Lucknow, and J Vakil in Bombay; and on its pharmacological properties by R. N. Chopra and B. Mukherji in Calcutta. But as each Indian group had worked independently the credit for the discovery of the pharmacological property of reserpine went to Ciba. This underscores the need for intimate collaboration between biological chemists, pharmacologists and clinicians for work on new drugs.

The scenario has not changed much since 1950. We need a far stronger industry–academe liaison, a permanent forum, where a coordinated exchange of ideas can take place.

Cooperation

At the research level much strategic work remains to be done. On the basis of a market survey we should discuss 'What are the pharmaceutical and agricultural products in which we are interested?' Also a great deal of meaningful and dynamic cooperation is required between DBT, the Department of Science and Technology (DST), CSIR, the Department of Atomic Energy (DAE), the Indian Council of Medical Research (ICMR), ICAR and biotechnology teaching and research centres. Will the government give a positive lead either directly or through DBT? Our national academies and scientific societies organize meetings and publish journals, their unwillingness and incapacity to interact with the government on such issues at the political level shows ostrich-like behaviour.

The coming generation will need a new music. Pathfinders in biology will seek new avenues to solve challenging problems. The training programmes are the hope of the future.

1. Smith, D J., Burnham, M K. R., Edward, J., Earl, A J and Turner, G., *Bio/Technology*, 1990, **8**, 39.
2. Modi, V. V and Lloyd, D., *Ind Biotech.*, 1989, **9**, 18

Acknowledgement I thank research students Anjali Sahasrabudhe and Sujata Chiplunkar for helpful discussion.

V. V. Modi is senior scientist of the Indian National Science Academy in the Department of Microbiology and the Biotechnology Programme, M. S. University of Baroda, Baroda 390 002.

Bioprocessing—the need of the day

Kunthala Jayaraman

Biotechnology training should also aim to produce bioengineers.

The introduction of postgraduate programmes in biotechnology sponsored by the Department of Biotechnology has given a tremendous boost to the teaching programme in modern biology. This is akin to the concentrated efforts made for the development of the atomic energy programme thirty years ago. It is an astute move in the groundwork to generate manpower for R&D in this area. The approach of concentrated funding in a few well-developed centres appears to be the most logical one for achieving major impact. I recall the strong opposition we faced against the introduction of molecular biology in the curricular programme in biology twenty years ago. Thanks to the news media, the awareness of the students and the public of this modern and exciting era of science has risen sharply. That is why the change has been made easier, and the 'old guards' of our educational system had to remain silent!

The research and teaching programmes in biotechnology take into account the diversity of educational backgrounds required to tackle technological problems in biology. Currently there are excellent pockets of research in molecular biology and basic genetic engineering, and some application-oriented programmes in diagnosis of infectious and tropical diseases and plant genetic engineering. However, there is the major lacuna of absence of active interaction between 'gene engineers' and process technologists. The latter group of specialists usually comprises biochemical engineers and instrumentation specialists with computational skills. While the chemical industry's requirement is quickly filled because of the fairly straightforward nature of the processes, in the biotechnology industry, where processes depend on biological systems, the complexity of the reactions makes process control technology more sophisticated and process parameters more diverse. There are a few centres in India where emphasis on chemical-engineering applications in biotechnology is seen, but a healthy amalgamation of gene engineers and biochemical engineers is not seen.

The curriculum in biotechnology at the M Tech level at Anna University in Madras aims precisely at this amalgamation process. There is a need for us to train bioengineers who can handle production of recombinant vaccines, monoclonal antisera in tissue-culture reactors, fermentation processes for pharmaceuticals, etc. The Anna University curriculum aims at training chemical engineers (B Tech graduates) in biological systems and introducing chemical-engineering principles to biologists (M Sc graduates). More such interaction should be established in the excellent centres in basic sciences so that biotechnology product development from laboratory to commercial level can become feasible.

A weak link in the industrial application of research programmes is the absence of pilot-scale validation facilities. As mentioned earlier, complex parameters governing the production of biomolecules in bacterial fermentations, animal cell cultures and plant tissue cultures demand a whole set of studies, and only a 'hands-on' approach can enable scale-up of these processes.

Another area that requires special attention is use of the trained manpower. One often sees that many of the youngsters coming through these educational programmes leave the country as soon as they have learned the basic techniques. There should be innovative measures to hire them as soon as they come out of these educational institutions and not subject them to a plethora of delays and bureaucratic procedures.

The last but not the least is the problem of consumables and materials for day-to-day work in biotechnology. Unless concrete measures are taken to solve these problems, the enormous amount of money spent on purchase of equipment and establishing laboratories will not give tangible returns.

Kunthala Jayaraman is in the Centre for Biotechnology, Anna University, Madras 600 025.