Biotechnology programme at Poona U—the beginning or the end?

V. Sitaramam

Emphasis on good teaching and stress on experimental skill are major features of Poona's successful biotechnology training programme. But increasing the number of specially-funded centres without improving quality of work is fraught with only-too-familiar dangers.

Two viewpoints may be presented concerning the performance of the biotechnology programme at the University of Poona in Pune, which are shared to a variable measure by most other major centres. These viewpoints are not mutually exclusive. I briefly sketch these, with the caveat that any complacency that more centres of the same kind would continue to yield good results may be a misplaced judgement. In this connection I share some of my own apprehensions and even aspirations about the future of the programme.

When the goings are good, the question arises as to where the laurels should rest. The viewpoints differ correspondingly, while the impartial observer even fails to see them as different points of view.

Viewpoint I (or, We have done it!)

a. Trumpets and cymbals

The biotechnology training programme at the university is now five years old. In these five years, the programme has performed adequately to be considered worthy of the endowment it received as a part of the national mandate in manpower development. More than 90 students (at about 20 per year) were admitted to the M Sc programme and have graduated. While the students are selected at the national level their performance, evaluated by external agencies such as CSIR and UGC through their joint entrance test, was consistently high, with 90–100% passing. Even in the Graduate Aptitude Test in Engineering (GATE) of the Indian Institutes of Technology (IIT), 11 out of 13 passed in 1990. I was told that these results do compare rather favourably with the performance of IIT graduates themselves!

b. Accident or design?

If we—the Poona biotechnology teaching faculty—have contributed positively to the relative well-being of our students, what factors have played a significant role? The foremost pertains to the realization by the faculty from the very beginning that the training in biotechnology must be experimental. It was clear that the M Sc programme should attempt to repair the damage inflicted in the name of science education at the bachelor's level as well (in terms of loss of time as well as poverty of ideas and attitudes required for a science education) while fulfilling the requirements at the M Sc level. Holidays could be dispensed with, replaced readily by a two-month summer training programme for each student in major laboratories in various parts of the country. Similarly, the mid-year vacation in the second year could cater to the completion of the compulsory project work. Practical training requires direct access to equipment. Above all, inculcation of the work ethic required long hours of laboratory work and frequent meeting of deadlines. The students come to us after B Sc, where the dominant learning mode is mindless cramming from books. A transition to learning by experience and active involvement is totally alien and takes considerable effort and persuasive skills.

c. To be or not to be quantitative?

The idea of equalization courses that cater to the immediate needs of the two distinct streams of students, viz. the physical-sciences students and the biological-sciences students, has played a crucial role in bridging the gap between them. Mathematics, statistics and computer programming on the one hand, and cell biology, biochemistry (including physical and organic chemistry), molecular biology and genetics on the other at a primary level in the first year rendered the subsequent programme easier for teachers as well as students. In fact, open access to equipment during free time (which is to become increasingly rare with each passing semester) allowed the students to learn (with a little friendly persuasion) techniques such as spectrometry in considerable practical detail. This in turn has permitted more ambitious practicals in the second year. Incorporation of statistical methods heavily in experimental protocols helped students to acquire familiarity with quality control.

d. Awareness or 'hands-on' experience?

Since it would be difficult to impart practical training at an advanced level unless the teacher/student ratio was high, the programme adroitly incorporated two features that are specific to Poona: first, division of the second-year students into groups for specializations (see table) with some common 'techniques' courses in biochemistry and biophysics; second, the enthusiastic participation of neighbouring national laboratories, such as the National Chemical Laboratory (NCL), the National Institute of Virology (NIV), and the National Tissue Culture Facility, in the teaching programme, particularly for the specializations, to ensure hands-on practical training. The tempo is maintained with a rigorous project equivalent to a full course, which has led to publishable work in several instances. In any event,

Specializations offered in the second year (i.e. III and IV semesters) of M Sc biotechnology

Specialization	Courses (theory and practicals)
III Semester	
Common courses	Biochemical and biophysical techniques, Project
Genetic engineering	Molecular biology (I), Recombinant-DNA technology, Microbiology
Biochemical engineering	Fundamentals of biochemical engineering, Microbiology, Enzyme techniques and separation processes
Animal tissue culture	Developmental biology Principles of animal cell and tissue culture, Animal cell cultures and applications
Plant tissue culture	Plant cell and developmental biology, Plant tissue culture techniques
Molecular biophysics	Molecular biology (I), Microbiology, Simulation and modelling
IV Semester	
Common course	Project
Genetic engineering	Molecular biology (II), Genetic toxicology, Experimental cell and molecular biology, Virology, Immunology
Biochemical engineering	Bioreactor design and transport phenomena, Biochemical processes and biotechnology, Virology, Immunology
Animal tissue culture	Special techniques in animal cell and tissue culture, Genetic engineering, Genetic toxicology, Virology, Immunology
Plant tissue culture	Plant physiology and phytochemistry, Application of plant tissue culture, Genetic engineering, Virology, Experimental cell and molecular biology
Molecular biophysics	Molecular biophysics, Bioenergetics and membrane biophysics, Immunology, Biological macromolecules

Each semester has three theory courses of 50 lectures each and two practical courses of 25 practicals each For specializations, the duration of each practical corresponds to 6 hours generally The project is a full course equivalent

every student has a minimum of 50 hours of work with half as many contact hours every week, besides various tests and tutorials. Given the choice between scholarliness (in the most pejorative sense of mere book-learning) and first-hand experience (in the noblest empirical tradition!), the Poona model preferred the latter

Viewpoint II (or, Well, the time was ripe!)

a. Historical inevitability

The national biotechnology manpower development mandate came to fruition through the efforts of the Department of Biotechnology (DBT), which has taken considerable pains to choose its centres, fund them well, and monitor them constantly. While the management was all that it ought to be, the enthusiasm was equally well received by the universities in affording a relatively smooth operation. For the first time, some integration with a meaningful focus has emerged in biology education in India The Poona experience has to be understood not merely in terms of how the biotechnology students, who are affiliated to the department of zoology, fared, but also in terms of how well the zoology M Sc students fare in the national tests. Fully backed by the university in all matters of management, the Poona programme succeeded, having stuck to the original formula without wavering, i e. affiliation of the programme to one nodal department without succumbing to any schism. The laurels and the brickbats are equally shared!

Looking back, the performance of the department of zoology was on the upswing even before the biotechnology programme came into being. The choice of this centre was thus in the fitness of things. The will to perform remains the most exacting requirement for an interdisciplinary programme such as this. Poona was not an accident: there has always been a commitment to funnel resources acquired through research grants towards teaching, without which the building of departments would be but an empty dream.

b. The glamour factor

It was, and continues to be, a matter of some importance that biotechnology has become an 'avant-garde' discipline in biology today. This helped funding, interactions and participation in teaching, enhancing the stock of true resource personnel and collaborations in research as well. It gave some impetus to a rethinking in terms of unification in the teaching of modern biology, which biochemistry or molecular biology alone failed to do.

Besides glamour, there was also some hard thinking on the part of the students. Our own students primarily have gone into research in most centres in the country rather than into industry and related jobs. The programme at Poona, in spite of being primarily a science degree, has not intended this result. But then, do the teaching faculty remain a dominant model for the students? Besides, the summer training that the students receive in various laboratories also plays a role in this choice. If students from Poona go in for higher academic training rather than to industrial jobs, we take heart from the observation that most students still prefer to continue their research within the country. We do not yet have enough data on their mores after Ph D.

Yardsticks

While it is possible to analyse *ad nauseam* the minutiae of the training programme and its requirements, it may be fair to summarize that there is no particular unanimity of opinion even among the teaching faculty as to what the yardsticks of good training and its external impact are. In particular, there appears to be some view that there is a minimum knowledge-base requirement that the M Sc biotechnology programme is supposed to fill. Model syllabi, a favourite pastime, are written twenty to the dozen, and observed more in default. It is amazing how well Indian students do in the laboratory when given a specific complete protocol, be it biochemistry or genetic engineering. It is equally amazing how poorly they do when given only an idea by which they are expected to develop their own experimental design. Should we teach our students in depth the things we actually do, or should we restrict ourselves to an overview, fulfilling the delivery of 'detailed and comprehensive' syllabi? Neither industry nor research laboratories should forget that a fresh

M Sc is still at his/her peak capacity to learn and that our job is only to whet the appetite for more demanding tasks and not to curb it with endless book-learning.

Whom do we select?

The Poona experience is worth noting since considerable thinking and efforts have gone into an evaluation of the entrance examination. Rigorous statistical evaluation indicated that neither a viva voce nor any laboratory/practical tests has contributed significantly to the selection process. However, these experiences, fostered by an active teaching programme, have also brought to fore the importance of the right attitudes in the students and the consequent need to persevere in attempts to improve the examination system. The Poona programme, despite its major emphasis on quantitative biology, has not encountered any difficulty thus far in handling students with a background in the physical sciences or those in the biological sciences. The will to perform is equally important for the students, an aspect that the existing examination system at the national level hardly addresses itself to. A more rigorous evaluation for general performance, intelligence and comprehension, and not textbook-oriented subject matter alone, would definitely help in selecting the right candidates. The time is ripe to examine these aspects and also to advertise more systematically at the national level to attract better talent.

Quo vadis biotechnology? (The beginning or the end?)

We have the general impression based on conventional wisdom that if something works we should stick to it. More of the same kind is considered likely to amplify the returns. The time has come to examine again whether this has been true in the past. With over a hundred universities, have we kept pace with the rest of the world in any subject—technology, science or the humanities? We still assess our performance by the numbers rather than by the quality. In the last few decades, we have slowly deteriorated or stood still while the developed countries have marched ahead in every conceivable subject. Why should biotechnology be an exception in the foreseeable future?

There is no need to dilate on this non-performance of the Indian educational system. There has also been no accountability on the part of the teaching faculty since there is no way to monitor their performance meaningfully by their teaching alone. Rather, it is important to see what impact their performance has on the students as they come in and how it contributes to their psyche as they leave. It appears that the students do perceive the involvement and performance of the teaching faculty as academicians. They do pose questions of an embarrassing kind. For instance: A lot of excellent publications are seen from the West, often carrying Indian names. Indians abroad are supposed to be good at statistics and computer software. What has happened to Indians in India? Somehow, we have not shown our mettle in originating and carrying to their logical conclusion ideas and products. Is it because we have not rid ourselves of our erstwhile colonial attitudes in science and its management? Students discuss these. How many products have really taken off from the ground in the country? Are there, really, avenues open for the entrepreneur? Do we have what it takes to develop a new process? Even when students do not directly challenge us with these questions, their actions speak volumes. They look for better addresses than for demanding programmes. They are simply not convinced about the will of the Indian industry to give them an environment for enhancing their capabilities. The sociology of the young students, many of them out of their homes for the first time—at a somewhat late age compared to engineering and medical students—creates its own complexity. However, to the extent that they perceive what lies ahead of them, the general approach is somewhat cynical.

Increase in numbers by expansion, unmindful of quality, as well as lack of vertical growth in the quality of work offer a deadly combination for the future of the biotechnology programmes. The major threat to biotechnology comes when it is perceived as a convenient bandwagon, unsupported by performance. The requirement for technological performance adds to the complexity of scientific performance rather than subtract from it. The critical focus rests on the teaching faculty, who represent the very first images to be imprinted in the minds of the new students.

What should we do?

The future of the training programme clearly lies in what makes the students tick. The students, as they come in, respond like taut strings to enthusiasm and commitment. They invariably comment that participative, practical learning is something new and exciting. That enthusiasm does not appear to last beyond the first year. By the second year, they have seen other labs and they are not impressed with promises alone. With the end of formal education approaching, when each has to take care of himself or herself, introspection begins as to whether it is at all worth it. It is at this point that the students sense the level of performance of their teachers. If not impressed, the disillusionment is absolute and cynicism manifest. One must also acknowledge that the Indian student in science takes much longer to find his roots than his Western counterpart.

The key to the future seems to be, at least to my simple mind, in taking advantage of the initial thrust already achieved. For once, a trend has been reversed in the country: universities, and not national laboratories, have been given major inputs for nurturing modern science in a coherent manner. It is clear that the initial inputs have been adequate to initiate, in these university departments, teaching as well as research on a larger scale than has been possible hitherto. After the first five years, the basic needs for teaching and a minimal level of research have been met. In the next five years, it is necessary to push through programmes such that productivity is judged in terms of the performance of students as well as that of the teaching faculty. If these centres are also recognized in tangible terms for their actual performance in specified areas of research, the consequent development of specific identities may capture the imagination of the young students in search of challenging careers. If the universities remain 'course bazaars', their stagnation is certain. It is also important to see that biotechnology does not attain a uniform character and that each centre develops its own specific character or 'flavour' based on the active interests of its own faculty.

Is this emphasis on the research growth of the centres justified? Are not the universities primarily for education and not research? Somehow the image that education, at least at the post-graduate level, can go on in the absence of high-powered research appears to be an original Indian thought, that too of recent origin. Even the original charter for Indian universities has not segregated education from research so effectively as we have now achieved in most places! In the absence of a stick, the carrot of research support may help change or maintain the pace

Some of these considerations may be true of all universities and all subjects. It may be true that not all subjects can be developed equally. Since progress is sporadic and not normative, why worry? Some progress is better than none. Biotechnology, if sustained in terms of its intrinsic logical growth, may yet offer a reasonable and plausible model for an improvement of the general scenario of education in the country. That will be a true beginning. But it will require considerable planning for the years ahead.

Acknowledgements I claim no originality for many of the opinions expressed herein I am indeed grateful to many of my colleagues and students, past and present, who provoked me constantly to rethink on any stand I have attempted to take There has been more to learn than to impart

V. Sitaramam is in the Department of Zoology, University of Poona, Pune 411 007.

Biotechnology training—innovative teaching and liaison with industry, MSU Baroda

V. V. Modi

Teaching should stimulate students to ask intelligent questions and seek ways of answering them. Biotechnology education cannot be limited to textbooks.

Biotechnology today has become synonymous with application of state-of-the-art molecular biology in industrial ventures; it deals with the use of microbes and plant and animal cells in the production of a wide variety of substances. For example, genes encoding penicillin-biosynthesis enzymes have been isolated and cloned[1]. Such cloned antibiotic-production genes can be used to develop antibiotics with modified structure or as probes to isolate from the soil other microbes that make similar but subtly different antibiotics. Genes for an antibiotic can be transferred into, say, a new host bacterium that ferments well at 40–50°C to investigate the feasibility of antibiotic production at high temperatures; the reduction in requirements of cooling water in the process could result in considerable cost savings. This can happen within a few years The impact on medicine and industry of the new technical ability to analyse, synthesize and rearrange DNA and to exploit monoclonal antibodies will exceed the most optimistic claims. Very soon deeper understanding of the organization and functional control of human chromosomes will emerge. We can ignore these developments only at our cost.

Planning for a work-force

There was clearly a need to train students and expose them to these developments. In 1984 the National Biotechnology Board (now the Department of Biotechnology, DBT) promoted and nurtured the establishment of specialized schools at more than a dozen centres, including the M S. University of Baroda (MSU), University of Poona, Jawaharlal Nehru University, Madurai Kamaraj University, Banaras Hindu University, Jadavpur University, the Indian Veterinary Research Institute, the Indian Institutes of Technology at Kharagpur and Bombay, the Indian Agricultural Research Institute and the All-India Institute of Medical Sciences. Universities were selected for support on the following criteria[2]: (i) appropriate existing expertise, (ii) infrastructural facilities, (iii) established research strengths in designated areas, (iv) major grants received from other funding agencies, and (v) proximity to research institutes or national laboratories already engaged in biotechnology.

On an average about 15 students are admitted every year at each of these centres to the master's-level teaching programme. Selection of candidates is done on the basis of an all-India open test, after which successful students are distributed among the centres according to merit and choice of centre.

MSc biotechnology at MSU

The course work includes theory classes in general microbiology, immunology, biochemistry, biophysics, biostatistics, developmental biology, basic genetics, pollution control and biodegradation in the first year. In the second year the emphasis is on genetics and molecular biology, genetic engineering, industrial and applied microbiology, advanced immunology, plant tissue culture and economically important plant products. These subjects are taught by staff specializing in the respective subject. Several academic positions were specially created for the biotechnology course, and, when required, cooperation from staff of other departments on the campus is also sought.

Suitable laboratory work including experiments designed to give the students a deeper insight into their theoretical knowledge, with focus on microbial biochemistry, immunology, developmental biology, fermentation technology and genetic engineering, is carried out.

As a part of laboratory work, dissertation problems are given to students on some aspect of ongoing projects. This gives them opportunities to come in close association with teaching staff and to work with committed research students. In a wholesome environment the M Sc students learn to do hard work enthusiastically, ask the right questions, take pains in verifying facts, and acquire some sort of refinement