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Identification of Microbial Technology Courses for Open University System

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Here is yet another piece in our series on distance education and the teaching of sciences.

As the world moves towards increasing economic turmoil and instability, recession and a general scarcity of resources, the time has come for us to reflect on a change in the educational climate. Academic activity, in our times, can no longer be the persuit of knowledge *per se*, with no concern for economic viability or generation of resources. On the contrary, there is a need — more pronounced than ever before — for the educationist to address to the demands of the technology and grow with them.

This article addresses this issue in a specific manner. It offers inputs for course development in a highly specialised area of technology.

INTRODUCTION

Microbial technology may be defined as the application of microorganisms and microbial processes in manufacturing industries. Traditionally, the largest microbial technology in commercial practice has been for the production of ethanol, baker's yeast and antibiotics. Recent developments in molecular biology and recombinant DNA have ushered in a new era of microbial technology poised to meet an extraordinary range of human needs in medicine, agriculture, industry and for the management of environment (Table 1). In the past two decades alone there has been an unprecedented accumulation of knowledge in this area related to basic biology, novel techniques and commercial enterprise technology. These developments have placed new challenges before the academic institutions to design and constantly update courses to cater to the specific needs of persons who would like to make a career in microbial technology. It is commendable that in this country, the Central Government took the initiative and established the Department of Biotechnology in early 1980s. The Department funded a significant number of research projects and academic courses in some reputed universities. Eventually, a few other universities also instituted graduate and postgraduate degree courses in biotechnology. All these academic courses are understandably aimed at imparting formal education in this field. In the present paper we examine the question of whether this formal education will meet the urgent requirement of those who need this information and training in microbial technology and who, by virtue of their present occupation, cannot find the time and the means for formal education. In the light of this question, we examine the possibility of involving the open learning system for imparting the requisite knowledge in this specific area; and also explore its strengths and weaknesses, if it becomes possible.

EVOLUTION AND INDUSTRIALISATION OF MICROBIAL TECHNOLOGY

The development of microbial technology may be regarded as having occurred in five stages. The first (antiquity-1886) pertains to the period prior to Louis Pasteur. During this period many microbial processes were in use without people being aware of the role of microorganisms. Pasteur's discoveries laid the scientifically sound foundation of fermentative production of alcoholic beverages and leavening of dough. The developments in the second phase (1886-1940) opened up the possibility of manufacturing pure fermentation products viz., ethanol, butanol, methanol, acetone and citric acid. In the third phase (1940-60) industrial-scale manufacture of several of these products was undertaken. Industrial-type fermentation was brought to high sophistication and efficiency.

Separation and purification techniques for fermentation products were perfected. This also marked the era of antibiotics. In the fourth phase (1960-80) a greater number of products involving complex technologies were commercially produced. Preparation of vaccines, fodder protein from microorganisms, pure aminoacids, technical purity grade enzymes (in washing powders) and bacterial polysaccharides was taken up on a large scale. The fifth phase (since 1980) has been based on the revolutionary discoveries of molecular biology, genetics, genetic engineering and process technology (Tables 2 & 3). This period has also seen high industrial and research activity. For example, food processing industry alone accounted for 7,500 new commercial products (Biotechnology Course, UKOU:1986). In USA figures for 1984 indicate that pharmaceutical industries constituted 62%, agricultural industries 53%, speciality chemicals and food industries, 20%,and commodity chemicals and energy industries, 15%, of the total number of industries. (They add upto more than 100 as many industries are engaged in the manufacture of more than one category of products). The new firms established in all these areas together were 26 in 1980, 43 in 1981 and 22 in 1982 (Office of Technology Assessment, 1984). There are many microbiological products and processes that are relevant to or have potential use in all these industries.

This rapid industrialisation based on microbiological concepts in turn led to a great deal of interest in microbial technology and its application. This is also reflected in the related high level advanced research activity and its application all over the world. In India also many research organisations are actively involved in developing new microbial technologies which benefit many industries. For example, Central Food Technological Research Institute, Mysore, has developed different technologies useful for food industries including breweries and distilleries. The Institute of Microbial Technology at Chandigarh is devoted exclusively to research and development work on microbial processes. It has already launched important projects on therapeutics and microbial enzymes. It also has a national centre for culture collection and gene bank. To a limited extent, similar work is being pursued in some of the Indian universities also.

Table 1 : Microbial Technology for Human Needs

Products	Processes
Medicine	
Pencillin, Antibiotics, Cephalosporins, Steroids, Anticancer agents, Insulin, Growth hormone, Interferons, Lymphokines, Urokinase, Factor VIII	Fermentations, Bioconversions, Recombination DNA technique
Agriculture	
Biofertilizers, Biopesticides, Crop improvement	Nitrogen fixation, Mass rearing, Fermentation, Genetic Engineering
Food Products	
Baker's yeast, Cheese, Yoghurt, Enzymes, Vitamines, Lactic starter culture, Single cell protein, Food colorants and flavours	Biomass production, Fermentation, Lyophilization, Coagulation, Proteolysis, Dextrinization, saccharification, Isomerization
Chemicals	
Crude oil, Polysaccharides, Xanthan gum, Fats and oils, Amino acids, Nucleotides, Flavours and Fragrances, Organic acids	Fermentation, Genetic Engineering, Use of Mutants, Anaerobic and aerobic fermentation
Environment Management	
Removal of toxic/excess chemicals and heavy metals, Metal concentration and detoxification, Waste water treatment, Degradation of pollutants	Desulfurization, Nitrification/Denitrification, Microbial leaching, Microbial metal accumulation, Aerobic and anerobic digestion
Energetics	
Gaseous fuels (methane, hydrogen), Liquid fuels, Enhanced oil recovery, Conversion of waste into value added products	Anaerobic fermentation, Hydrolysis and fermentation

Table 2 : Phases in the Development of Microbial Technology

Period	Microbial Processes	Industrial Developments
V 1980-	Recombinant DNA	Application of biotechnology in industries
	Genetic engineering	Increase in the efficiency of production
	Expression of mammalian protein in microbes	
	Transgenic plants	Wide array of products
IV 1960-80	Cell culture, tissue culture and different kinds of reactors	Industrial complex technical developments
	Developments in process technology	More industries
	Application of many microbial processes	
III 1940-60	Isolation and purification techniques	Industrialisation of microbial processes
	High sophistication & efficiency	
	Reliability	
II 1886-1940	Fermentation technology	Biotechnology products identified
	Engineering aspects	
I antiquity-1889	Traditional fermentation processes	Traditional products

Table 3 : Evolution in Industrialisation of Microbial Products

INDUSTRIAL PRODUCTION OF VARIOUS PRODUCTS
DEVELOPMENT OF NEW & REVOLUTIONARY PRODUCTS
INSULIN, FACTOR-VIII **BOVINE GROWTH HORMONE**
PRODUCTS DIRECTLY INVOLVED IN HUMAN METABOLISM

VACCINES, **SINGLE CELL PROTEIN**, PURE AMINO ACIDS,
BACTERIAL POLYSACCHARIDES, TECHNICAL PURITY ENZYMES
PHARMACEUTICALS, FOOD PRODUCTS, FINE CHEMICALS

LARGE SCALE PRODUCTION, ANTIBIOTICS PRODUCTION
CHEMICALS FROM PETROL
DRUGS AND CHEMICALS

ETHANOL, BUTANOL, METHANOL, ACETONE, CITRIC ACID
MAINLY CHEMICALS

ALCOHOLIC BEVERAGES, LEAVENING OF BREAD,
FERMENTED FOODS (IDLI, DOSA, MISO ETC.)
TRADITIONAL FOODS

MICROBIAL TECHNOLOGY EDUCATION — FORMAL APPROACHES

Recognising the knowledge boom in microbial technology and the industrial application of several microbial processes, considerable efforts are being made in our country by government organisations and universities to introduce new courses and training programmes in microbiology and related areas (Table 4). The undergraduate (B.Sc.) and postgraduate (M.Sc.) courses offered through the university system are meant for preparing personnel in microbiology, but they are available only to those who have the time and means for such education. This system is difficult for and unsuitable to those who are employed. This is the basic rationale for the introduction of the open learning system. Also the existing courses in microbial technology place greater emphasis on specialised knowledge rather than on a broad based coverage of different aspects of the subject which are relevant at the level of production. Furthermore, the existing courses are not manifold, neither are they aimed at different levels of requirement nor are they useful for varying target groups. The short term training programmes, offered by different organisations, provide training in different aspects of microbiology; but they are too short and thus inadequate. The short term training programmes may not be effective for several reasons including the absence of post-training follow-up action, which is

Table 4 : Some Curricula/Courses and training programmes in Microbiology

Course/training Programme	Offered/sponsored by	Duration of the programme	Target group
University courses			
• B.Sc. Microbiology	13 Universities	3 years	Fresh +2 Sciences
• M.Sc. Microbiology	20 Universities	1-3 years	B.Sc. Students
• M.Sc. Ag. Microbiology	8 Universities	2 years	Agri. students
• M.Sc./M.Tech. Biotechnology	14 Universities	2 years	B.Sc./B.Tech. students
• M.Sc.(Forestry/Horticulture)	1 University	2 years	B.Sc. students
Training Programmes (some examples)			
Alcohol Beverages and Quality Control	Karn excise Dept. (Mysore)	16th March 1992 to 28th March 1992 (17 days)	Personnel from industries
Solid state fermentation	DBT (Mysore)	11 Feb. –28 Feb. '91 (17 days)	Personnel from industries and research organisations
Analysis of aflotoxin in food & feed materials	CFTRI (Mysore)	25 Feb.–18 Mar '91 (14 days)	Personnel from industries & research scientists
Chemolithotrophic bacteria & their applications	DBT (Pune)	9 April-17 April '90 (18 days)	Mid-career scientists & technologists.
Biotechnology of methanogenic anaerabes	DBT (Coimbatore)	Oct 22-Nov 7, 1992 (17 days)	Scientists and Technologists
Gene delivery & targetting	DBT (Madurai)	Nov 21-Dec.11, 1990 (21 days)	Scientists and Technologists
Modern approaches in bioprocess technology of enzymes & fuels	DBT (Madurai)	Dec. 26, 1990-Jan 7,1991 (12 days)	Scientists and Technologists.

• *Source*: *Universities Handbook*, Association of Indian Universities, 1992

neglected in many cases. Moreover, for financial and other reasons, the plans for offering training programmes for different levels of personnel are implemented to a very limited extent only.

MICROBIAL TECHNOLOGY—TARGET GROUPS

The formal approaches discussed above may prove insufficient for a multi dimensional field like microbial technology which is related to many disciplines, as well as to society because of its applicability to industries, in public service organisations and to most activities in daily life. Microbial technology includes not only the production of material in bioreactors or the production of new catalysts by genetic engineering, but extends to aspects of both human and animal care, waste and pollution management, enhanced oil recovery, mineral leaching, advanced plant breeding, diagnostic and analytical equipment, biosensors, bioelectronics and renewable energy systems based on biomass feedstocks. Further, modern microbial technology is interdisciplinary incorporating physical, chemical and biological processes. It would prove a great advantage if the knowledge of microbial technology is made available to a heterogeneous and large population ranging from specialists to laymen, from the urban to the rural poor, from politicians and community leaders to scientists and educators. This high rate of applicability in different areas, including industries, along with the rapid advance of technical knowledge and the related growth in sophistication and complexity of the productive processes gives rise to the demand for a constant flow of research and new knowledge to various organisations and personnel. This is more so in industries where the application of the technologies developed takes place on a large scale. The high rate of technological developments also puts emphasis on a highly skilled manpower. It is difficult to visualise the prevalent education system, limited in means, methods and resources, meeting these demands. It is, hence, imperative to adopt a more flexible and accommodating mode of instruction.

MICROBIAL TECHNOLOGY — INDUSTRIES — OPEN LEARNING

The relevance of open learning to industries (whether microbiology concepts are involved or not) is established in Cooper's (1987) definition : "Open learning is an attempt to break down the traditional barriers to training such as prequalification, age, geographical location, availability, scheduling, learning style and cost." Fricker (1989) has discussed the advantages and disadvantages of open learning to industries and companies (Table 5).

Table 5 : Advantages and difficulties of open learning to the organisations and/or companies

Advantages	
1.	Offers work-based training
2.	Training packages for local specific needs
3.	Operatable independent of the size of an organisation
4.	Puts greater responsibility on the learner (worker)
5.	Gives emphasis on needs of organisations and individuals
6.	Brings content expertise into the organisation
7.	Makes the learning approach cost-effective
8.	Prepares people for new challenges and new jobs
9.	Offers target specific courses and programmes
Difficulties	
1.	Demands a greater number of skills from tutors Sound subject knowledge interpersonal relationships communication skills
2.	Demands establishment of learning resource centeres
3.	Requires high investment initially

Open distance education system, being the most industrialised form of education, offers a different approach to education. Its structure, methodologies, multi-media approach and learner centred character make the system more flexible, accommodating, socially relevant and methodical. This is reflected in a quote from a recent book on Open Learning in Industry. (Temple, 1991): "In recent years open learning has moved from its original and marginal role in continuing and second chance education into the new field of industrial training. A number of changes in work practice and increasingly sophisticated demands for flexible training have made this method of delivery not just desirable but often essential." Although a number of science and technology courses are already being offered through the open learning system all over the world, nothing significant is being done in the developing countries like India, for identifying courses to meet the aforementioned demands arising out of the knowledge and technology which can effect massive programmes of industrialisation. However, there is now a growing realisation of the potential of the open university system for industrial development.

It is important to identify and prepare microbial technology courses for different groups of people for implementing through the open university system. Before identifying courses of different types it is essential to make a detailed survey of learner-needs, their academic background, present and future potentialities and plans of different industries, government policies and the like. Different approaches as discussed below may be adopted for identifying and implementing courses for different levels of target groups.

IDENTIFYING MICROBIAL TECHNOLOGY COURSES — SOME APPROACHES

In the open distance learning system one can follow different approaches to suit/solve a particular objective/problem. The development of a programme/course is generally more on scientific and industrial lines. This scientific approach ensures more defined work procedures and methodologies and a learning system more able to adapt itself to the changing and specific requirements of a heterogeneous group of learners.

One of the approaches to meet the demands/needs of a large and heterogeneous group of learners is to regard the general public as a collectivity of a number of specific target groups, and accordingly aim information at them individually, tailoring the material in suitable ways. This approach may be highly useful where a broad based knowledge of microbiology is not needed and/or when a specific input of knowledge is needed. For example, in any industry there are different levels of working personnel coming from different backgrounds. Different personnel — supervisors, works managers, shift engineers — need different inputs. Each category needs only a certain portion of the microbial technology know-how in a more detailed way. Hence in each case, the knowledge level will be very well defined. A subject specific approach may be adopted when the knowledge in a particular area is needed the most. This may be more useful for higher level learning.

When a large populace needs a broad based knowledge of microbial technology, a general awareness approach may be followed. As this is particularly useful to industries, this may be called the industrial approach. In a field like microbial technology which has applications in a range of industries, this approach will be highly beneficial.Many of the basics, various techniques, implications of a given development(s) to a company's future plans etc., should be known in varying degrees to different personnel, from top management (policy makers) to lower level managers and supervisors, at least in a general way. This approach must succeed in fulfilling the needs of a large variety of target groups through a single general programme. For example, UK Open University has successfully launched a biotechnology programme largely organised from an industrial perspective.

Modular approach is another important approach useful when the interests and needs of a given group are widely varied. Microbial technology is interdisciplinary in nature and capable of creating multi-dimensional impact on the society and economy, hence education in this area is needed by a wide array of people coming from different backgrounds, whose interests and needs may vary greatly. Besides giving a general awareness course, if we can categorise various levels of microbial technology education in line with industrial requirements, we may be able to practise more flexibility in catering to the immediate needs of the learners. This approach will also enable the learner to accumulate the credits from other courses s/he has studied over a period of time and aim for higher level degrees and/or certificates.

CONCLUSION

While knowledge and population explosion in general demands a radically new approach to imparting education in science and technology, high industrialisation and the multi-dimensional nature of microbial technology, with its far reaching impact on societal development, demands a constant interaction between scientists, academics and industries and between industries and society. This type of constant interaction between the different sections connected with developments in microbial technology is possible only through a flexible and accommodating education system which does not suffer from the constraints of place and time. Further, the system should be able to incorporate different approaches that may be necessary to meet the needs of people requiring different levels of knowledge. Open University system, which has increased flexibility, high productivity and the ability to respond more readily to market demands (Kulandai Swamy, 1992), may be a more suitable approach for a fast developing and industrially potential field like microbial technology.

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