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EDITORIAL

Big science, small science

The shake-up at the Unit Trust of India (UTI), this country's largest mutual fund organically tied to government, has highlighted the sharp divide between the interests of numerous small investors and the power of a few big investors. In the developing storm cloud over yet another financial scam, there have been rumours in the press about the unwise investments of the UTI in some of the giants of Indian industry; there have also been murmurs that several business houses had advance warning of the impending freeze on trading, allowing them to pull out their investments before the day of judgement. The entire story appeared as a classic case of the 'big' versus the 'small'; the latter, of course, generally ignored and unlamented. Clearly, in the harsh and pitiless world of the financial markets, big fish feed in an unabashedly predatory manner on small fish. But then, this is also true of most aspects of our daily existence. How is it in the world of science? Are there hidden tensions between the realms of 'big science' and 'small science'? Do mammoth organizations and projects elbow out the little individuals in science? Is there at least minimal space for 'small science' anymore?

The definitions of 'big science' and 'small science' are necessarily loose and arbitrary. All of 19th century science, and of course everything that went before, was small science; amateur scientists flirting with the joys of discovery. There was little distinction between scientists, inventors and tinkerers; Faraday, Darwin, Franklin and Edison are among the icons of this early phase. Eccentricity and individuality were among the most striking qualities of many of the remarkable achievers of modern science's early period. Organized science probably took root in early 20th century Germany. The organic chemistry laboratories were forging links with chemical industry by the end of the 19th century; the fruits of basic science were beginning to ripen. Research groups in the best of laboratories were growing in size; the directorial Professor, marshalling his forces much in the manner of an army general, was increasingly evident in early 20th century chemistry. But 'big science' was really formally born in the 1940s, in the midst of World War II, when the Manhattan project provided a striking demonstration of the power of well organized and formally directed science. America learnt its lessons well; in the half century that followed, 'big science' has made remarkable contributions to every area of science and technology, its most visible recent success was celebrated when the human genome sequencing programs neared the finish line. Big science is characterized by well-defined goals, very large financial outlays, ostensibly well thought out strategies and an unmistakably hierarchical administrative structure; large numbers of scientists are deployed at the work bench, reporting to superiors in an, often, pyramidal model reminiscent of big industry. Small science, in its most extreme form as we know it, is practiced in Universities and academic institutions. Invariably, a member of the faculty works with a small group of students; quite often, each individual works on a separate research problem, the head of the group really acts as an academic mentor. Small science projects generally have limited goals, with the ambitions of the mentor and the students rarely rising beyond the publication of their results in journals they judge as superior. But, it is the hundreds, indeed thousands, of 'small science' laboratories across the world that train the scientists of tomorrow, many of whom will, in fact, graduate to the world of big and applicable science. Small science, where investigators can stray from the mainstream, is critical for the process of discovery; the lack of a rigid organizational structure is essential for many truly original individuals to be productive.

The purpose of my musings is really to worry about 'big science' and 'small science' in India. Well organized, governmental funding of science, particularly basic science, is only about a quarter century old. The science establishment has grown dramatically during this period; there are multiple funding agencies and an ever-increasing number of claimants for a limited pool of resources. The political perception of science has also changed; there is much less visible sympathy for the view that basic science needs to be nurtured steadily, in the long term national interest. Small science is clearly out of favour, despite the lip service that is sometimes paid to the importance of sustaining academic research and strengthening academic institutions.

Instead, there is a growing appreciation of the apparent virtues of 'big organized science'. The Department of Atomic Energy, the far flung laboratories of the Defence Research and Development Organization and the Indian Space Research Organization are the best examples of well-structured institutions capable of practicing big science. Their strategic objectives have, apparently, always been clearly defined and their financial requirements, generally, favourably viewed. But, big science is slowly beginning to creep into other institutions, which aim to tap the resources that seem earmarked for highly visible science. This drift towards the world of big money and even bigger promises is happening in many areas of science. For example, the change has been most evident in biology over the past few years. Several laboratories have jumped, with the greatest alacrity, on the genomics bandwagon. Suddenly, highly organized, structured research programs with well-formulated goals and highly desirable (but often unreachable) objectives have become fashionable, even in institutions, which in simpler times were once the preserve of small science. This uncomfortable transformation can, at times, lead to a form of institutional schizophrenia. The thrust for this drive to organize comes from the funding agencies; in biology the flagship is the Department of Biotechnology. There have also been other mechanisms for enforced coordination, like the New Millennium Fund program managed by the Council of Scientific and Industrial Research. Here, large sums of money are promised to conglomerates of researchers, often drawn from academia, government laboratories and industry. This fondness for big science may only reflect an evolution in our funding mechanisms; a drive by the agencies to harness the power of well directed organized research. But, in an age of limited resources and increasing demands it clearly represents a step away from traditional small science.

Does the growth of big science affect the practice of small science? There is an almost clear and evident prejudice against basic research, nowadays. Structured, applicable science promises so much that government agencies are often carried away by prospects rather than performance. In an interesting commentary Gregory Petsko remarks that it seems 'that most scientists are prone to believing – or perhaps hoping is a better word – that two and two can, sometimes, with the aid of the right technology, make five'. He cites three topical examples of this 'misguided faith': 'stealth technology' that allows aircraft to evade radar detection, 'encryption and authentication methods' to build totally secure computer systems and structural genomics, which hopes to obtain *useful* (and that is the important word) structural models of all proteins using a 'combination of experimental structure determination and comparative model building' (*Genome Biology*, 2001, **2**, 1009.1–1009.2). On paper, funding research that is directed towards solving all our most important problems appears politically attractive; even Parliamentary committees cannot fail to be impressed by a litany of good intentions. But, many 'big science' projects often attract a brand of managerial scientists, for whom grant money is a badge of honour; often grants accumulate upon grants, institutions buy equipment they do not need and little attention is paid to the problem of locating bench scientists to do the real work necessary to address chosen problems. Big science confers on its practitioners almost instant recognition; attracting money nowadays is far more important than taking a modest step forward in science. The result is that the votaries of big science soon spread like an unstoppable infection through the committee rooms of funding agencies; trampling the little that remains of our small science of academia. The agencies, enamoured by the prospects of quick technological fixes, promised by big science, have begun to downgrade individual investigator-driven research, by the quiet and effective process of administrative neglect.

Is 'small science' really small? Ironically, in many areas of science, the vision of individualistic science practiced in isolated laboratories as cheap and inexpensive is no longer really true. Even the most modest of our academic institutions require investments of the order of a few crores of rupees to provide the range of equipment that is necessary for modern research in physics, chemistry, biology and a host of other sciences. In the 1970s and 1980s the first steps in shoring up the academic research infrastructure were taken. But, in more recent times the focus has shifted. Replacing aging and obsolete instruments for basic research is hardly a priority; setting up centres for shared instrumentation is unpopular and talking about research without an immediate application is unfashionable. In this environment a new breed has appeared; the scientific buccaneers who harness the limited resources of government to build 'big science' laboratories. Much of this happens at the expense of 'small science', the traditional individual investigator-driven project which is the staple of academic research. The tensions between big science and small science are palpable; they are an inevitable product of our times. But it may help if government agencies adopted a more thoughtful attitude and worried about the relative merits of looking after the interests of its 'small science' constituents, as opposed to focussing only on 'big science'. Like the UTI they might eventually learn that, in the long run, it pays to nurture small investors and investments.

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