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EDITORIAL

Teaching Research: Addressing a New Generation

The romance of revolution inspired William Wordsworth to write his immortal lines:

*'Bliss was it in that dawn to be alive,
But to be young was very heaven!'*

The poet had just returned from France, where the winds of change were blowing rather hard. The French revolution, like all other revolutions since, was just about to enter its darker and more turbulent phase. Wordsworth's lines celebrate the advantages of being young when times change rapidly. The verse sprang to my mind when I received an invitation to speak at a gathering of mostly young scientists, all of whom were recipients of the Department of Biotechnology's Ramalingaswami Fellowships, which seek to attract biologists to research careers in India. Times are indeed changing and changing rather rapidly in Indian science. A growing number of schemes seeking to attract the young into science have been introduced in recent years. The now venerable Kishore Vaigyanik Protsahan Yojana (KVPY) scheme, which provides scholarships for undergraduates in science, is quickly being dwarfed by the INSPIRE fellowship scheme of the Department of Science and Technology (DST). For young scientists just coming out of a Ph D program there are multiple postdoctoral opportunities, with the D. S. Kothari fellowships of the University Grants Commission (UGC) being an attractive prospect. A little more experience (a stint overseas may help) is enough to qualify researchers, at the beginning of their careers, for a plethora of new schemes; the Ramanujan fellowship and Inspire Faculty fellowship schemes of DST and UGC's recently announced 'faculty recharge' program. Research grants have increased in number and the quantum of funding has increased steadily over the last few years. Many new academic institutions, some devoted exclusively to science, have been created. There is a growing perception that jobs in academia are significantly more attractive than in the past. In a bid to attract new faculty to man the growing enterprise of higher education and research, biologists have invented a new device. Meetings of 'young investigators' with institutional heads, seeking to spot fresh talent, are now held periodically in India and the United States. The locations are always attractive, ensuring good participation. The research job market appears to be expanding with institutions focusing on

young researchers hoping to return to India from western laboratories.

The invitation I received to speak at the gathering of Ramalingaswami fellows was precise and explicit. I was asked to speak about 'doing science in India, then and now'; more precisely on the 'status of Indian biology, then and now'. Clearly, the organizers were aware that I had been around for a long time trying to do research in areas in which I had a moderate degree of expertise. Since I had observed the changing face of science in India for nearly forty years, I was expected to reflect on the past and the present, ending undoubtedly on an optimistic view of the future. I approached my assigned task with some element of regret. It is not entirely a comfortable transition from the position of a player to that of a commentator, for both cricketers and scientists. I was also charged with the difficult task of providing 'an insightful perspective'; an assignment that I was clearly incapable of completing. Even while I was wondering about the wisdom of talking about Indian biology's progress through the decades, I was fortunate to receive an unexpected gift of a book: *Secrets* by Ruskin Bond (Penguin Books, New Delhi, 2011). In his engagingly direct and simple prose, Ruskin Bond points to the advantages of aging: 'One of the nice things about growing old is that we have so much to look back upon – a stream of memories that never runs dry; people who have been dear to us; the friends of one's youth; faces from the past; adventures; memorable events; dreams lost and found; the good, the bad, the beautiful....' Heartened by Ruskin Bond's words, I gathered some courage to look back at Indian biology, as I saw it as a young man and as I see it now, tempered by age.

Biology in India has been the subject of many recent commentaries. Not too long ago the *Journal of Cell Biology* featured the Taj Mahal together with the DNA double helix on its cover (2009, **184**, 342). A little later *Science* carried an editorial entitled 'Young leaders for biology and India' (Tole, S. and Vale, R. D., *Science*, 2010, **329**, 1441). In preparing for my task of reflecting on the past and present of Indian biology, I re-read these two commentaries that presented a perspective that seemed unfamiliar to me. The future, undoubtedly, belongs to the young. The *Science* editorial concluded with sound advice: 'The best guarantee for future success is to imbue young scientists with a sense of mission, to nurture

not just the science but a culture that fuels the will to succeed in countries long thought of as second choice options for research careers.' Reading the last few words I could not but wonder: Was India of the 1960s, 1970s and 1980s a 'second choice option' for those exposed to Western laboratories? Or was it indeed a 'first choice option' for those who were committed to research, but also deeply attached to home turf? Like Ruskin Bond, memories suddenly seemed to flood the mind. The last four decades have been marked by political, economic and technological changes. The Emergency, the era of import licences and cyclostyling machines are images from the 1970s. The first of India's major funding agencies, DST was born in the 1970s and began taking the first steps towards transforming the way in which research was encouraged and supported. The 1980s began with DST's Baroda seminars, which led to the formation of program advisory committees and introduced peer-review of individual investigator generated projects. The M Sc Biotechnology programs appeared in the 1980s and photocopying machines and word processors entered offices. Politics was turbulent and as the decade ended the economy teetered on the brink of a crisis. The 1990s began ominously with an imminent payment default, but the transformation happened soon afterwards, as the economic liberalization coincided with the information technology revolution. The new century, one in which many of the most promising researchers in India have begun their careers, has seen a dramatic growth in the scientific enterprise. In thinking about biology's past I turned inevitably to the institution builders who conceived their ideas in the 1970s and executed them in the 1980s. Two of India's most prominent biological laboratories, the Centre for Cellular and Molecular Biology (CCMB) at Hyderabad and the National Institute of Immunology (NII) at Delhi were built in the 1980s. Molecular biology in India grew out of the strong tradition of biochemistry and genetics in many institutions, pushed forward by scientists working in difficult conditions across the country. Structural biology, an old discipline with a new name, grew out of modest laboratories at Madras University. The past can sometimes be overwhelming and as I attempted to gather my thoughts it appeared wise to break into the present.

What advice can an aging scientist, limited by only a nodding acquaintance with biology as it is practiced now, give an audience of ambitious and focused young researchers. The old clichés, work hard, follow your instincts, choose your problems carefully, do what is important not what is doable, sprang immediately to mind. Brushing aside the temptation to tread familiar ground I decided to address two issues that are matters of concern to many young researchers, beginning careers as independent investigators in India – research facilities and teaching. Everyone I have met (or almost everyone) seems to want more of the former and less of the latter. For those with an insatiable desire to accumulate sophisticated research

facilities, I turned to Richard Hamming: 'It is a poor workman who blames his tools. The good man gets on with the job, given what he has got and gets the best answer he can.' This old quote from a computer scientist dates back to the 1980s and was hardly what my audience wished to hear. I pressed on to my pet topic; the need for researchers to teach. Indeed with the creation of the IISERs, there is a purposeful move to integrate undergraduate science education with research. Teaching can greatly benefit young researchers. Richard Bach (author of an old 1970s favourite, *Jonathan Livingston Seagull*) said it well: 'You teach best what you need to learn.' Einstein, quotable on most subjects, said: 'Teaching should be such that what is offered is perceived as a valuable gift and not as a hard duty.'

The future of science in India depends substantially on those who are starting out as researchers today. It will depend critically on the students who enter science, hoping to build careers in their chosen disciplines. Science, as taught today, can hardly enthuse a new generation, which is fortunate enough to encounter an ever expanding range of career options. The excitement of science and the pleasures of research can only be communicated by exposing students at the earliest opportunity to laboratory work, in which outcomes are not always anticipated. A recent editorial in *Science*, which appeared after my encounter with the audience of young researchers, argues that it is important to 'advocate and provide support for replacing standard laboratory courses with discovery-based research courses' at undergraduate level. In a critique that is undoubtedly relevant, even for the best of our programs, the authors add: 'Too often, even the active learning elements of today's teaching regimens – laboratory courses – simply repeat classical experiments rather than engage students in compelling experiments with the possibility and excitement of true discovery' (Gates, Jr S. J. and Mirkin, C., *Science*, 2012, **335**, 1545). The issue of *Science* also carries two essays written by winners of the IBI *Science Prize* for Inquiry-Based Instruction. Both essays deal with experiments in biology. The essay, 'Investigating Arabia Mountain: A molecular approach' describes the involvement of a group of undergraduates to the problem of investigating microbial diversity in the local environment using DNA analysis (Jacob, N. P., *Science*, 2012, **335**, 1588). The second essay, 'Adapting to osmotic stress and the process of science' highlights an exercise in bacterial genetics providing insights into evolution, resulting in a publication (Gasper, B. J., *Science*, 2012, **335**, 1590).

Teaching students in the classroom and in the research laboratory may be an investment which will ensure that the future of biology in India is secure and bright. This will undoubtedly be true for the other disciplines of science. For young researchers, teaching must be a joy, not a chore to be avoided.

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