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GUEST EDITORIAL

Scientific progress – it takes a village

I recently spent a year on sabbatical in India as a Fulbright-Nehru scholar, primarily at the Indian Institute of Science (IISc), Bengaluru and additionally at the National Centre for Biological Sciences (NCBS), Bengaluru, travelled to several other Indian research institutions, and met with numerous students, postdocs and faculty. This guest editorial depicts my reflections on the scientific enterprise in India, based on my numerous conversations with Indian scientific colleagues over the years, and which were further consolidated during my sabbatical. These views and impressions are unavoidably subjective and limited by my direct experiences with particular institutions in the US (University of Pennsylvania and University of Maryland) and in India (IISc and NCBS). Further, many of remarks may not be specific to science in India and could apply to the scientific enterprise in other countries as well.

‘Do you see any major differences in the quality of students, faculty, and the science between the US and Indian institutes?’ is a common question that comes up in casual conversations with scientific colleagues in India and elsewhere. Besides the broad expected remarks about culture-related differences in the student–professor relations, my answer has invariably been ‘no’, at least not systemically.

‘Why then do you think there is an apparent gap between the two in terms of high-profile research publications?’ would be the inevitable follow-up topic of conversation. Now, this paradox seems to be a significant preoccupation of scientific leadership at the Indian research institutions, and understandably so. Below are my reflections on the potential reasons for the ‘impact’ gap and possible avenues to counter them, distilled from my conversations with colleagues in India.

Strictly by the numbers, 4 in every 10,000 people are associated with science in India compared with 80 in the US (www.nature.com/news/india-by-the-numbers-1.17519), which is 20-fold lower per capita and about 5-fold lower in terms of absolute numbers. This is not unreasonable considering that the US has 30-fold higher per capita Gross Domestic Product (GDP). The economy and national priorities being what they are, India is not likely to compete with the rest of world, at least in the near future, in terms of the number of people doing

research, as ironic as it may be. The focus then ought to be on efficiency and quality, in other words, maximizing India’s talent and resources.

Efficiency is most easily addressable, in principle, and in this context it comes down to removing unnecessary barriers for individual researchers to pursue their vision and carry on their work to the fullest. A few themes emerged that frustrate researchers across the board. First is the need for a simplified, streamlined and unified grant application process, along with transparent and timely review, and prompt disbursement of awards. Getting a research grant sanctioned does not do much good until the researcher gets the money to procure the supplies and/or personnel and carry out the study. Delayed disbursement of funds can be especially acute for students and postdocs with families to support, for whom not getting paid on time can cause undue stress – adversely affecting their well-being and productivity. The primary condition for a solution to this problem, it seems to me, is the will of the national science leadership. The complexity of the task is appreciable, with multiple agencies involved, and the difficulties of securing reviewers, etc. However, many other countries, with a longer history of government-funded research, have managed to find a workable solution. India ought to be able to emulate the well-oiled review machinery of the West. Second is the need for giving researchers greater flexibility in how the funds are used. For instance, a researcher proposes avenue *A*, but based on a recent report decides in favour of avenue *B*. He/she ought to pursue the most effective course of action based on the most recent evidence. Scientific advances do not follow funding cycles. Such flexibility should be encouraged. Science administrators can and should demand reasonable justification, but should not restrict the researcher if returns on investments are to be maximized. Third is delays in procuring experimental material, which, in large part, must be imported. In the current competitive environment, a delayed experiment may be as good as not doing the same. Again, this is an area where the national leadership, in collaboration with the Customs department, should create simplified categories for risk assessment, which can be vetted in advance and not when the material is en route. Furthermore, taking a long-term view of the issue of procurement, it would behoove India to invest in

its biotechnology industry to provide quality products locally, thus improving the cost as well as efficiency. The current domestic demands for specific technologies and products are perhaps not high enough to incentivize the domestic biotechnology industry. However, only through government investments such developments can be incentivized until they become self-supporting. Fourth is perhaps less obvious and has to do with the involvement of the support staff of these institutions in the scientific mission. The staff should be brought into the fold to appreciate the urgency of a scientific mission, and in addition be provided with other incentives. This might be achievable through outreach efforts by the faculty and the leadership towards the staff to make them feel invested in the overall mission of their institution. This is perhaps more of an issue in larger institutions, with greater hierarchy and greater mobility of staff within them.

Quality, on the other hand, is subjective. It is difficult to define precisely, but reveals itself if one has the proper viewpoint. One distinction of a work of quality is that it is accepted broadly as fundamental, or truly novel and creative, versus incremental or me-too kind of work. Another way to ascribe quality is through its impact, which is often not apparent immediately. Making these distinctions fairly, however, requires time and care. Regardless of how we define quality, accountability for the faculty, either through a tenure system, or a rigorous, well-considered, consequential five-year review should be in place at all higher education and research institutions. To counter-balance accountability, there ought to be a robust and caring mentoring for young, as well as mid-career, researchers. Senior faculty, department chairs and deans should regularly interact with the younger members to not only provide feedback on scientific matters, but equally importantly, to keep them focused, ambitious and inspired. The cheerleading aspect of mentoring is rare and something to be considered by the leadership. This again takes care and time, and ought to be appropriately acknowledged and rewarded.

Paucity of opportunities to network, not only with researchers in other countries, but also with the editors of high-profile journals to improve visibility, is another potential contributor to the 'impact' gap. Science administrators should realize that travelling to attend conferences and meet collaborators is not a perk, but a responsibility and a necessity (www.nature.com/articles/d41586-018-07772-5) for the researchers to be visible and equally importantly, keep a finger on the pulse of the field, because there is typically a substantial delay between the time a

research is done and presented, and the time it is published. There is no substitute for physical interaction where ideas emerge unexpectedly. Providing a travel budget to faculty and discretionary freedom to use the funds is critical. Towards increasing the networking opportunities, the national science budget can be maximized by increasing funding for international conference organization and inviting key people from abroad. It is a smart investment. The greater the interactions are, the smaller the gap will become.

One advantage the faculty at an Indian research institution has over his/her US counterpart is that the students and postdocs are directly funded by the government. This ought to afford the faculty, in principle, to take a more long-term, potentially risky, but impactful view on research. Furthermore, science is becoming increasingly multidisciplinary, and solutions to the most pressing challenges are likely to come through multidisciplinary interactions. Students, faculty and institutional leadership should invest time and resources into providing opportunities for such interactions.

Students, while struggling to finish their next experiment and next paper, must realize that they are among the very few chosen ones in the world, entrusted with expanding human knowledge. They should conserve a part of their time to ponder over fundamental, big questions, independent of their supervisors. A supervisor is only a guide. He/she should actively encourage mentees to be open-minded, follow their own curiosity, and make new connections across fields. The supervisors should strive to be superseded by their mentees – how else can science grow? Also, they should take time to check whether their mentees are healthy, happy and inspired. All this may seem detrimental to the short-term productivity of an individual lab, but is likely to pay off in the long run for Indian science while training students to be scholars, beyond great technicians.

I do believe that science in India is on a great trajectory, and is yet to reach its full potential. With careful government policies, streamlining of the funding and procurement processes, mentoring and compassionate accountability coupled with flexibility, science in India will continue to grow and flourish.

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