Chapter VIII

Science and Technology

CHAPTER VIII

Science and Technology

I. INTRODUCTION

Science and technology (S & T) has long been recognized as an important ingredient in the socio-economic development of Malaysia. It played an important role in supporting the growth of the national economy. Scientific and technological advances achieved in the field of agriculture enabled Malaysia to diversify its plantation crops and attain higher productivity, resulting in a much higher *per capita* income for both the estate and the smallholder subsectors. With regard to food crops and livestock, research and development (R & D) resulted in improved, higher yielding, and disease resistant varieties, thus increasing the level of attainment towards food self-sufficiency targets. Some progress was also made in industrial R & D, but significant impact is yet to be felt.

In the social services sector, significant progress was achieved in the field of medicine and public health, resulting in declining incidences of deadly diseases, improved nutritional status, especially among those of school-going age, and a reduction in infant mortality. The overall effect was an improvement in the general health of the population as evidenced by the rising average life expectancy of Malaysians.

The current uncertainties in the international economic environment, coupled with the difficulties in maintaining the competitiveness of manufactured products, necessitates an even greater role of S & T in the industrialization programme of the country. A strong base in S & T and vigorous support of R & D will, therefore, be crucial. During the Fifth Malaysia Plan period, the role of S & T as an effective tool for development will be further intensified, especially in the light of emphasis on increasing agricultural productivity and intensifying resource-based industrial development as well as expanding the manufacturing base to include heavy and high-technology industries. Greater private sector involvement will be encouraged. Opportunities will be provided for interactions between both primary and secondary industries and R & D institutions, including universities. Further efforts will be directed to increasing centralized planning and co-ordination in

research programmes, strengthening the existing infrastructure for S & T management, expanding education and training in S & T, improving the technology transfer mechanism as well as encouraging and facilitating the utilization and commercialization of research results.

II. PROGRESS, 1981-85

Management of science and technology

A substantial institutional base already existed in the country to support the development of S & T, comprising six statutory and eight departmental research institutions in the various ministries. In addition, there were research laboratories for various S & T disciplines in the universities. There was, however, an absence of overall direction and comprehensive and explicit strategies and policies on S & T, resulting in research institutions continuing to establish their own objectives and priorities. Recognizing the need for such a policy, initiatives were undertaken for its formulation by the National Council for Scientific Research and Development (NCSRD). The Council, established in 1975 and serviced by a secretariat attached to the Ministry of Science, Technology and Environment, was responsible for formulating policies on S & T and guiding R & D towards meeting national objectives. Due to certain constraints, NCSRD was not able to fully play its role in the promotion of S & T for national development.

Resource allocation for research and development

National R & D expenditure in Malaysia for 1982 accounted for 0.5 per cent of the Gross National Product (GNP). This was very low since 1 per cent of GNP is considered to be the level at which R & D can begin to effectively support socio-economic development in a country. The national ratio also compared unfavourably with newly industrialized countries, such as South Korea, which spent 0.95 per cent of its GNP on R & D in 1982, and developed nations, such as Japan, which spent 2.78 per cent of its GNP. Of the national R & D expenditure, the private sector contributed only about 10 per cent compared with 45 per cent and 70 per cent in the case of South Korea and Japan, respectively. Owing to the past dominance of agriculture, R & D expenditure concentrated on agricultural production, with little emphasis on other areas, particularly industry. Furthermore, few attempts were made to strike a balance among the various categories of research, namely, basic, applied, and developmental.

Scientific and technological manpower

S & T was given emphasis in the national education system. The rising enrolment in and graduation from the local universities in science and engineering disciplines since 1970, as shown in Table 8-1, was indicative of this emphasis. Furthermore, there was an increase of science and engineering graduates trained abroad. While the universities had been responsive to S & T manpower needs, they

were, however, hampered by constraints in funding for both teaching and research, shortage of experienced staff, and low enrolment in graduate studies in the sciences and engineering disciplines.

Manpower development at the subprofessional and technician level had, however, not kept pace with that of graduates and professionals. The shortage of these personnel was due not only to insufficient institutional supply but also, more importantly, to the less attractive remuneration and opportunities offered at this level, especially in the public sector. This led to a situation where diploma holders preferred to pursue further studies at the degree level, thereby causing serious shortfalls in the supply of subprofessionals and technicians.

Performance of research and development institutions

Agricultural research. In the agriculture sector, three major research institutions, namely, the Rubber Research Institute of Malaysia (RRIM), Palm Oil Research Institute of Malaysia (PORIM), and the Malaysia Agricultural Research and Development Institute (MARDI), continued their research on the major crops. With increasing support from the Government during the Fourth Malaysia Plan period, substantial research was conducted and promising results obtained.

Among the research accomplishments of RRIM during the Fourth Plan period were the development of promising new and high-yielding clones adaptable to several environments. Combining the technique of plant tissue culture and new agronomic practices, the immaturity period of rubber trees was reduced to about four years. RRIM was also successful in developing low-intensity tapping system and mechanized tapping knives. In the downstream activities, RRIM through chemical modification, succeeded in producing epoxidized natural rubber (ENR) having special properties. New uses of rubber, such as in bridge bearings, rail-pads, and elastoplastic seals for runways, were also developed. Research on rubber effluent enabled the factories to meet the stringent requirements of the Environmental Quality (Prescribed Premises) (Raw Natural Rubber) Regulations, 1978.

The research efforts of PORIM were essentially directed towards increasing the yield of oil palm and the mechanized harvesting and collection of oil palm fruits. Improved varieties were being propogated through tissue culture techniques. With respect to food end-uses, successful formulations of various types of margarine, *vanaspati,* shortening, and cocoa butter substitute were developed. Specific formulations for various products were also developed for different new markets, such as South Korea, East Germany, and Australia. A major development in collaborative research was the setting up of pilot plants to produce palm diesel from crude palm oil, palm stearin and palm fatty acid, and vitamin E from fatty acid distillate and the leaves of oil palm.

TABLE 8-1

MALAYSIA: ENROLMENT AND OUTPUT OF DEGREE AND DIPLOMA HOLDERS BY TYPE OF EDUCATION FROM LOCAL INSTITUTIONS, 1970-85

	Enrolment				*Output*		
Course	*1970*	*1975*	*1980*	*1985*	*1971-75*	*1976-80*	*1981-85*
Degree	7,677	13,698	20,018	32,650	13,987	19,435	26,838
	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)
Arts	4,877	7,583	9,727	15,471	9,038	11,356	14,802
(%)	*(63.5)*	*(55.3)*	*(48.6)*	*(47.4)*	*(64.6)*	*(58.4)*	*(55.2)*
Science	2,408	4,642	8,046	12,505	4,451	6,513	9,317
(%)	*(31.4)*	*(33.9)*	*(40.2)*	*(38.3)*	*(31.8)*	*(33.5)*	*(34.7)*
Technical	392	1,473	2,245	4,674	498	1,566	2,719
(%)	*(5.1)*	*(10.8)*	*(11.2)*	*(14.3)*	*(3.6)*	*(8.1)*	*(10.1)*
Diploma	3,318	11,722	12,262	26,696	4,615	15,767	22,848
	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	*(100.0)*
Arts	1,368	5,362	5,063	14,776	1,534	6,420	9,808
(%)	*(41.2)*	*(45.8)*	*(41.3)*	*(55.4)*	*(33.2)*	*(40.7)*	*(42.9)*
Science	889	3,448	3,279	5,133	1,641	4,754	5,636
(%)	*(26.8)*	*(29.4)*	*(26.7)*	*(19.2)*	*(35.6)*	*(30.2)*	*(24.7)*
Technical	1,061	2,912	3,920	6,787	1,440	4,593	7,404
(%)	*(32.0)*	*(24.8)*	*(32.0)*	*(25.4)*	*(31.2)*	*(29.1)*	*(32.4)*

Source: Ministry of Education.

During the Fourth Plan period, MARDI concentrated its research efforts on rice, tobacco, vegetables, cocoa, fruits, livestock, and food technology. Six new varieties of rice with yields up to 6.5 tonnes per hectare were developed and the technique of direct seeding was introduced. New varieties of tobacco, chillies, cocoa, and pineapples were developed and fertilizer regimes formulated. Research was also conducted on the uses of agricultural by-products and wastes for livestock feeding. The techniques of freeze-drying were successfully applied to the development of convenience food from local fares. Improvements were made in the processing and packaging of traditional fermented and non-fermented products.

Fisheries research. The Fisheries Research Institute in Pulau Pinang was active in conducting research on fish population dynamics with a view to optimizing sustainable exploitation of resources. Aquaculture technology for prawns and production of fries for *siakap* were developed and the biology and ecology of cockles and other shellfish established. Studies were carried out on water pollution affecting marine life and on artificial reef and mangrove ecology.

Animal production and health research. Research on animal production and health was carried out by the Department of Veterinary Services, and to some extent, by MARDI. Considerable successes were achieved in animal breeding and nutrition, providing further support for the beef, dairy, pig, and poultry industries. Local production of meat and eggs continued to increase. An important development in beef production was the mini-feedlot system where confined cattle were fed almost exclusively on palm-kernel cake. Weight increases of up to 1 kilogramme per day were achieved. The local dairy industry, based on smallholder operations using *Sahiwal-Friesian* crossbreds, began to make its impact on the local liquid milk market. In the area of animal health, the Veterinary Research Institute and various diagnostic laboratories continued to carry out research on animal diseases and vaccine production.

Forestry research. Research conducted at the Forestry Research Institute of Malaysia (FRIM) during the Fourth Plan period principally concentrated on widening the uses of rubberwood and oil palm trunks. The high demand for rubberwood in furniture making and other uses was evidence of success in this area. Initial findings on the uses of oil palm trunks showed potential as raw material for particle board and pulp for paper production. Another significant area of research was the propagation and large-scale planting of economic species of rattan and bamboo. With the change of status of FRIM from a department to a statutory body in 1985, forestry research was poised for greater activity and productivity.

Industrial and mining research. The Standards and Industrial Research Institute of Malaysia (SIRIM) continued to pursue its objective of promoting industrial quality assurance standards and certification of Malaysian manufactured products during the Fourth Plan period. In addition, the emphasis of SIRIM was also directed towards the development of indigenous technologies and the adaptation and transfer of imported industrial technology to small and medium-scale industries. SIRIM also successfully developed an appropriate biogas technology for adoption by farmers. In addition, a wide range of simple and novel machinery was designed and fabricated for use by industries such as plastic glove making, semi-automatic *keropok* frying, groundnut decorticating, bread packaging, and soap mould making.

The Malaysian Institute of Microelectronic Systems (MIMOS) in the Prime Minister's Department was established in January, 1985 to conduct basic and applied research in microelectronics, with emphasis on technologies having potential applications in innovative high technology products for local distribution and export. Initially, MIMOS concentrated on providing training in Very Large System Integrated (VLSI) design which is the key technology in microelectronic products. In addition, it was active in exposing the potential of microelectronics to local industries.

The Nuclear Energy Unit (UTN) in the Prime Minister's Department continued to provide training and research in the applications of nuclear science and technology as well as in the supply and use of short-lived radioisotopes in agriculture, food technology, engineering, medicine, and the environment during the Fourth Plan period. Among other activities of UTN were the research done on food irradiation and the use of nuclear energy for non-destructive testing.

In the mining sector, the Mines Research Institute of Malaysia continued to play an active role in R & D for the development of mineral production in the country. Efforts were directed towards the development of technology in ore body evaluation, mining engineering, and mineral processing. Significant results were achieved in the use of modern alluvial drilling machines for prospecting and geophysical methods and soil analysis for geotechnical studies related to ground stability and mining safety.

Medical and public health research. In the field of medical and public health, the Institute of Medical Research (IMR) continued to provide diagnosis and other laboratory support services to relevant agencies. A rapid diagnostic test was developed to investigate snake bites and an antivenom against the Malaysian pit viper was successfully produced. The R & D activities of IMR established the presence of widespread resistance of the malaria parasite to chloroquine, thus alerting the need for alternative drugs for prevention and treatment of the disease. Research on scrub typhus showed that it was a major cause of fever in rural areas and that the disease could be effectively prevented and treated by the antibiotic

doxycycline. Another major achievement was the success in culturing human filarial parasite outside the human host, thus, opening up the possibility of developing an effective vaccine for the treatment of filariasis. This achievement led to the production of monoclonal antibodies for immunodiagnosis of the disease, a system for testing new antifilarial drugs, and the possibility for future vaccine production. Sensitive to the social problems currently facing the country, steps were taken by IMR to establish a dadah laboratory as a centre of reference for the detection of drug abuse. In the early part of 1985, a new virus laboratory was established to screen blood samples from donors and other high-risk groups for Acquired Immunity Deficiency Syndrome (AIDS).

Defence research. Research in the Malaysian Armed Forces began in 1968 with the establishment of the Defence Technical Centre which provided scientific and technological services to the armed forces. It was subsequently renamed as the Defence Research Centre in 1972 and restructured into the Defence Science and Technology Centre in 1985. It became the centre for the receiving and transferring of defence technology as well as assisting in the production of essential defence items.

University research. Research in the universities gained momentum but still lacked adequate funding. The generally low graduate enrolment in the local universities also affected their R & D, most of which was generated through graduate study programmes. The contribution of university R & D in some areas, however, was significant. There was increasing R & D collaboration between universities and industry. A significant contribution to the development of R & D for the industrial sector during the Fourth Plan period was the establishment of industrial liaison units within each of the local universities to facilitate technology interchange between the universities and industries. Through these units, the expertise and resources of the universities were increasingly tapped by industry. Many areas of applied research conducted by the Government R & D institutions were complemented by the universities. These areas include agriculture, forestry, animal husbandry, fisheries, and food processing. Research in the use of solar energy and the diagnosis of human diseases were also actively undertaken by the universities.

Technology transfer

The importation and utilization of foreign technologies helped the growth and development of the national economy during the Fourth Plan period. The number of agreements on technology transfer, both by type and industry group, registered with the Ministry of Trade and Industry between 1981 and 1985, are shown in Table 8-2 and Table 8-3, respectively. The largest number of agreements were concluded under the technical assistance and know-how programme. The food, electronic and electrical, and the motor-vehicle industries benefitted most from

technology transfer agreements. The Co-ordinating Council for Industrial Technology Transfer (CCITT) was established in 1982 to formulate strategies for strengthening the process of technolgy transfer. The responsibility of the Council was transferred to NCSRD in 1985.

TABLE 8-2

MALAYSIA: TECHNOLOGICAL TRANSFER AGREEMENTS BY TYPE, 1981-85
(Number)

Type of agreement	*1981*	*1982*	*1983*	*1984*	*1985*	*Total*
Technical assistance and know-how	64	48	61	54	51	278
Joint venture	22	14	14	17	9	76
Management	6	10	13	10	6	45
Trademarks/patents	8	8	7	18	5	46
Service	7	2	7	2	1	19
Basic engineering	5	4	4	6	—	19
Others	19	8	55	12	24	118
Total	131	94	161	119	96	601

Source: Ministry of Trade and Industry.

TABLE 8-3

MALAYSIA: TECHNOLOGICAL TRANSFER AGREEMENTS BY INDUSTRY GROUP, 1981-85

Industry group	*1981*	*1982*	*1983*	*1984*	*1985*	*Total*
Electronics and electrical	16	19	15	21	21	92
Motor vehicles and shipping	16	11	31	17	20	90
Chemical	21	5	15	17	17	75
Food	12	1	37	6	10	66
Non-metallic	4	16	9	17	-	46
Fabricated metal	14	7	12	3	-	36
Basic metals	10	13	5	5	-	33
Rubber and leather	14	2	7	5	4	32
Hotels	2	4	8	7	4	25
Textiles	5	2	5	6	1	19
Plastics	6	1	2	7	-	16
Pulp, paper printing	-	4	1	6	3	14
Palm oil and petroleum	3	3	4	-	-	10
Scientific and optical equipment	-	3	5	-	-	8
Others	13	3	5	2	16	39
Total	131	94	161	119	96	601

Source: Ministry of Trade and Industry.

III. PROSPECTS, 1986-90

During the Fifth Plan period, S & T is envisaged to play a greater role in national development. This role will demand the vigorous support of R & D in generating better efficiency, improved productivity, and increased competitiveness not only in the agriculture sector, but also in all other sectors of the economy, particularly manufacturing. It will, thus, necessitate a concerted effort to mobilize the national scientific resources which will entail the formulation of a national policy on S & T and its incorporation into overall development planning. A well-conceived national policy on S & T will also determine the direction of R & D activities of both the public and private sectors in support of the socio-economic goals of the country.

The present system of management of S & T is substantially decentralized in approach. Under the Fifth Plan, a more centralized planning and co-ordinated implementation approach will be pursued with a view to achieving higher productivity in R & D. Towards this end, a comprehensive review of the science policy organization as well as legal and institutional arrangements in S & T will be undertaken. The NSCRD, as the major science policy organization, will be strengthened to provide effective intersectoral jurisdiction in planning and management, while an independent mechanism will be provided for evaluation and assessment.

Recognizing the vital role of R & D in national development, the expenditure on R & D will be increased during the Fifth Plan period. In addition, a balance in the conduct of the three categories of research, namely, basic, applied, and developmental, is expected to be achieved through a more defined ratio in resource allocation. In this way, a firm basis for technological development will be established.

In the past, private sector involvement in national R & D was minimal. Its expenditure on R & D in 1982 represented only 10 per cent of national R & D expenditure compared with 5 per cent by the universities and 85 per cent by the public sector. With more emphasis on R & D being given to downstream activities, it is expected that the private sector will increase its efforts and resources in undertaking developmental research by taking advantage of a series of fiscal and other incentives.

Indigenous competence in R & D is essential in upgrading the scientific and technological capabilities of the country and this, in turn, is linked to national S & T manpower development. The current shortcomings in manpower development planning related to the planning mechanism and training institutions will be rectified.

The effective implementation of R & D policies and programmes will require the strengthening of S & T management. During the Fifth Plan period, a programme to train potential and prospective research leaders will, therefore, be undertaken. The means for ensuring progress in knowledge and continuous upgrading of technology will continue to be provided through sabbatical leave and staff exchanges among R & D institutions, universities, and industries.

During the Fifth Plan period, S & T programmes will be directed towards efforts at achieving higher productivity and acquiring a strong base for industrial diversification. In this connection, high technology and strategic programmes, which will expand the industrial capacity and enhance the technological capability of the country, will be introduced in line with the recommendation of the Industrial Master Plan (IMP). The Government will also ensure the successful implementation of these new programmes.

In order for S & T to make a headway in society, it is imperative that the society be enlightened in this field and interested in pursuing it as a means of achieving cultural, social, and economic progress. Science, therefore, becomes a way of life and a means of enriching culture. In recognition of this need, the Government will continue to create an environment conducive to scientific creativity and technological innovations.

IV. STRATEGIES FOR THE DEVELOPMENT OF SCIENCE AND TECHNOLOGY

Management of science and technology

Under the past decentralized system in S & T management, research institutions were largely guided by sectoral goals without the benefit of an overall national objective. During the Fifth Plan period, a more centralized planning and co-ordinated implementation will be provided through the NSCRD, which will be equipped with the necessary facilities to carry out its functions more effectively. A comprehensive review will be undertaken to examine overall research direction, objectives, and priorities in line with the national science and technology policy so that not only emphasis on production and manufacturing aspects will be better focussed but also the various R & D agencies and universities will be co-ordinated to play their roles more effectively. A programme for the training of research leaders will be undertaken and appropriate S & T indicators developed, as part of the strategy for improved management in S & T.

Resource allocation for science and technology

The strengthening of the science policy organization will be accompanied by an increased allocation to S & T that will be centralized under the central Research and Development Fund. This Fund will finance R & D activities that enhance the national scientific and technological potential and increase its contribution to the

achievement of socio-economic development goals. The Fund will, thus, enable the rapid mobilization of resources to capitalize on new S & T developments advantageous to the country. The total expenditure on R & D of both the public and private sectors is expected to increase progressively as a proportion of GNP.

Categories of research and development

Resource allocation to R & D institutions and universities for research will be improved to ensure adequate funding for research. The proportion of the budget for research activities in the R & D institutes and universities will be increased. In order to strike a balance in the conduct of the different types of research, the universities shall play a major role in basic research, while the public sector research institutes will concentrate on applied and developmental research. The private sector will be encouraged to utilize and commercialize the research results through their role in developmental research. Table 8-4 provides a general guideline as to the proportion of resource allocation for basic, applied, and developmental research, giving an overall ratio of 18 : 35 : 47, respectively.

Private sector involvement in research and development

During the Fifth Plan period, increased private sector participation and investment in R & D, especially in resource-based and high-technology programmes, is necessary for achieving higher rates of growth in the industrial sector. Tax and other incentives, will, therefore be introduced to encourage private sector participation to a level that is supportive of overall national R & D efforts. The private sector involvement in R & D can be in several forms such as inhouse R & D activities, research in collaboration with or contracted to the universities and R & D institutions, and contributions made to the central Research and Development Fund.

TABLE 8-4

MALAYSIA: DISTRIBUTION OF RESEARCH ALLOCATION TO TYPES OF RESEARCH BY DIFFERENT CATEGORIES OF RESEARCH INSTITUTIONS
(%)

Research institution	*Type of research*			*Distribution*
	Basic	*Applied*	*Developmental*	
Universities	40	50	10	*22*
Government research institutes	10	35	55	*52*
Private research bodies	5	20	75	*26*
Total allocation	18	35	47	100

Scientific and technical manpower

In the attainment of indigenous competence in S & T, the institutions of higher learning have a major role to play. Such institutions assist in producing middle and high-level manpower capable of absorbing imported technology, executing R & D, generating indigenous technology, and in adapting research results in economically productive ways. Manpower development for the scientific and technical sector is currently faced with problems of inadequate co-ordination and linkages between the development planners and the users and producers. During the Fifth Plan period, medium and long-term scientific and technical manpower development planning will be streamlined and a mechanism for continuous review instituted.

In the coming years, there will be a change in emphasis among academic disciplines, and new fields of teaching and research will continue to emerge in response to national needs. It is necessary, therefore, to provide the means for the universities to carry out effectively their teaching, research, and service responsibilities.

The manpower needed for accelerated growth of the economy is not only confined to graduates in science and engineering but also include the subprofessionals and technicians. The training of this group will, therefore, be emphasized. The manpower planning mechanism to be established and streamlined for this purpose will address the need for training and producing technically proficient professionals and support personnel capable of undertaking the tasks of technological modernization. Emphasis will also be given to the development of a managerial and entrepreneurial group with strong background in S & T. Innovation and technological change depends upon these managers and entrepreneurs undertaking the risks of applying new technical ideas and invention in the production and marketing of goods and services.

Research and development priorities

The high growth rate of manufactures in the 1970s led to optimism about the role of manufacturing in future development. Furthermore, the severe impact of the recent recession highlighted the vulnerability of the economy to changes in external demand and emphasized the need for diversification of production and exports. National R & D efforts will, therefore, be directed towards increased productivity and diversification of the industrial base in order to enable Malaysia to achieve a more competitive edge and penetrate overseas markets. The achievement of these objectives will require that special emphasis be given to the conduct of downstream research for resource-based industries. In respect of non-resource-based industries, R & D will be directed towards production processes and product development in order to achieve higher levels of manufacturing.

High technology and strategic activities

Several new areas have been identified as high priority for Government support in R & D activities. These activities are classified as high-technology R & D areas and strategic activities. The high-technology activities include, among others, the area of microelectronics, laser technology and electro-optics, biotechnology, materials technology, manufacturing technology, and software technology. The strategic activities include remote sensing, oceanography, applied climatology, and computer-aided design (CAD), computer-aided manufacturing (CAM), and computer-aided engineering (CAE) programmes.

High technology has played a major role in generating economic growth as well as increasing productivity in industrialized countries. It is also important for Malaysia to develop its technical competence in this field in view of the need to foster innovations and technological change in the country to support the development of an efficient and highly competitive export-oriented industrial sector. In this regard, microelectronics has been identified as an important element in achieving industrial productivity and competence. During the Fifth Plan period, research in microelectronics by MIMOS will be further supported. Research in the other areas of high technology will be pursued in line with the national objective to develop indigenous technological competence, particularly in the exploitation of the natural resources and other comparative advantage.

The activities classified as strategic may not directly contribute to productivity gains and innovations, but are, nevertheless, important in monitoring the natural resources, safeguarding national security, ensuring human health and wellbeing, and in enhancing R & D productivity. Remote sensing has become a major tool in agricultural, forestry, mineral, and other resource management as well as in security surveillance and environmental control monitoring. The acceptance of the 200-mile Exclusive Economic Zone (EEZ) has widened the territorial responsibility of the country. The need to assess, exploit, and manage the resources of this zone becomes urgent. This necessitates the establishment of R & D programmes in oceanography. Rapid urbanization has caused drastic changes in urban microclimate which, in turn, affects human wellbeing and productivity as well as the energy economy of urban areas. A concerted and co-ordinated effort in the study of urban climatology will help reduce the negative aspects of urbanization. CAD/CAM/CAE technology has increasingly become instrumental in enhancing industrial productivity and competitiveness. In certain cases, it allows skill gaps to be bypassed and is, therefore, especially important for developing countries like Malaysia. A central facility for CAD/CAM/CAE training is, thus, considered an important requirement.

The high technology and strategic activities which will be given priority will require the support of new scientific disciplines. Consequently, a study will be initiated to identify these disciplines which can be incorporated in the curriculum

and research programmes of the universities and research institutions. The strengthening of the programmes will be pursued selectively in order to avoid unnecessary duplication and to conform with the concept of centres of excellence. Greater collaboration among public R & D institutions, universities, and industry will be required.

Transfer of technology

The development of indigenous technological capacity and capability depends on the transfer of technology from abroad which are often imported at very high costs. Few of these technologies have been assimilated and improved upon because of the lack of technical expertise in this country to undertake such processes. In view of this, the Government will institute mechanisms necessary for the selection of technologies for industrial development, appropriate for the exploitation of the comparative advantage of the country. The Government will also consider the establishment of regulatory, administrative, and technical instruments for effective technology transfer and absorption, while giving special emphasis towards the commercial exploitation of locally-generated technologies.

Popularization of science for national development

The process of demystifying and popularizing science begins by wide exposure in schools and continues through adult life through various exposures and experiences. During the Fifth Plan period, measures will be taken to improve existing facilities which promote general education in science, including botanical and zoological gardens and science centres. Consideration will be given to the establishment of new facilities such as science-based muzeums and planetaria. Various programmes at the school level will also be pursued in order to foster greater manipulative skills and technical aptitudes from an early age.

The scientific potential and resources of the country will also be nurtured and mobilized to support the role of S & T in development. In order to encourage the participation of scientists in national development, the Government will consider the establishment of a national academy of science. This academy is intended to serve as a means of giving recognition to individual achievements and contributions to S & T. It will provide a formal forum for scientific and professional groups to raise and discuss issues and generate policy recommendations to Government pertaining to S & T. The academy will also serve as a motivating force for scientific excellence and provide leadership to the scientific bodies on their contribution to national development.

V. ALLOCATION

The development allocation for R & D during the period 1986-90 is $400 million.

VI. CONCLUSION

It is clear that during the Fifth Plan period and beyond, S & T resources will be mobilized to play an increasingly bigger role in development. In this connection, great importance will be accorded to strengthening the four main components of the S & T system. These comprise an international pool of S & T from which Malaysia must have the capacity to draw and to which it must also contribute; a national S & T infrastructure which is effective; a private sector that can create wealth through the application of S & T; and an enlightened society which can provide the social framework and resources necessary for the above components to operate.

Strategies and programmes drawn up for the Fifth Plan in S & T will take cognizance of the four components. Currently, there are many gaps in the S & T infrastructure that need to be redressed as well as new activities that require urgent attention. The implementation of the wide array of programmes will be phased according to priority, and a start in many of the new activities will have to be made during the Fifth Plan period.