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International experience in human resource development in biotechnology: achievements and lessons learnt

Tatsuji Seki
International Center for Biotechnology (ICBiotech)
Osaka University
Osaka, Japan
E-mail: seki@icb.osaka-u.ac.jp

Toshiomi Yoshida
JSPS Bangkok Liaison Office
113 TWY Office Center
10th Fl., Serm-mit Tower
159 Sukhumwit Soi 21
Bangkok, 10110, Thailand
E-mail: yoshida@icb.osaka-uac.jp

Takuya Nihira
ICBiotech
Osaka University
Osaka, Japan
E-mail: nihira@icb.osaka-u.ac.jp

Edgar DaSilva
Visiting Professor,
ICBiotech,
Osaka University
Osaka, Japan
E-mail: e.dasilva@wanadoo.fr

Biotechnology is an important and emerging field but is largely interdisciplinary in nature. Biotechnology is an academic field that is rich in applications relating to the use of agricultural resources and residues that occur naturally and abundantly as assets of economic significance in virtually all Asian countries.

The UNESCO International Postgraduate University Course in Microbiology designed and held in Japan, in fulfilment of the recommendations adopted at a UNESCO General Conference, in Paris, France, has been conducted over a 30-year period for the purposes of stimulating academic investment in the concepts and project applications of microbiology for national development and regional cooperation. Training is oriented towards developing a spirit of scientific enquiry, education and research in the Asian region and is provided throughout a twelve-month period.

Microbiology occupies a strategic position in many Asian developing countries with agrarian-based economies. The emergence of novel bio-industries provides further economic inputs that help sustain technical advancement and economic progress. In this article, we are trying to look into one of the major area of biotechnology that is the microbiology. Internal and external teams of top-level national and foreign experts have evaluated the activities of the course. Achievements and lessons learnt are described.

*Corresponding author

BACKGROUND

The Government of Japan submitted a resolution to the 12th session of General Conference of UNESCO to initiate in the biennium 1963/1964 a programme promoting research in microbiology for the benefit of humankind. Acceptance of the Japanese resolution in 1963 by UNESCO's Member States acknowledged the necessity of domesticating and harnessing the resource of microorganisms for the benefit of all countries. Furthermore, it led to the beginning and to the establishment of a programme of long-term international training courses (Table 1) amongst which the long-term UNESCO International Postgraduate University Course in Microbiology features as an integral component of capacity-building activities in developing countries by UNESCO's Natural Sciences Sector.

In 1972 in close association with the International Fermentation Symposium that was held in Kyoto, twelve trainees underwent intensive training in fermentation technology in a two-month course. The success of this activity generated an attraction and enthusiasm in researchers from the developing countries to the potential

Table 1. International post-graduate courses launched by the recommendation of UNESCO.

Location	Scientific Field
Australia	Soil Science
Belgium	Soil Biology
Czechoslovakia*	Biology
France	Tropical Botany
Germany	Applied Entomology
Hungary	Statistics
Japan	Microbiology** Chemistry/Chemical Engineering
Netherlands	Water Engineering
Romania	Petroleum Geology
Spain	Electronics for Bioreactor
Sweden	Physiology

*now the Republic of Slovakia

**Establishment of Microbiology Course with the participation of Osaka, Tohoku, Tokyo, Kyoto and Kyushu universities

of tapping the microbial labour force for technical advancement; and, to the possibility of instituting a longer period of training in Japan in microbiology. Thus, the *raison d'être* for the organization of the first 12 month course in 1973 by the then Department of Fermentation Technology, now the Department of Biotechnology, for the provision and dissemination of scientific knowledge and technical skills was established.

In 1978 the course was administered and managed by the newly established International Centre of Cooperative Research and Development in Microbial Engineering (ICME) at the Faculty of Engineering, Osaka University. In recognition of the wide acceptance and success of ICME's activities and achievements since its year of inception, ICME began a new period of national, regional and international linkages, in 1995, as an independent institute in Osaka University with a new identity *i.e.* the International Centre for Biotechnology (ICBiotech) with a mission to pursue academic advancement and collaborative research in biotechnology. After the establishment of ICME, the international course has been under the management of both the Department of Biotechnology and of ICBiotech.

Since 1973 eminent Japanese scientists as course Directorswith other Japanese colleagues and universities inspired the development and evolution of the program outline of lectures and experimental work throughout the 30 year life period of the course. Their professional commitment and high academic standards have contributed to the fulfilment of the mission statement of the Course. Furthermore, they have helped in shaping the scientific advancement and formation of biotech careers of over 400 of Asian young men and women coming from some sixteen countries.

INSTITUTIONAL ARRANGEMENTS

For the past three decades the course has been organized by Osaka University with the support of the Ministry of Education, Sports, Culture, Science and Technology (*Monbukagakusho*) made through the Japanese National Commission for UNESCO and the four cooperating universities of Tohoku University, Tokyo, Kyoto University and Kyushu. This institutional arrangement involving four active collaborating universities is unique and has been recognized worldwide as a distinctive feature that makes the course as a regional and international

Table 2. Proposed research themes offered at the 5 participating universities.

University	Research themes	Host research laboratory (-ies)
Osaka	Environment organisms Probiotic bacteria Functional genomics in yeast Yeast lipid biotechnology Chromosome engineering in yeast Enzyme engineering Production of useful biomaterials by cyanobacteria and plant biotechnology Biochemical engineering for fermentation processes Application of mixed cultures in food production Ecosystem engineering Visual detection of specific genes on DNA and chromosomes Protemome analysis and related studies Development of new techniques in transformation Biomolecular engineering Microbiology of oil assimilating bacteria Microbial utilization of renewable resources Computer-aided control of bioprocesses Cell culture engineering Plant taxonomy Microbial taxonomy by DNA and RNA similarity Genetic and biochemical studies of biomembranes Molecular biology of mammalian gene expression and organellebiogenesis	ICBiotech, Graduate School of Engineering
Tohoku	Gene cloning of useful enzymes from microorganisms Structure and function of polyamine in anaerobes Molecular biology of oxygen tolerance in lactic acid bacteria Genetics and ecology of rhizobia Nitrogen-fixing bacteria in gramineous plants Metabolic engineering of microbes for overproduction of	Graduate School of Agricultural Science

	amino acids Molecular biology of glutamic bacteria	
Tokyo	Regulation of secondary metabolisms and morphogenesis of *Streptomyces* Application of microbial abilities for the solution of environmental problems Molecular biology of *Aspergillus* Protein production by *A. oryzae*	Graduate School of Agriculture and Life Sciences
Kyoto	Microbial enzymes, mainly glycosidases, and their genes Microbial and enzymatic production of biologically and chemically useful compounds Screening, biochemistry and molecular biology of new microbial enzymes Extreme environmental microbiology Thermostable enzymes of hyperthermophiles Protein engineering Development and application of cold active enzymes from cold adapted microorganisms Enzymology of microbial enzymes	Graduate School of, Engineering, Graduate School of Biostudies
Kyushu	Biotechnology of Pseudomonads Biotechnology and genetics of saccharolytic clostridia Diversified utilization of renewable resources Bioprocess control for anaerobic fermentation Biochemistry, genetics and fermentation of bacteriocins of lactic acid bacteria	Graduate School of Agriculture

Source: National Commission for the Development of Biotechnology, Chile

ñ: For year 2000 the values were estimated.

a: Biotechnology company: a company that uses modern biological technologies (e.g. recombinant DNA, biochips, cell culture technology, tissue engineering, bioinformatics, genomics, proteomics, etc) to fabricate commercial products and/or provide services.

b: Employees: persons hired for a wage or fixed payment in exchange for personal services. Full-time equivalent identification has not been considered.

c: Revenue: total payment from sales of goods and services, minus the cost associated with returned or undeliverable merchandise.

contributor to biotech research, and to the development of young careers in Asia and elsewhere.

The sponsors of the course have been the Japanese Government, UNESCO and the International Cell Research Organization (ICRO). Cooperating organizations morally supporting the course are The Society for Bioscience and Bioengineering; the Japan Society of Bioscience, Biotechnology and Agro-chemistry, and the International Committee on Economic and Applied Microbiology/

Table 3. Selection of participants per region.

Region	Countries	No. of Participants
East Asia	China, Korea*, Mongolia	5-6
Southeast Asia	Cambodia, Indonesia, Laos, Malaysia, Maldives, Myanmar, Philippines, Thailand, Vietnam	8-9
Central, South and West Asia	Afghanistan, Bangladesh, Bahrain, Bhutan, India, Iran, Nepal, Pakistan, Sri Lanka	1-2

*refers to the Republic of Korea

International Union of Microbiological Societies (IUMS).

No financial support to the course is provided either by ICRO or any of the cooperating organizations.

ISSUES COVERED IN DIFFERENT PROGRAMMES

The course program begins with a two-month introductory phase in Osaka University. In this pre-research phase and following interview and assessment tests participants are provided with back-up lectures and laboratory training prior to a 10 month course engagement of each participant at an assigned laboratory for purposes of gaining in-depth knowledge and skills in the use of advanced research techniques through the conducting a research project by the participant.

The lecture component is comprised of fundamental, advanced and specialized lectures and seminars accompanied by laboratory experiments that help participants refresh or update their laboratory skills prior to their assignment to the participating universities. The total duration of the course is of one-year from October to September of the next calendar year.

The proposed research themes in the courses offered to the participants for conducting a 10 month research project at an assigned laboratory are summarized in the Table 2. Conducting of a research project is obligatory since it allows the candidate to gain an in-depth knowledge of the subject matter and to gain confidence and skills in learning and using advanced research techniques.

COOPERATION AMONG ASIAN COUNTRIES

The administration and organizational implementation of the UNESCO International Postgraduate University Course in Microbiology are with the International Center for Biotechnology (ICBiotech) which, with other Japanese academic institutions is dedicated to the improvement of international cooperation amongst Asian countries. Committed to industrial biotechnology studies involving microbial engineering and the related sciences for purposes of maximizing the applications of the sustainable utilization of abundant natural resources in Southeast Asian countries, ICBiotech, in addition, provides the required backstopping infrastructure necessary for the smooth functioning of the course program. The course ---its work plan, life, and other ancillary activities such as study tours and scientific visits to research and technical institutes enjoying national and worldwide recognition were overseen by a Steering committee chaired by the President of Osaka University who was responsible for the course.

The Steering Committee, comprised of the Secretary-General of the Japanese National Commission for UNESCO, eight professors from Tohoku (1), Tokyo (1), Kyoto (2), Kyushu (2) and Osaka (2) universities, and the Director of the Administrative Bureau of Osaka University, decided the final slate of course participants. The physical involvement of such high-ranking officials and academic staff illustrates the degree of professional commitment and time that guarantee the high quality of the course in capacity building in Asia. The timetable of the application process and the comprehensive and necessary information to be submitted by the applicants are mentioned in the Annex 1 and Annex 2.

Applications made by recommendation or in a private capacity are not accepted. The selection of participants consists of two steps: (1) preliminary screening and (2) selection at the steering committee meeting. Items shown in Annex 2 are screened during the first step and recorded with details on the origin of the applicants' countries and regions (Table 3). Preliminary screening is done by three to four professors of ICBiotech and of the Department of Biotechnology, Graduate School of Engineering, Osaka University. The number of candidates selected in the first screening is approximately twice that of the participants which meet the required levels of qualification. Prior to final selection during the Steering Committee Meeting, comments and/or guideline views of accepting Japanese professor(s) are taken into consideration at the preliminary

Table 4. UNESCO Support towards the Course.

Years	Amount (USD)
1974/1975---- 1984/1985 From UNESCO Headquarters (Paris)	Average US $10,000
1985/1986 ----1989/1990 From UNESCO Headquarters (Paris)	Average US$3,000
1990/1991 ----1996/1997	Suspension of support
1997/1998 ----1991/2000 From UNESCO Headquarters (Paris)	Average US$5,000
2000/2001 ----2001/2002 UNESCO Jakarta Office	US$7,000
2003 UNESCO Jakarta Office	US$4,700

selection in some cases. When necessary, the health certificates of applicants are checked at the Health Centre of Osaka University.

The items considered for each applicant in the preliminary screening are based on several criteria such as academic records of undergraduate and graduate courses; record of research achievement after university graduation; record of publications; field of research preference during the course; language proficiency; recommendation letters and prospective view after the course. Where relevant, the views of the laboratory hosting a successful assigned applicant may be taken into consideration. The number of candidates meeting the course qualifications is about 2 fold for consideration at the final selection meeting. The number of participants considered is limited by the restrictions of the available budget. The health certificates of candidates successful in the first screening are checked again by doctors at the Health Administration Centre of Osaka University.

BUDGETARY ASPECTS

The course is financed mainly by an annual budgetary allocation of US $350,000 from the Government of Japan made available through the Japanese National Commission of UNESCO in the Ministry of Education, Science, Sports, Culture and Technology. Details concerning internal budgetary allocations and considerations between the Japanese National Commission for UNESCO and Osaka University have been reviewed by the internal and external evaluation teams, and are outside the scope of this present article. For nearly a decade, UNESCO provided significant support that was suspended in 1990 as a result of financial constraints. In 1997 UNESCO (Paris office) resumed providing support with a much lower amount. Since 2001, UNESCO support has been made through the UNESCO Jakarta Office and Regional Bureau for Science (Table 4).

In 1998 as a consequence of a cutback in the ODA budget, the number of participants was reduced to seven. In the following year, the total number of participants was restored to 14. A year later, though the fellowship amount was adjusted to the same level as that for a Monbukagakusho fellowship, the provision of scholarships, and course implementation was carried out as before. In 2002, governmental support to the course was reduced in accordance with the cutback of the ODA budget. The shortfall in financial resources was met with by Osaka University. In 1993, the 20th anniversary of the course --- a remarkable milestone in itself was feted in Osaka University through a commemorative ceremony and a technical symposium.

EVALUATION AND RESULTS

An in-depth evaluation of this 30 year old activity was organized notwithstanding the annual assessments done following the conclusion of each course held since its inception in 1973. Additional reasons for this wide-ranging evaluation exercise were the increasing financial constraints resulting from economic climate of recession, and the

Table 5. Course activities graded by the internal and external evaluators and diplomatic personnel.

Grades of Evaluation		
Item 1.Program outline, implementation and Process*	Internal	External
Application and selection methods		
1. Method of application	A	A6**
2. Method of selection	A	A3; B3
Program outline		
1. Content of Program (inclusive of Lectures)	B	A4; B2
2. Laboratory Experiments	A	A5; B1
3. Study Tours	A	A5; B1
4. Research Training	A	A6
5. Research presentations	A	A5; B1
6. Accommodation	B	A1; B 4;C1
Item 2. Trainee performance and career potential of graduates* **		
1. Activity of graduates in their home countries	A	A5; B1
2. Graduates in international collaboration	A	A6
3. Overall Evaluation of the courses		
a) Course requirement	A	A6
b) Course effectiveness	A	A5; B1
c) Course usefulness	A	A6
Overview Evaluation		
Overview Evaluationby diplomats in Osaka representing the participants' countries of origin and External Evaluation Team	A	A6

*A: more than sufficient contribution for the purpose; B= good; C=average; D=low; E=none.

**Figure indicates the number of views expressed.

***A: More than sufficient activity by graduates; B=good; C =average; D=low; E=none.

constantly evolving science of biotechnology. Moreover, the evaluation coincided with the temporary closure of the course for 2003 resulting from the nation-wide review of the Japanese university education system and the possibility of cessation of governmental funding. Hence, the evaluation provided an opportunity to consider a newly-

resumed course with wider adaptation of course programs to reflect current biotech developments and future trends, and bio-societal issues such as biosafety and intellectual property rights.

The evaluation exercise involved internal and external exercises. The internal evaluation was conducted by an 8 member team of professors from each of the five participating universities (with four representatives from Osaka University and one each from Tohoku, Tokyo, Kyoto and Kyushu universities). The external evaluation was fortunate to have three highly acknowledged external Japanese evaluators and three foreign experts possessing wide experiences in international cooperation dealing especially with science education in a 6 member team comprised of distinguished scientists coming from Japan, the Philippines, Thailand, and the USA.

The meeting of internal and external teams was held separately under the Chairmanship of the Director of ICBiotech using data collected and surveys made on course alumni by ICBiotech staff. The evaluation teams examined the following: application and selection methods; the timetable of application and selection; documents required for application; necessary information required by the applicants; course programme; accommodation; medical care; pledge; etc.; graduated participants' performance reports; evaluation by graduated participants; evaluation by academics in the participants' countries of origin.

The inputs from evaluation by diplomats in Osaka representing the participants' countries of origin were also invited.

There is virtual unanimity in the results of the evaluation by the internal and external evaluators respectively as well as in that of the overview evaluation made by the consuls in Osaka representing the participants' countries of origin (Table 5).

Notwithstanding the resulting unanimity in the evaluation, several suggestions and viewpoints were expressed for consideration in framing the future perspectives of the new course. Policies concerning non-acceptance of private applications and recommendations, of the documents to be submitted by applicants, and of the timetables of application and selection were endorsed.

Since existence of the course from 1973, a total of 2831 applications from Asian countries were received with an average of 94 per year throughout the 30-year period. This resulted from dissemination and distribution to 343 locations involving UNESCO headquarters in Paris, France, eight UNESCO Regional offices in Cambodia, China, Bangladesh, India, Indonesia, Nepal, Pakistan and Thailand, 16 cooperating National Commissions for UNESCO (Cambodia, China, Bangladesh, India, Indonesia, Laos, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, the Philippines, the Republic of Korea, Sri Lanka, Thailand and Vietnam) from amongst the 23 National Commissions in Asia, and 318 universities and academic research institutions in Asia. Despite this widespread dissemination and that on the ICBiotech and Osaka University web-sites, concern in the evaluation has been expressed that there were still many countries in Asia that were unaware of the existence of the course and the many benefits it provides in the teaching of microbiology for development. A wider distribution via Internet was recommended as the approach to UNESCO alone was found to be insufficient. Moreover, there seemed to be a lack of appreciation by UNESCO headquarters of the course and of the annual contribution made by the Japanese government.

Final selection by the Steering Committee took into account a recheck of the health certificates; and, the differing levels of graduate education amongst and in the countries of origin of the participants. Moreover, greater weight age in consideration is given to academic records rather to accompanying letters of recommendation. On occasion the Steering committee exercised its discretion in giving favourable consideration to candidates from late developing countries like Cambodia, Laos and Myanmar. However, the trainees themselves have pointed out that they stand to suffer as beneficiaries of such well-meaning considerations as they come face-to-face with their own lack of knowledge and inexperience in following lectures and in conducting experimental work involving use of sophisticated laboratory equipment and protocols. There is an increase in the number of applications from these countries which are adopting national policies favouring advanced science education for their young scientists. As a follow-up of these observations, the use of Internet is being planned to reinforce objectivity in selection; and, to reduce the heavy burden of assessment placed on Japanese university staff during the preliminary screening stage. A decrease in applications from the advanced developing countries such as Malaysia and the Republic of Korea was noticed and probably results from the numerous opportunities for training and from the availability of large pools of well-trained staff and Ph Ds' in these countries.

Other components of the programme outline ---study tours, laboratory experiments, research training and research presentations were highly appreciated and received with enthusiasm by all participants with the hope that time allocations for research training and experimental work, and budgetary resources for study tours, be increased. Some dissatisfaction relating to the lecture component can be ascribed to the differing levels of ability to understand the more advanced and specialized lectures. The external evaluators pay tribute to and emphasize the devoted commitment and enthusiasm of the Japanese professors who give willingly of their time and resources; and recommend the inclusion of cross-cutting themes such as bio-safety and intellectual property rights.

In general, assistance and facilities provided for accommodation were appreciated though actual living

Table 6. Origin of selected participants (1973-2002).

Countries	1973-77	1978-82	1983-87	1988-92	1993-97	1998 -2000	Total
West and South Asia							
Afghanistan	1	0	0	0	0	0	1
Bangladesh	5	4	3	3	3	4	22
India	14	9	5	2	1	1	32
Nepal	0	1	0	0	0	0	1
Pakistan	2	0	0	0	1	2	5
Sri Lanka	3	1	1	0	0	0	5
Southeast Asia							
Cambodia	1	0	0	0	1	2	4
Indonesia	7	8	6	8	6	5	40
Malaysia	1	2	2	1	2	1	9
Myanmar	0	0	1	0	0	2	3
Philippines	8	9	14	12	11	7	61
Singapore	1	2	1	0	0	0	4
Thailand	12	14	9	13	9	11	68
Vietnam	0	0	2	2	9	9	22
East Asia							
China	13	11	12	10	3	4	53
Rep. of Korea	1	8	14	19	22	11	75
Mongolia	0	0	0	0	2	4	6
Total	69	69	70	70	70	63	411

conditions may have had a bearing on the evaluation made by the participants. Also, there is general agreement that teaching staff be spared the burden of attending to accommodation problems and that participants and international sponsors take note that the accommodation provided for the course participants and those scholars on Japanese government fellowships is of the same uniform standard. There are no differences for the two categories of students.

ROLE OF JAPAN IN REST OF ASIA

The external evaluation team without hesitation recognizes the significant contribution made by Japan towards the technological development of the region of Southeast Asia through the judicious use of microbial technologies. Their unanimity is embedded in the agreement that the course should not be terminated. The Consuls of the Thailand,

Indonesia and Vietnam possess a better knowledge of the course activity by virtue of their participation in previous opening and closing ceremonies of the course. All Consuls expressed their individual satisfaction with the course and promised to approach the UNESCO National Commissions in their countries. An interesting outcome was the proposal to obtain additional financial resources from the private sector. As this course has been highly evaluated in their countries (Cambodia; Indonesia; Mongolia; Thailand; and Vietnam) a suggestion to expand the course from microbiology to other biotechnology fields was made. Also efforts need to develop various projects that increase sharply the visibility of Japan's international contribution. This aspect cannot be achieved by the course alone even though the continuity of the course is an essential factor in this aspect

A questionnaire sent to high officials in main universities of Bangladesh, Indonesia, Malaysia, Philippines and Thailand. elicited the following pertinent remarks:

· Young scientists from developing countries e.g. Mongolia: found the course to be very useful and wished its non-termination since the course provides opportunities to:

a) Acquire the theory and use of high-grade equipment that is not easily available in their home countries.

b) Expand their fields of scientific research in microbiology and opportunities for career development.

c) Engage in international technical and cultural exchanges.

d) Enrich the participants' understanding of Japanese science and culture.

· Techniques learnt can be adapted for use by the participants' on return mindful of existing conditions in their home countries. Since participants were often frustrated by not having equipment, chemical reagents and high-level technical resources to which they had been exposed in Japanese laboratories for use on return their home countries. This latter fact needs further attention.

· Emerging fields such as bioinformatics, bioprocess technology, gene cloning, biopharmaceuticals, monoclonal antibodies and vaccine production technology should be further highlighted in the course.

· The international postgraduate university course in microbiology has been found to be a suitable spin-off resource in functioning as a human network of course graduates that helps in finding solutions to their requirements in some of the late developing countries concerning constraints relating to existing research facilities.

· The annual successes of the UNESCO courses added further to the well-known worldwide reputation of Osaka University in international cooperation. Hence, there is a need for the continuation of the course to address the growing (academic) population in microbiology and biotechnology of Asian developing countries, and to expand the current number of participants from 14 to 28.

· Fundamental, advanced and specialized lectures should cover: molecular biology, chemistry and bioprocess engineering; metabolic engineering and other fields of Biotechnology such as plant and animal science/engineering; animal cell culture and medical biotechnology.

ACHIEVEMENTS AND COURSE OUTPUTS

In Asia opportunities for career development in the academic world are rather limited with preference being accorded to hierarchical status and seniority rather than to meritorious capacity and ability. The survey that had a response rate of 57% was carried out amongst the 411 participants from 17 countries (Table 6) in the 30 courses held during the period 1973 – 2002.On a regional basis, the course alumni contacted was as: East Asia: 134, West and South Asia: 66; and Southeast Asia: 211. The composition of the survey respondents totalling 235 is as: 194 from the academic sector (universities and research institutions); 41 from the private sector (alumni having moved from their universities) and the domestic sector (housewives).

It is evident that the selected participants look upon the course as a "once-in-a-lifetime opportunity" to advance their academic careers and contribution to science education in their home countries. This conclusion is borne out the inputs made by the survey respondents several of whom are contributing to institutional governance and administration (Table 7).

The data on a stand alone basis shows that the course has made a positive contribution to the career development of its graduates and to the advancement of science education in their home countries through the prestigious administrative positions held in the framing of science policy and decision-making. Table 8 provides data on the number of publications authored by course alumni. This output emerged from the research activities of course alumni was a rewarding and unexpected surprise to the course management personnel and Japanese professors.

These survey results and post-course outputs came as an unexpected bonus to the course management, and to the professors and administrative staff of the five participating universities. Whilst constituting an indisputable fact that the research activities of the course have had a significant input in this development, it was on the other hand a matter of great satisfaction, pride and reward and to the host professors of the five participating universities to see their inputs and efforts having borne in the post-course careers and work of their students.

Table 7.Present academic position of graduated course participants.

Professorships and Academic Positions achieved by graduates		University Administrative positions in institutional governance	
Position	**Number**	**Position**	**Number**
Professor	47	President	4
Associate Professor	53	Vice-President	5
Assistant Professor	20	Faculty Deans, Directors	19
Lecturers	40	Deputy Deans	15
Research Associate	34	Heads, Chiefs of Section	15
		Associate Head	4
Total	194	Total	56

Generally-speaking all participants (100%) found the course activity and utility to be excellent. These positive responses indicate that the purpose of the course had been achieved satisfactorily. More than 95% of the participants found the course to provide a solid basis in scientific education and research work back in their own institutions. And though 75% found the course to be beneficial in the development and advancement of their careers, 25% were of the view that it had no impact in furthering either their managerial or academic careers. In the latter case, this may be ascribed to the fact that training provides leads to a diploma and not to a Ph.D. degree as many course participants in successive courses so desire. This desire that this course be recognized for the Ph.D. is another indication of the high quality of the research training and the lectures provided. However, on an overall basis, it is clear that the course has been catalytic to help course graduates to obtain their PhD degree back in their home countries and to engage in international cooperation as key resource persons making significant research contributions through:

I. The Japan Society for Promotion of Science Core University Program for Southeast Asian countries functions out of Osaka that coordinates the entire activity the outputs of which are:"

· A bilateral project on Microbial Technology in Agro-industries between Thailand and Japan (1978—1982).

· Bilateral programs in Biotechnology between:

(1) Japan and Philippines (1985–1994).

(2) Japan and Singapore (1985–1994).

(3) Japan and Thailand (1985–1994).

In these programmes the course participants joined the activities such as collaborative multilateral research projects in the field of biotechnology in which the participants joined the activities as key resource persons to form a close network of trained resources in course alumni that contributed to the advancement of science education in the Department of Microbiology, Faculty of Science, Kasetsart University, Thailand; Faculty of Agricultural Technology, Gadjah Mada Univeristy, Indonesia, and BIOTECH, University of the Philippines, Philippines. This network provides a human face to the follow-up work of the UNESCO postgraduate course that guarantees the international character of the research projects and that illustrates the stance of Japan with Southeast Asian countries.

II. In the Asian Microbiology Network Program by the Japanese Science Technology Agency, (STA)

III. The Culture Collection Program in the Bioresources Center (BRC) started in 2002 by the Ministry of Economy and Industry (METI) with activities in culture collection research and the gene collection project

IV. The new project "Tropical Bioresources and Green Chemistry Strategy" supported by the Special Coordination Fund for Promoting Science and Technology with Professor Toshiomi Yoshida as project leader.

LESSONS LEARNT

As a result of the evaluation and the views obtained from as wide a circle of course alumni, consular representatives, high officials in the main universities of several countries, and notwithstanding the high grades obtained as well as the

Table 8. Number of publications authored by course alumni.

Number of publications	Number of authors
100 and more (maximum 200)	10
50 to 90	10
20 to 49	27
10 to 19	27
<10	161
Total	235

remarkable and sustained appreciation of the course activities carried out annually over a 30 year period, there are several lessons to be learnt. These are as:

There needs to be a far greater effort to disseminate the course through Internet and through the website of UNESCO and its network of regional offices in Asia as a means to counteract the unawareness of the course and the lack of cooperation by some National Commissions in the region of Asia.

The significant contribution of Japan, through the course to the advancement of developing countries in Asia in scientific research in biotechnology –a field in which Japan occupies an acknowledged world position, is not widely known to decision-makers and policy-framers in these countries, and needs to be addressed through more interactive consultation with the concerned UNESCO National Commissions.

To offset the effects of budgetary constraints, more efforts should be made to secure additional financial resources and especially from the private sector since such resources can help meet costs incurred for the travel of Japanese lecturers, expansion of scientific visits and study tours, etc.

UNESCO should provide a credible financial contribution rather than one that is “nominal” in content.

To address the frustration that course participants experience on return to their home countries after exposure to high-quality lectures and equipment, the organization of lectures on “On how to conduct research in the developing countries” would greatly help course participants to adapt, innovate and respond to existing conditions in doing research in their own home countries.

Consideration should be given to the use of Internet to enhance the efficiency of the preliminary selection process and to reduce the burden on the staff of ICBiotech and the participating universities engaged in this exercise.

Differing levels of comprehension of course lectures and laboratory protocols need to be addressed by more attention to language proficiency, and through the provision of a series of introductory lectures and experiments that could help reduce the gap between participants from the late and the more advance developing countries.

More emphasis should be given to the analysis of experimental data and results.

Provision of facilities contributes to better learning and conduction of research *i.e.* as was seen in the day-care facilities made available for a young child.

In view of the numerous annual demands made, attention should be given to recognizing the course as a pre-training course for the Ph. D. degree.

CONCLUDING REMARKS

Since 1973 when efforts continued at an impressive level in harnessing the beneficial activities of microorganisms for human welfare, microbiology, indeed, as come a long way. Successive course prospectuses have reflected the changing emphasis given to fermentation technology, use of renewable resources, genetics, computer-aided bio-process, ecosystem study, and now the emerging fields of bioinformatics, gene cloning biopharmaceutical production, vaccine technology, and transgenic “animal” factories. Today, biotechnology is an amalgam of disciplines embracing the life and engineering sciences through biochemistry, mathematics and the computer sciences to genetics, molecular biology, microbiology, medicine and the neurosciences, thus giving rise to close interaction with domains of information technology and nanotechnology. In this regard, the evaluation of the course has shown that the concept of biotechnology and its practice varies in style, scale and substance amongst and in the countries of Asia and especially in the region of Southeast Asia.

The evaluation has also shown through the differing levels

of science education and research in Asia that there is an obvious need to address deficiencies in science education in the late developing countries and to maximize the research capacities of the advanced developing countries into network cluster groups for greater efficiency in the use of limited financial resources.

In conclusion, unanimous agreement in the internal and external evaluations provides satisfactory justification that the course has made to international cooperation in microbiology, and to Japan's position as a benefactor in the provision of technical assistance and knowledge in the exciting and modern field of biotechnology to Asia.

Annex 1.Timetable of application and selection.

Timeline	Operation
Mid-February	Mailing of prospectus to UNESCO Field Offices, National Commissions, etc.
End of May	Deadline for receipt of applications
End of June	Preliminary selection
Beginning of July	Check of Health certificates when necessary Selection by steering committee
Mid-July	Informal notification to selected applicants Formal letter of acceptance from Monbukagakusho Arrangement for participants' entry to Japan Letter of entry permission to Japan for participants

Annex 2. Documents to be submitted by the applicants.

Application Form
Five copies of Applicant's photograph
Health Certificate
Academic undergraduate and postgraduate records
Copy of latest diploma/degree
Certificate of proficiency in English
Two letters of reference*
List of scientific publications

*one being from institution/organization Director indicating that applicant was granted one year leave of absence from current job position.