the same time have elements of dichotomy. However, the dichotomy is nowhere as clear-cut as that between large-scale and small-scale industry. This makes the discussion slightly more complicated in comparison to the discussion on industry.

Mega science is a type of highly organized scientific research activity where many scientists are engaged in tracing out solutions to a small number of specific problems, requiring large laboratories, costly equipment and powerful computers. Obviously, this entails investment of large amounts of money that can only be financed by national governments in most countries. India is no exception to this. These laboratories house many expensive, mostly imported, equipment and instrumentation. Official funding for mega science projects has not really been parsimonious, in recent decades, given that its entire source is public money. Even so, influential scientists argue, perhaps correctly, that government science budgeting in India is far smaller than in China. Our slower progress in scientific research is thus often attributed to a fund-crunch, relative to countries who have done better. The point that this argument misses is that our investment in primary and secondary education – imperative for generating sufficiently large numbers of technically skilled and creative scientific personnel – is also far smaller than that in those countries, many times over.

It is important to note that, in mega science, original and creative research is not always the real goal. The scope of truly creative work in research pro-

grammes conducted in most of the large laboratories around the world is somewhat limited. The reason behind this is that the activities in these organizations centre around pre-planned programmes. In most cases, scientists strive to implement the plans and programmes set up by those who are at the helm of affairs. Hence there is hardly any scope for carrying on 'free' or 'blue-sky' research, or what we call 'small science'.

However, the number of scientists engaged in small science research in universities across the world exceeds by far the number in large laboratories. In countries where the extent of scientific advancement is higher compared to that in India, small science is the dominant sector of creative research. Small science provides the right opportunity for a talented researcher towards enabling her talents maximally. In this pursuit, she is free from any constraint imposed on her from the authorities, and can focus on her own research agenda. Such pursuits often get hindered within the fetters of restriction of pre-determined programmes that mega science invariably entails.

In countries where original research achievements are more advanced than in India, there is no dispute over this matter. There, the best arenas for research are the universities where teaching and research go on hand-in-hand. The rationale behind this system is that, if teaching and research do not go in unison, both eventually lose their productivity. This inference finds support from the fact that news about Nobel Prize-winning original research usually comes from universities than from large laboratories.

This by no means implies that mega science research activities in large research organizations are of limited use; rather the opposite is true. In most cases, research in the small science mode is bound to come to a halt beyond a point, due mostly to a resource crunch. When the actual merit of a creative piece of

work requires to be carefully assessed through precision experimentation on a large scale, it becomes impossible for any single university to come up with the necessary resources for this purpose on its own. Then, in order to properly judge the mettle of such creative work, many scientists assemble in large laboratories. It needs hardly be said that no invention can be taken for granted unless it survives rigorous and precision testing, and such testing needs mega science. In some cases this fine testing may go on for many years. This is not only just because the funding needs to be generated, but also the instrumentation involved behind such testing needs to be procured. Instruments available in the market are often inadequate for such type of high-precision experiments. It often happens that the technology necessary for innovative instruments has not yet been developed. In that situation technology needs to be developed *ab initio*. This work is a part of fundamental research which belongs to small science. Thus mega science conjoins small science and is complementary to it. This discussion precludes arms and war-oriented research, as also R&D in industrial sectors which are usually profit-oriented. In those sectors the scope for fundamental, creative research is severely limited, at least in our country.

Let us now look at the situation in India. Modern scientific research commenced during the colonial period in the country. But surprisingly enough, allotment of research funding by the then government was scanty. The British cannot take credit in the matter of research achievements of stalwarts like J. C. Bose, C. V. Raman, Meghnad Saha, Satyendranath Bose, and so on. In independent India of the 1950s, A. K. Raychaudhuri, S. D. Majumdar, S. Pancharatnam and G. N. Ramachandran have done their world-famous research in colleges or universities with paltry amounts of government funding. At that

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time even if there were one or two big research centres, fundamental research work was mostly done in educational institutions. One distinguishing character of the research at that time was that it was basically creative and original in nature. In the pre-independence era, a great enthusiasm that was prevalent in the minds of the Indian scientists was to express their nationalistic sentiments through such research. It may be construed as a part of India's struggle for independence. During the first decades just after Independence, with minor amendment this sentiment continued: 'we do science our way'. The degree of commitment of our forerunners has been unquestionable.

Nevertheless, at around this time, an erroneous decision was taken at the governmental level, for which we have been paying a heavy price until today: a clear separation was effected between science education and research. The ominous effect of this concept reflected in setting up of national research institutions with huge government funding. In these centres no scope for imparting education even at the postgraduate level is available. Only a handful of bright and talented students have direct access to these government laboratories. It is needless to say that these institutions are far better funded compared to the ill-fated educational institutions. For this governmental decision in our country, mega science and its practitioners gradually began to swamp and overwhelm small science pursuit. The situation remains pretty much the same even today, despite the latest governmental move of establishing a few elitist institutions like the superbly endowed Indian Institutes of Science Education and Research (IISERs). Indian universities continue to remain the backwaters of science research in India, where usually students and faculty unable to enter research institutions go to. With such disparate funding proportions, not to mention the concomitant media publicity, the idea that has been carefully nurtured over the years is that unlike Western countries, India is a land of mega science and it is not necessary to engage in small science. Consequently, most talented young scientists of our country today, invariably seek positions only in organizations where they can escape the 'burden' of teaching and engage in full-time research. Smart students, immediately upon completion of

their Master's degrees in universities, push and shove to get admitted into research institutions. Amongst those who remain in the universities, there are a few who are very good, but they are really very few and far between. Indian universities have thus been reduced to degree-awarding 'teaching factories', thanks to the educational 'caste system' created by governmental policies.

The long-term consequences have been detrimental for both teaching and research. Educational institutions have now become places with faculty, many of whom have alienated themselves from education and are stuck in the monotonous rut of a daily routine, or, what is worse, have got involved in party politics. With this dismal condition, many students of colleges and universities are keener themselves to enter the race for political power as a career option, rather than aspire towards academic success. Academic activities like research in small science, toiling day and night for the pursuit of truth, and the urge for creation all have just withered away. Most colleges and universities are now so intensely politicized that it is extremely difficult to pursue research in these institutions. For those who are exceptions to this trend, recognition at a national level remains a far cry in regard to the high-profile scientists at national laboratories. Striking a parity between education and research – considered as maxim in Europe and USA – remains a distant dream for us. It needs hardly be said that we are lagging behind in the realm of creative fundamental research at an international level, because of the rat race towards the glamour of planned mega science, shunning truly creative small science out of sheer apathy.

The judicious reader may well question the above argument with the rejoinder: has not mega science placed our country on the map of scientific advancement of the world? In our national laboratories, much stress is being given nowadays to 'mainstream' research in modern science. This was beyond imagination in the past. It may be argued that most stalwarts like Bose, Raman, Saha and Bhabha had set up their own laboratories. In these institutions research clearly dominates over teaching. We, following their footsteps, have established laboratories of international standard and there is no denying the fact that this effort has heightened development of sci-

entific culture. Those institutions are well known to the scientists of the world. The argument apparently seems justified. But is it really so?

Admittedly, in some national laboratories in India, a few researchers are engaged in work of reasonably high quality. As a consequence of such endeavours, the average level of scientific research in India has been raised. One may, however, ask the following question: who sets the agenda of the so-called mainstream research which has ostensibly earned recognition for our national laboratories? From whose imagination have sprung the problems that so many skilled and competent Indian scientists feel compelled to keep trying to solve? These questions may appear irrelevant from the standpoint that science research is an ongoing international activity and in it, questions regarding the source or initiation of an idea are not important. The task of the scientist is merely to add to this flow, to the best of her ability.

Such a rejoinder would have been satisfactory and acceptable, had it been observed that at least a few of the so-called mainstream science ideas originated from India. This, however, is seen largely not to be the case. Scientists in national research institutions in today's India have seldom provided world leadership in setting agenda for mainstream research; that leadership rests with renowned scientists of Europe (including Russia) and USA. Our researchers feel quite comfortable to be guided by them.

No guru can help but be happy with a disciple who is obedient and sincere, and in all likelihood, would like to see such a pupil succeed. This, in turn, may account for the recognition that our researchers have in the West. In this endeavour, both the leader and the led are contented because, for the former, having a competent shishya from overseas, pushing his ideas, certainly helps, while for the latter, the uncertainty and risk of wandering alone through dark unknown alleys, armed with only the light of one's own imagination and effort, can be avoided. It is so much easier to tread the path shown by the guru. It is a win-win situation for everybody concerned.

Undoubtedly, our scientists nowadays, unlike those of earlier days, are far more successful, because they have now devised ways and means which ensure recognition at home and abroad. Bose, Raman or Saha were not so fortunate

during their lifetime. Their intellectual dissonance with mainstream science led by the West often marred their reputation. An inevitable consequence of creativity in science is intellectual conflict. 'If you can't join "em", beat "em"'. Replacing this discord with pursuit of extant fashions set abroad cannot be regarded as hallmarks of creativity.

The glorious achievements of Indian science that remain eternal are all instances of small science. Intellectual conflict is healthy for creation only in the case of research in small science. In the case of mega science, however, such 'disloyalty' may throw one away from the mainstream and that effect is a great danger for an established scientist.

Will successful Indian scientists always remain dependent on intellectual

leadership and patronage from abroad? Do ordinary people have to continue to admire them, only because they diligently followed fashions originating elsewhere? The answer, unfortunately, seems to be in the affirmative, unless the practice of giving priority to mega science in this country is substantially altered.

If competent Indian scientists today, neither engage in teaching the large pool of smart students in this country, nor take pains to train them research-wise, but continue with their obsession of frequent visits abroad for research ideas, then one can be rest assured that no world-class scientific discovery would come out from this country in the near future. In our problem-stricken country, investment of public money for advancement of

science can only be justified if scientific research is substantively original and creative, and not built exclusively on following fashions started abroad. To attain this goal, a far higher priority needs to be accorded to small science, in contrast to the primacy currently given to 'mega science'. Without strengthening university education manifold, Indian science will continue to remain in the backwaters, and our scientists will have to continue to look for patron saints in the West for their survival.

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High impact factor journals have more publications than expected

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Journal impact factor is widely used in research evaluation. By using the 2016 Journal Citation Reports, we find that high impact factor journals publish more publications than expected and low impact factor journals publish less publications than expected. Our findings may be useful to optimize the journal based evaluation system.

Journals indexed by the three citation indices, namely, Science Citation Index (SCI), Social Sciences Citation Index (SSCI) and Arts & Humanities Citation Index (A&HCI) of the Web of Science (WoS) are usually deemed as the world's leading international and regional journals. Publications in these indexed journals are widely used in research evaluations¹⁻⁴. In order to maximize the impact of their works, scholars may prefer to publish in high impact factor journals⁵. However, such journals generally have higher manuscript acceptance standards. So, some important and interesting questions arise: what is the relative share of publications in high impact factor journals? Is the relative share of publications in high impact factor journals less than those in low impact factor journals?

The 2016 *Journal Citation Reports (JCR)* accessed on 9 July 2017 was chosen as the data source of this study. Journal impact factor (JIF) quartile as a field-normalized indicator published by *JCR* was used to identify high and low impact

factor journals (for more information about JIF quartile, readers may visit <http://ipscience-help.thomsonreuters.com/incitesLive/9053-TRS.html>). We regard quartile 1 (Q1, within the top 25% of JIF among a certain category) journals as high impact factor journals. Similarly, quartile 4 (Q4, within the bottom 25% of the JIF among a certain category) journals are deemed as low impact factor journals. Journals that belong to more than one category may also belong to more than one JIF quartile. In order to avoid the double-counting problem, a journal was allocated to the highest quartile if it had more than one quartile⁶.

According to the 2016 *Journal Citation Reports – Science Edition*, nearly 9000 SCI journals are almost evenly distributed among four JIF quartiles. As shown in Figure 1, each JIF quartile accounts for about 25% of all the SCI journals. However, the distribution of publications (only articles and reviews considered) in these journals is different. Although high impact factor (Q1) jour-

nals only account for 27% of all SCI journals, about 44% of all SCI publications is published in these journals. On the contrary, only about 13% of SCI publications is published in low impact factor (Q4) journals.

We examined the distribution of journals and publications among four JIF quartiles in social sciences using 2016 *Journal Citation Reports – Social Sciences Edition*. SSCI journals are almost evenly distributed among four JIF quartiles. As shown in Figure 2, each JIF quartile accounts for roughly 25% of all the SSCI journals. Comparatively, the publications in journals of these four JIF quartiles are unevenly distributed. Although high impact factor (Q1) journals account for 26% of all SSCI journals, about 36% of all SSCI publications is published in these journals. On the contrary, only about 15% of SSCI publications is published in low impact factor (Q4) journals.

Using the 2016 *JCR*, we found that high impact factor journals had more