Finally, in response to the comments from both Ramaswami and Vidyasagar, I agree that the calculus of influence, and hence of promotion and recognition, can be highly variable from institution to institution, and in some cases can be counterproductive. One contributor to the scientist-as-CEO syndrome in the US is the proliferation of institutions in which the faculty have no underlying salary support, and instead are free agents responsible for raising all or most of their salary from grants, whose collective grant overhead pays off the mortgage on their research institute. These institutions create a problem of major proportion for their faculty and the field, and force faculty into becoming major 'operators' as Vidyasagar has called them. I advise all my students and fellows not to commit their careers to institutions that do not make a commitment to them. India will be well served to avoid this model of soft-money support for their faculty of research institutions. The rapid growth it allows during periods of federal largess has too many negative consequences in the long run.

To close, I hope the discourse initiated by Ramaswami, Balaram and Vidyasagar stimulates continued discussion about the extent to which any model from one nation applies well to another in support of the research enterprise. The US research has benefited from the existence of several models, yet none is perfect, and all could be improved. A careful and nuanced understanding of the relative tradeoffs will certainly help maximize the impact of research on national priorities and hopefully help the careers of young scientists develop in the ways that embrace and enhance their creativity, imagination and courage, which often blossom in the earliest stages of a career.

1. Vidyasagar, M., *Curr. Sci.*, 2009, **96**, this issue.
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3. Ramaswami, M., *Curr. Sci.*, 2009, **96**, 639–640.

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Higher education in India – aiming higher?

A recent cover story in the 9 February issue of *The Journal of Cell Biology* (*JCB*)[1] titled 'The biological sciences in India: aiming high for the future' was the subject of editorial comment by Balaram[2], and a critique by Ramaswami[3]. I am inclined to fear that the real truth may be as Balaram understates it: that the original article in the *JCB*, which had probably sardonic and skeptical overtones, was trying to point out: How can Indian biology aim 'high' or 'even higher' when the base for it is so inadequate? For example, the total number of faculty in the biological sciences in a list of 20 of India's leading institutions is less than the number holding NIH grants in a single institution, i.e. the University of California at San Francisco, and the same place has more postdoctoral fellows (~1000) than the total number in all the modern biology laboratories in India.

This is true of science in India in general. We have about 120,000 scientists in our country while the United States, which is approximately a quarter of our size demographically, has ten times as many. Anecdote has it that there are more Indian scientists working in the US (about 150,000) than in India. For any country to aspire to the highest levels of excellence in science, it must be founded on a base as broad – it has to be built like a pyramid and not as free-standing pillars.

What is true of biological research in particular, and scientific research in general, is even more symptomatic of the higher education scenario in the country. Recently, the UGC brought out two key documents on this[4,5]. India does a poor job of educating its masses. Only about 10% of those in the age group 18–23 years make it to college. There are countries which manage 80–90%! The Knowledge Commission projects that to raise the Gross Enrolment Ratio (GER) from 10 to 15%, we will need about 1500 universities, instead of the 450 or so that we have now. The UGC reports make a determined effort to lay down the basis for the approach and strategy for the higher education sector over the next plan (2007–12) and beyond. However, to the discerning mind, what is clear is that as before, our efforts are half-hearted and nowhere near enough.

To the uncritical mind, India's progress has been remarkable. According to one of the two UGC reports cited above[5], the number of universities has grown from 32 (1950–51) to 343 (2004–05) in 54 years – a compounded annual growth rate (CAGR) of 4.5%. During the same interval, the number of colleges has grown from 695 to 17,625, a CAGR of 6.2%. From 1980–81 to 2003–04, the total enrolment in degree and diploma courses has increased from 29.8 to 112.0 lakhs, a CAGR of 5.9%. According to Thorat[4], from 1950 to 2008, the number of universities has increased from 20 to 431 (CAGR = 5.4%), colleges from 500

Table 1. Enrolment of students in higher education in lakhs from three different sources. Numbers in bold are as surveyed and then interpolated linearly for graphical projection in Figure 1

Year	SES	NSS	PC
1981	**29.8**		
1982	31.56		
1983	33.32	**58.9**	
1984	35.08	61.96	
1985	36.84	65.02	
1986	**38.6**	68.08	
1987	40.66	71.14	
1988	42.72	**74.2**	
1989	44.78	76.87	
1990	46.84	79.53	
1991	**48.9**	82.20	**106.1**
1992	51.96	84.87	111.5
1993	55.02	87.53	116.9
1994	58.08	**90.2**	122.3
1995	61.14	93.67	127.7
1996	**64.2**	97.13	133.1
1997	70.58	100.60	138.5
1998	76.96	104.07	143.9
1999	83.34	107.53	149.3
2000	89.72	**111.0**	154.7
2001	**96.1**	122.03	**160.1**
2002	101.4	133.05	
2003	106.7	144.08	
2004	**112.0**	**155.1**	

SES, Selected Educational Statistics, NSS, National Sample Surveys; PC, Population Census.

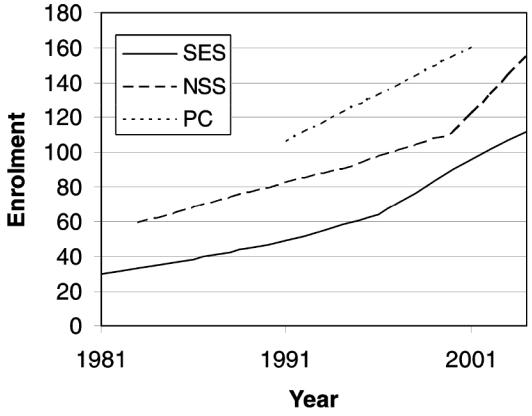

Figure 1. Graphical projection of the enrolment of students in higher education in lakhs from three different sources.

Table 2. State-wise distribution of colleges in the country during 2000–01 (from ref. 5). It is meaningful from the policy-making point of view to see how the states are provided for on a population basis

Division	Population 2001 census	Colleges in 2000–01	Colleges/million
Mizoram	888,573	31	34.89
Goa	1,347,668	43	31.91
Manipur	2,166,788	68	31.38
Karnataka	52,850,562	1473	27.87
Chandigarh (UT)	900,635	24	26.65
Puducherry (UT)	974,345	24	24.63
Meghalaya	2,318,822	48	20.70
Orissa	36,804,660	699	18.99
Maharashtra	96,878,627	1804	18.62
Andhra Pradesh	76,210,007	1402	18.40
Nagaland	1,990,036	36	18.09
Himachal Pradesh	6,077,900	98	16.12
Assam	26,655,528	355	13.32
Punjab	24,358,999	320	13.14
Madhya Pradesh	60,348,023	790	13.09
Tamil Nadu	62,405,679	816	13.08
Sikkim	540,851	7	12.94
Daman & Diu (UT)	158,204	2	12.64
All India	1,028,610,441	12,806	12.45
Gujarat	50,671,017	620	12.24
Chhattisgarh	20,833,803	241	11.57
Haryana	21,144,564	241	11.40
Andaman & Nicobar Islands	356,265	4	11.23
Delhi (UT)	13,850,507	154	11.12
Kerala	31,841,374	352	11.05
Jammu & Kashmir	10,143,700	101	9.96
Uttarakhand	8,489,349	75	8.83
Bihar	82,998,509	660	7.95
Rajasthan	56,507,188	420	7.43
Uttar Pradesh	166,197,921	1216	7.32
Arunachal Pradesh	1,097,968	8	7.29
Tripura	3,199,203	21	6.56
Jharkhand	26,945,829	170	6.31
West Bengal	80,176,197	483	6.02
Lakshadweep (UT)	60,650	0	0.00
Dadra & Nagar Haveli (UT)	220,490	0	0.00

to 20,677 (CAGR = 6.6%), teachers from 15,000 to 5.05 lakhs (CAGR = 6.2%) and enrolment from 1 to 116.12 lakhs (CAGR = 8.5%). We see that growth in the various sectors over the last 50–60 years has ranged from 4.5 to 8.5%. This is impressive, but can be easily explained as having kept pace with the economy, starting out from a very low base at the time of independence.

There are many gainful and painful insights and realizations that we get from the statistics in these studies. For one, we are not good at maintaining records. These reports consider three alternative sources for information. They are the Selected Educational Statistics (SES) of the Ministry of Human Resources Development, the National Sample Surveys (NSS), and the Population Census (PC). And they vary widely, often comparing apples with oranges. For instance, the SES which remains confined to students in graduate programmes and above in public and private institutions, probably under-reports the situation. The NSS and PC figures add those in distance education as well and include certificate and diploma holders. Table 1 and Figure 1 show that we do not have an accurate estimate of the number of students in the age group of 18–23 years who are enroled in some form of post-school training and education. Indeed, say for 2001, the estimate ranges from 96.1 to 160.1 million! This will mean that our estimate of the GER will itself vary from a low estimate of 8.4% to a high of 14.1%, i.e. by nearly six percentage points. We must aim at much better book-keeping. So who is to say if the target for the 11th Plan of raising GER from 10% to 15% has been achieved or not, when we have errors of the same order in our book-keeping itself!

Even where we have the right numbers, we do not present it in a manner where proper judgement can be exercised. Table 2 shows in one of the columns the state-wise distribution of colleges in the country during 2000–01 as presented in the UGC reports[5]. No meaningful conclusion can be drawn from such a representation, except that if compared with the corresponding figures for 2004–05, the relative growth rates can be estimated, as is indeed done in the UGC report. For example, the UGC report points out that the north-eastern region accounts for only 3.5% of the colleges and that among the southern states, Kerala has the highest growth rate in the number of colleges from 2000–01 to 2004–05. Here, I have found it more meaningful from the policy-making point of view to see how the states are provided for on a population basis. Tables 2

Table 3. State-wise distribution of colleges in the country during 2004–05. Note that Uttarakhand and Kerala have improved significantly

Division	Population 2001 census	Colleges in 2004–05	Colleges/million
Manipur	2,166,788	81	37.38
Karnataka	52,850,562	1865	35.29
Goa	1,347,668	46	34.13
Puducherry (UT)	974,345	33	33.87
Mizoram	888,573	30	33.76
Chandigarh (UT)	900,635	29	32.20
Andhra Pradesh	76,210,007	2096	27.50
Uttarakhand	8,489,349	216	25.44
Maharashtra	96,878,627	2441	25.20
Meghalaya	2,318,822	56	24.15
Orissa	36,804,660	815	22.14
Nagaland	1,990,036	42	21.11
Kerala	31,841,374	667	20.95
Tamil Nadu	62,405,679	1242	19.90
Punjab	24,358,999	468	19.21
Himachal Pradesh	6,077,900	113	18.59
Madhya Pradesh	60,348,023	1116	18.49
Sikkim	540,851	10	18.49
All India	1,028,610,441	17,622	17.13
Jammu & Kashmir	10,143,700	168	16.56
Lakshadweep (UT)	60,650	1	16.49
Chhattisgarh	20,833,803	338	16.22
Gujarat	50,671,017	797	15.73
Assam	26,655,528	396	14.86
Delhi (UT)	13,850,507	184	13.28
Daman & Diu (UT)	158,204	2	12.64
Haryana	21,144,564	267	12.63
Uttar Pradesh	166,197,921	2037	12.26
Rajasthan	56,507,188	636	11.26
Andaman & Nicobar Islands	356,265	4	11.23
Arunachal Pradesh	1,097,968	12	10.93
Bihar	82,998,509	665	8.01
West Bengal	80,176,197	554	6.91
Tripura	3,199,203	22	6.88
Jharkhand	26,945,829	173	6.42
Dadra & Nagar Haveli (UT)	220,490	0	0.00

and 3 show the result of such an analysis. Six of the eight states from the North East are actually performing better than the national average. Uttarakhand and Kerala, which were performing more poorly than the national average in 2000–01, have improved significantly during the subsequent four years. The performance of West Bengal is surprisingly disappointing; a point that escaped the compilers of the UGC reports. West Bengal led the renaissance of India, but has now fallen on bad times, it would seem.

The UGC report on Higher Education[5] shows the projected enrolment for the 11th Plan period (2007–12) in general education (i.e. excluding professional courses such as engineering and technology, and medicine) at the UG, PG and doctorate levels (see table 19, p. 43). In 2011–12 there are expected to be 11,671,000 students at the UG level, 1,116,000 students at the PG level and only 78,000 students at the Ph D level. That is, only 0.6% of the students go on to the Ph D level. Is this sustainable for the long-term health of the higher education and R&D sectors in the country? No one has been known to have attempted the sums so far. Let us try a simple stock and flow analysis to see why we are now in a trap of low expectations. There is arguably a stock of 120,000 scientists in our R&D sector. Let us presume optimistically that all are Ph Ds. Let us also assume that this stock is replenished every 40 years, so that this will mean a flow of 3000 Ph Ds a year for sustaining this stock. Let us now go to the higher education sector. We can roughly estimate that there will be about 14 million students in the age group of 18–23 years in general education colleges in the country. We shall assume a teacher–student ratio of 1 : 20. This will mean a requirement of a stock of teachers numbering 0.7 million. Again, let us assume that these are all Ph Ds and that this stock is replenished every 40 years. This will mean that we need to have a flow of 17,500 Ph Ds a year. There is therefore a total need of about 20,000 Ph Ds a year, if we assume that all scientists and all college teachers have this qualification as a mandatory requirement. If we assume that the residency period for an average Ph D in India is 4 years, this means that we must have 80,000 Ph D students in the country. Indeed, this is exactly what we are having now. Apparently, Indian science and higher education have settled comfortably into a low-level equilibrium groove[6], driven by the tyranny of low expectations. We are complacent with the 10% of the age cohort getting a college education and with 0.6% of these going on to complete a Ph D.

Instead of aiming higher, we are descending inexorably down into a spiral that takes us to a low-level equilibrium point.

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5. Higher education in India: issues related to expansion, inclusiveness, quality and finance, UGC, November 2008.
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