Interfacing biological, physicochemical and engineering sciences—IMTECH

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A successful biotechnology industry hinges on integration of research in modern biology with inputs from the physicochemical and engineering sciences and an instinct for recognizing commercial possibilities of laboratory work.

Technologies based on the synthetic or degradative activities of living organisms have been intimately associated with the development of human societies all over the world. Most of these processes were established through empirical experience stretching over generations. Organized industrial ventures based on biological activities are, however, mostly twentieth-century phenomena. Especially in the last four decades or so, rapid advances in various branches of the life sciences have led to deep insights into the basic mechanisms regulating many of these processes and have provided powerful tools for modifying the metabolism of the concerned organisms to maximize desired activities. The techniques of creating desirable combinations of genes have been refined to such an extent that, in theory at least, it is possible now to design organisms for specific purposes. Closer at hand are the capabilities provided by the recombinant-DNA techniques for the production of a large array of biologicals at scales and costs considered impossible only a decade ago. Concurrent with these advances in basic biology came the realities of dwindling supplies of traditional raw materials and energy sources. These factors have spurred intense efforts towards efficient exploitation of various biological processes for the production of industrially important commodities in the developed countries. The spectrum of this renewed interest covers bulk industrial chemicals, recovery of metals from low-grade ores or even sea water, coping with industrial pollution of our environment, the traditional antibiotics and pharmaceuticals, and a whole new range of medically important diagnostics and therapeutics. These activities are grouped under the generic name biotechnology, which results from the amalgamation of the biological sciences with the physicochemical and engineering sciences. Microbial technology forms a subset of activities under biotechnology in which the properties of prokaryotic or eukaryotic microorganisms are exploited for industrial purposes. A successful microbial technology today is likely to involve the foresight of a microbial physiologist, the skills of a gene manipulator, the imagination of a mathematical modeller, and the dexterity of a chemical engineer.

Biotechnology in India

The potential of microbial technology in national economy has been amply realized in the developed countries by both industry and government. Thus, in these countries, microbial technology has become an area of furious activity, encompassing generation of venture capital, formulation of regulatory frameworks, and intense R&D efforts. In glaring contrast, the Indian scene in the area of microbial technology is definitely dismal. Other than an outmoded ethanol industry thriving more on stringent protection of the vital raw material, cane molasses, and price controls of the end product than on its inherent vigour, the impact of microbial technology on the Indian economy has been virtually nil. Attempts were made in the fifties and sixties in both the public and private sectors to establish fermentation-based industries through technology imports. Unfortunately the momentum generated by the end of the sixties was allowed to be dissipated in the seventies through regulatory constraints and myopic policies imposed by the government. As a fallout of these acts of omission or commission, we face the nineties with the stark reality that our self-sufficiency in the production of adequately pure quantities of even the very first antibiotic, penicillin, is often questioned. Although we have a very active drugs and pharmaceuticals industry that excels in formulations and, in some cases, production of bulk synthetic drugs, it has not yet been possible to establish a solid foundation for fermentative production of various drugs and industrial chemicals in either the private or the public sector. A thorough analysis of this sector of the Indian pharmaceutical industry published in 1984 (ref. 1) by the National Council of Applied Economic Research describes the situation, perhaps euphemistically, as 'a varied picture, containing a few bright patches amidst several dark spots'. The primary cause of this failure can be traced to the inherent complexity and multidisciplinary nature of microbial technologies, for which a corps of highly motivated and innovative individuals with intensive training in physical, biological and engineering sciences is required for providing the necessary inputs. Since independence, we have created a plethora of institutions of higher learning, sometimes with the best of intentions, often out of political expediency. It turned out that adequate sustenance of most of such institutions is totally beyond our fiscal capabilities or will. Many of these substandard institutions continue to churn out poorly trained graduates who can hardly be expected to make successes of complex technological enterprises. The better-supported of such institutions, on the other hand, turned out to be clearing-houses for export of the best-trained of our students to fuel the biotechnology revolution elsewhere. Scattered efforts have been made in various universities and publicly supported R&D institutions with minimal