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INDIA

Technical Report

Mission 15-28 March, 1986

Prepared for the Government of the Republic of India
by the United Nations Industrial Development Organization,
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Based on the work of Edwin Lightfoot,

Consultant on Biotechnology

United Nations Industrial Development Organization

Vienna

ABSTRACT

A two-week visit to the National Chemical Laboratory, Pune, India, was devoted to discussions with staff scientists and formal seminars, with the purpose of identifying promising avenues of research in biotechnology.

It became clear early in the mission that this laboratory has developed into a highly effective research organization and has largely outgrown the limited possibilities of the cellulose-sucrose-ethanol project providing specific impetus for this assignment.

Discussions therefore centered on plans for exploiting the promising possibilities just opening up in biotechnology and in the supporting biological sciences.

The formal seminars were devoted to quantitative modelling of life processes and to the development of separation processes needed for commercializing biotechnology.

Short visits were also made to neighbouring institutions, in part to determine the professional environment of the laboratory.

A schedule of significant activities is attached.

INTRODUCTION

The National Chemical Laboratory at Pune is a high-quality multi-disciplinary research centre which, in addition to microbiology and biochemical engineering, has impressive strength in the basic chemical and biological sciences and in chemical engineering. It is also active in some of the newest and most promising aspects of biotechnology, for example plant tissue culture and overproduction of biologically active proteins.

The staff members with whom I interacted would be highly regarded in any laboratory or university with which I am acquainted, and their research is definitely of world class. They are typically personally acquainted with leading researchers in their fields, in the US and elsewhere, and the facilities available to them here are quite good. Their most pressing professional problem appears to be the relatively small number of similar high-quality institutions in India. This leads to some professional isolation and lack of balance : gaps in expertise, inevitable in all research centers, are not so easily filled by interactions outside NCL. Conversely I find that the conditions here are more conducive to reflection, and hence to greater depth of intellectual effort, than in the US.

NCL is situated near the largest concentration of the Indian chemical industry, in and near Bombay, in proximity to the "Bombay High" oil and gas fields. This chemical industry is vigorous and is based on reserves of moderately priced oil and gas sufficient at least for the rest of this century.

Under these circumstances the glucose project is something of an anachronism. Cellulose is not a promising fermentation substrate, and ethanol is an expensive chemical feedstock. The staff of the center is fully aware of this situation, and they were in the process of reformulating their goals when I arrived.

The glucose project has, however, been highly productive and has made important contributions to the scholarly literature. Their work on xylanases is very promising from an ecomic point of view, their immobilization of enzymes on polyvinyl alcohol is both imaginative and practical, and they have developed good working relationships with each other and many useful skills.

The related work on etnanol from molasses is highly developed at the level of fermentation biochemistry, and it is economically attractive. It is time for intimate cooperation with chemical engineers on reactor design and separations.

The chemical engineering division has moreover developed a strength in reaction engineering and separations which provides an attractive base for expansion into both ethanol production and more modern areas of biotechnology.

SUMMARY OF MISSION ACTIVITIES

After a brief orientation meeting with Dr. L.K. Doraiswamy, Director, and selected division heads, I began extensive informal discussions and a series of formal seminars. These were all pleasant and rewarding experiences, and I found them personally quite beneficial. I also visited Hindustan Antibiotics, the National Defence Academy and both the I.I.T. and U.D.C.T. in Bombay.

The discussions here at NCL led to a commonality of views which I summarize as recommendations below. These latter are mine in the sense of expressing my own perceptions, but they were arrived at jointly.

It was quickly apparent that the seminars should exceed the narrow frame of the glucose project and that they should be aimed at the cutting edge of biological and separations technology. This was a welcome development and a challenge. The effort expended to meet this challenge sharpened my own perspective, and I return home better prepared for my own research.

The first two seminars were intended to explore the goals of biological modelling, to relate these to major social concerns, and to discuss the critical problems of modelling strategy. The framework was that of higher animals, but micro-organisms were also discussed, and parallels with intracellular mammalian metabolism were emphasized.

These were followed by a three-part series on separations, emphasizing respectively the

(1) *Structure and organization of separations as a coherent discipline*

(2) *Development of a developmental strategy for processes of importance in biotechnology, and*

(3) *Scale-up and design of separation equipment*

Emphasis was given to situations likely to arise in biotechnology.

Visits were also made to Hindustan Antibiotics in Pune and to both U.D.C.T. and I.I.T. in Bombay. Seminars were given at each of these institutions, and interaction with the professional staffs was both substantial and useful.

RECOMMENDATIONS

As the quality of this laboratory continues to increase, emphasis of the UNIDO support programme should change. The primary concerns now should be to consolidate gains made in recent years and to use the chemical engineering division both as a base to promote nationwide excellence in chemical engineering and to support key associated technologies. These efforts will require provision of external contacts, needed to make up for the gaps and lack of balance inevitable in any isolated institution. Such contacts are best achieved by fostering ***professionally significant*** *leaves abroad for a few key people best able to profit from them.*

The chemical engineering division is now comparable to the best institutions anywhere, but this success is still fragile. It is particularly important to note that the prime mover behind this development, Dr. L.K. Doraiswamy, will have to retire soon, probably within three to five years. His loss will affect the whole laboratory, but it will be particularly severe for chemical engineering. It is therefore desirable both to recruit within the chemical engineering division and to strengthen the existing staff. Important to the latter of these goals is obtaining significant external professional experience for the most promising younger people. Short

tours are no substitute for deep collaborative research efforts, or for formal training in key disciplines not well developed here. Moreover, in these days of tight educational budgets overseas, it is neither fair nor realistic to expect host institutions to finance training activities.

With the many demands of a vigorous but still immature Indian chemical industry it is particularly important that younger staff learn to relate theory and practice in key emerging technologies.

The glucose project has been highly effective, producing significant results and developing skills and awareness in biotechnology. It is, however, now time to build on the experience gained and to concentrate on projects of maximum probable impact on Indian technology. Some results of the glucose project, for example xylanase production and novel immobilization techniques, are immediately useful. These should be further developed in cooperation with the chemical engineering division. It is, however, also time to develop staff skills in key aspects of genetic engineering.

Existing large-scale fermentation processes, such as antibiotic manufacture, are of major present importance and in need of modernization. Efforts in conventional biotechnology should emphasize increasing the competitiveness of these vital and commercially important industries. Work on EtOH production from molasses has been highly effective, and it is time for chemical engineering development. Reactor design for efficient large-scale operation is not yet complete, and important separations problems remain. Ion exclusion may prove useful for removing salt and fine particulates from molasses. Use of grid trays instead of bubble caps in alcohol rectification may prove desirable.

Longer-range research efforts should reflect the high level of competence of leading NCL staff and should be directed towards the most promising technologies. In biotechnology these derive from recent advances in biochemistry, genetics and associated disciplines, and they include diagnostics, new medicinals, mass culture of plant and animal cells, and a whole spectrum of tissue growth between individual cells and conventional agriculture. NCL scientists are doing excellent work in many of these fields already, and their efforts in these areas should be vigorously encouraged.

The good people here are already well acquainted with their professional counterparts elsewhere, but opportunities for effective interdisciplinary research are less well developed. It is therefore important to provide relatively long-term external activities of this latter sort.

Above all it is important to consolidate the impressive gains made in this laboratory in recent years and to help it prepare for major challenges ahead.

The Indian chemical industry is rapidly maturing, and it is time to prepare it to stand on its own feet in the world market. This will require major rebuilding of many existing plants and moving into the most advanced technology.

The full resources of NCL will be needed for these purposes.

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PROGRAMME OF PROFESSOR EDWIN N. LIGHTFOOT

UNIVERSITY OF WISCONSIN
MADISON, WISCONSIN, USA

Date	Day	Programme
19 MARCH - 4 APRIL 1986		
19 March (FN)	Wednesday	Arrival Pune
(AN)		Visit to NCL; Preliminary Discussions with LKD, RAM
		Preliminary Discussions with LKD, RAM and JB
20 March	Thursday	Discussions with JB, RAM and bio-group
		Seminar I: "The Proper Study Of Mankind Is Man Even For Engineers"
21 March	Friday	Discussions with NCL scientists
22 March	Saturday	Discussions and dinner with LKD
23 March	Sunday	Pune sightseeing with LKD and BDK
		Lunch at Blue Diamond
24 Marc (FN)	Monday	Seminar II: "Biological Modelling Strategy"
(AN)		Visit to Hindustan Antibiotics Ltd., Pimpri, Pune
		Seminar on recovery of pharmaceuticals
25 March (FN)	Tuesday	Seminar III: "Structural View of Separation Processes"
(AN)		General lecture under the auspices of Technology Forum, Pune - "Recovery From Dilute Solutions"
		Dinner in honour of Professor Lightfoot (Director's residence)
26 March	Wednesday	Public Holiday; Pune sightseeing and rest
27 March	Thursday	Free
28 March	Friday	Free
29 March	Saturday	Discussions and dinner with CRE group
30 March	Sunday	Pune sightseeing and informal discussions
31 March	Monday	Seminar IV: "Operating Characteristics Of Process Equipments"
1 April	Tuesday	Discussions with NCL scientists
2 April	Wednesday	Discussions with Dr. L. K. Doraiswamy
3 April	Thursday	Visit to UDCT, Bombay
		Seminar: "Recovery From Dilute Solutions"
4 April (Early Morning)	Friday	Visit to IIT Bombay; Seminar: "Structure Of Separation Processes"
5 April (Early Morning)	Saturday	Departure for USA