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EDITORIAL

The Gathering Storm: A Case for Science

Memorable phrases, often found in the titles of books, reports, lectures and speeches attain immortality, being used and reused in varying contexts. Two of my favourites, that spring immediately to mind are both related to science. Vannevar Bush's famous characterization of science as an 'endless frontier' is one. The Bush report, produced in mid-1945, set the tone for the public engagement with science in the United States and in many ways transformed the way in which governments view science and technology. In his letter of transmittal Bush noted that 'science offers a largely unexplored hinterland for the pioneer who has the tools for his task'. Bush coined the phrase almost immediately after the power of nuclear fission was recognized. DNA was not yet established as the 'genetic principle'; Oswald Avery's work had been published, but largely ignored. The double helix and the molecular biology revolution lay far in the future. The antibiotic era was in its infancy. The transistor and the laser were still to be invented. Computers were on the distant horizon. The phrase, 'endless frontier' evoked an image of a subject whose horizons continually receded into a misty distance, even as the pace of scientific progress quickened. In a recent editorial Bruce Alberts asks a provocative question: 'Is the frontier really endless?' (*Science*, 2010, **330**, 1587). In reflecting on the vast amount of genetic information present in human cells, whose function we do not yet understand, Alberts notes that 'our "dark genome" – is needed for processes whose nature mostly remains a mystery'. He goes on to ask: 'Was Vannevar Bush right in 1945 when he described science as the "endless frontier"? Can we assume that if we solve the mysteries of the dark genome, new puzzles will arise?' Alberts is optimistic: 'One can certainly hope so, because life would lose much of its grandeur and joy if we ever reach the finish line, with no further frontiers to challenge us'. The 'endless frontier' must indeed be a descriptor of a horizon that forever remains elusive. The other phrase that I have always been attracted to is C. P. Snow's characterization of the apparently unbridgeable chasm, that existed at the dinner tables in Cambridge, between the humanities and the sciences as 'the two cultures'. Snow launched his now immortal phrase when he titled his Rede Lectures at Cambridge as 'The Two Cultures and the Scientific Revolution', in 1959. The 50th anniversary of the birth of this phrase was widely obser-

ved by many commentators in 2009. One observer noted that 'few literary phrases have had as enduring an afterlife as "the two cultures" coined by C. P. Snow', but added that 'few people actually seemed to read Snow's book bearing that title' (Dizikes, P., *New York Times*, Sunday Book Review, March 19, 2009). He went on to argue that 'the deeper point of "The Two Cultures" is not that we have two cultures. It is that science above all, will keep us prosperous and secure'. Curiously, the concluding sentence of Vannevar Bush's letter of transmittal accompanying the 'endless frontier' report anticipates Snow: 'Scientific progress is one essential key to our security as a nation, to our better health, to more jobs, to a higher standard of living, and to our cultural progress'.

In 2005, the National Academies of the United States produced a report on the challenges faced by the science and technology enterprise in America, as a result of growing global competition and diminished national interest in science education and research. The report ominously titled *Rising Above the Gathering Storm* used a phrase borrowed from Winston Churchill's first volume, in his epic six part account of the Second World War. Churchill was a master of rhetoric and the captivating turn of phrase. His critics, and there were many, often accused him of letting his penchant for theatrics cloud his view of facts. *The Gathering Storm* is a volume that details the political and social developments in Europe in the period between 1919 and 1939; a time when the author appeared to have been put out to pasture, in the political wilderness. Churchill constantly warned an unheeding public of a dark future, as Germany rearmed under the Nazi leadership, while Britain clung to the comfortable vision of a 'world without war'. Churchill's famous phrase, resonant in its grim air of foreboding, has been used in many contexts. The report of the National Academies uses the Churchillian phrase to focus attention on the apparent perception of a future that threatens the preeminence of American science and technology. The 2005 report, published as a book in 2007 (*Rising Above the Gathering Storm: Energizing and Employing America for a Better Future*, National Academies Press, Washington, DC, 2007) appeared at a time when the Chinese surge in scientific activity was beginning to be perceived as a competitive threat. Although the economic downturn and the current recession had not yet set in, worrying trends in

the sphere of science education and research seemed evident. Five years later, in the shadow of the ongoing economic crisis a second report appeared recently. *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5* (National Academies Press, 2010) reviews progress made in the five years since the original call to action. Both reports must be required reading (and subsequent reflection) for policy makers in India where the science, technology and education enterprise may have already entered 'the storm'.

The 2005 report by the US National Academies was a direct outcome of questions posed to the science bodies by members of the US Congress. Two questions were asked: (1) 'What are the top 10 actions, in priority order, that federal policy makers could take to enhance the science and technology enterprise so that the United States can successfully compete, prosper, and be secure in the global community of the 21st century?' (2) 'What strategy, with several concrete steps, could be used to implement each of those actions?' These questions are general enough to be relevant anywhere, especially in India where so much seems to be desired in the area of science research and education, but no well thought out, purposeful plan of action seems to emerge. In the 2010 review, the 'four overarching recommendations' of the original report are summarized: (1) 'Move the United States K-12 education system in science and mathematics to a leading position by global standards'. (2) 'Double the real federal investment in basic research in mathematics, the physical sciences and engineering over the next seven years (while, at a minimum, maintaining the recently doubled *real* spending levels in the biosciences)'. The parenthetical statement is a clear acknowledgement of the dramatic investments in biomedical research in the United States over the past decade. (3) 'Encourage more United States citizens to pursue careers in mathematics, science and engineering'. (4) 'Rebuild the competitive ecosystem by introducing reforms in the nations tax, patent, immigration and litigation policies'. Clearly, science policy makers in America are uncomfortable with overly restrictive immigration policies which limit the pool of researchers.

The 2005 report listed '20 specific implementing actions which included programs to create a new generation of science and mathematics teachers and to "strengthen the skills of 250,000 current teachers" by encouraging and subsidizing master's degree programs and enhancing "participation in workshops", specific recommendations for research funding ("sowing the seeds") and enhancing higher education ("best and brightest"). A particular point of interest in India would be the resolve to "improve visa processing for international students". Several "incentives for innovation" were also proposed. The 2010 review notes, somewhat dramatically, that most actions to boost science and technology competitiveness in the last five years have been taken in other countries and lists "Saudi Arabia, China, Russia, India, Luxembourg and the United

Kingdom". India is credited with launching "a multi-year initiative . . . to make the country a global nanotechnology hub including constructing 14 new "world class universities"'. The National Academies report then lists a number of consequences of the economic downturn and makes a curious comparison with other countries which also struggle in an adverse economic climate: 'Yet many such nations do not face the task of sustaining the lifestyle which has come to be enjoyed – and expected – by America's citizenry'. The 2010 review notes that 'a paradox exists in the debate over whether there is a shortage of scientists and engineers or whether there are too many scientists and engineers for the jobs that are available'. The conclusions of the 2010 review are undoubtedly intended to raise the level of investment and public commitment to the science and technology enterprise in the United States: 'In balance, it would appear that overall the United States long term competitiveness outlook (read jobs) has further deteriorated since the publication of the *Gathering Storm* report five years ago'. There is a Churchillian tone in the concluding sentence: 'The *Gathering Storm* is looking ominously like a Category 5 . . . and, as the nation has so vividly observed, rebuilding from such an event is far more difficult than preparing in advance to withstand it'. 'Category 5' refers to the highest intensity of hurricanes that often form in the Atlantic Ocean.

Those interested in science policy issues would do well to read the 2010 review of *The Gathering Storm* report. It provides insights into the formulation and implementation of policy in an advanced country, which does not confront the multitude of problems that need to be addressed in India and the many countries of the developing world. We need to assess and review our policies for investments in science and higher education. Far too often, populist public pronouncements result in grandiose, ill thought out schemes which cannot be implemented. The '14 world class universities' are only one example of desire that will remain unfulfilled in the absence of a purposeful plan of action. Setting unrealistic goals serves little purpose. *The Gathering Storm* report provides many quotes, some of which are strangely reminiscent of the ideas espoused by Vannevar Bush and C. P. Snow several decades ago. In India, as in other countries, the proponents of science have always argued for enhanced investments in research. Today it is clear that even greater attention needs to be paid to the education pipeline, which will produce the scientists of tomorrow. Is money and more money the solution to the problems that affect scientific research and higher education in India? Money is undoubtedly necessary, but by no means sufficient to ensure progress. Ernest Rutherford, quoted at the start of the 2010 National Academies review said it well: 'Gentlemen, we have run out of money. It is time to start thinking'.

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