Chapter VI

Science and Technology

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I. INTRODUCTION

6.01 The development of science and technology (S&T) is essential for Malaysia's overall socio-economic advancement. The widespread application of S&T will provide more effective and sustainable means towards achieving a competitive, diversified and global-based economy in order to attain higher standards of living in the future. The Fifth Malaysia Plan provided the watershed in the development of S&T in the country. Considerable progress was made in the formulation and execution of S&T policy initiatives. The Fifth Plan, therefore, not only provided for the first time a comprehensive orientation in terms of size and management of research and development (R&D) expenditure as well as the volume of R&D activities, but also laid a stronger foundation for future S&T management and policy development.

6.02 For the Sixth Malaysia Plan, the goals of S&T policy will be to ensure continuous scientific and technological developments that will sustain high rates of economic growth, accelerate overall development and lay the foundation for the attainment of a scientific and technologically advanced industrial society by the year 2020. This is with the view to establishing a scientific and progressive society which is innovative, forward looking and will contribute to advances in S&T. In this context, the Government will continue to provide the basic infrastructure and conducive environment for S&T development. The private sector is expected to complement the Government's efforts and play a more effective role than in the past.

II. PROGRESS, 1986-90

6.03 Despite the economic slowdown during the early part of the Fifth Plan, considerable achievements were made in terms of S&T development within the country. This was seen not only in terms of the size of R&D

expenditure and volume of R&D activities but also in S&T management and policy initiatives.

S&T Policy

6.04 The S&T policy essentially supports national development strategy. It underscored the important role of technological change for development and the need to utilize foreign technology in combination with a gradual strengthening of domestic technological capability and capacity through the process of assimilation and innovation. The policy thrust was, in principle, based on the interfacing among the public and private sectors and the scientific and technological community. The strategies and programmes evolved were aimed at widening and improving the S&T base and ensuring the development of comparative advantage in the production of goods and services.

6.05 Towards the latter part of the Fifth Plan period, the Government launched the Action Plan for Industrial Technology Development (APITD), as a follow-up to the implementation of the Industrial Master Plan. The APITD essentially provides broad strategies and programmes for strengthening the scientific and technological capability through endogenous technological development with the acquisition of selective technology from abroad and developing the requisite human resources and infrastructure. It also addresses the need to emphasize the importance of basic sciences in the education system and build a society that is more appreciative of modern S&T.

S&T Management

6.06 During the Fifth Plan period, a more centralized and co-ordinated management system for R&D and technology development was established. This approach was particularly relevant within the context of manpower and budgetary constraints and achieving efficient and effective S&T application and utilization. Towards this end, the implementation of the Intensification of Research in Priority Areas (IRPA) strategy and mechanism was initiated in early 1987 with the aim of ensuring selectivity and quality of R&D activities in the public sector. Four IRPA Panels were established to coordinate, assess and recommend R&D related activities in the areas of agriculture, industry, medical and selected strategic areas. The IRPA mechanism initiated the process of consultations and consensus among scientists, academicians, industrialists and researchers from the public and private sectors. In addition, the National Council for Scientific Research and Development (NCSRD) was reconstituted and a Cabinet Committee on S&T was established.

6.07 Several other measures to expand the institutional support structure for S&T were implemented. Apart from strengthening the existing R&D institutions and agencies covering a wide range of research areas, two new institutes, namely, the Malaysian Cocoa Board and the Remote Sensing Centre were established, to increase research activities in these two areas. As part of the measures to create a more conducive environment for private sector product innovation, the Government initiated measures to encourage greater involvement of industry in R&D activities. This included the promotion of collaborative efforts among the private sector, universities and research institutions as well as the provision of fiscal and financial incentives and the requisite infrastructure, such as the Technology Park Malaysia.

Allocation for Direct R&D and Performance

6.08 The budgetary allocation for direct R&D within public sector agencies during the Fifth Plan period was about $414 million. This excluded related capital and operating expenditures. From the total allocation, about half was for agriculture, 34 per cent for industry and 17 per cent for other sectors.

6.09 National R&D expenditure for 1989 was estimated at 0.8 per cent of Gross National Product (GNP), more than 80 per cent of which was by the public sector. The share of the private sector in national R&D expenditure was far below the level expected. Although the national R&D expenditure as a proportion of GNP, and in particular the private sector's contribution is relatively small in comparison to the R&D expenditures of industrialized countries and the Newly Industrialized Economies (NIEs), there has been a general increase in R&D expenditure, particularly towards the latter part of the Fifth Plan. While it is premature to evaluate the impact and potential contribution of the research already undertaken, progress was made towards expanding R&D programmes and projects across research agencies and economic sectors.

R&D in the Agriculture Sector

6.10 R&D activities in the agriculture sector continued to be dominant given the long existence of a number of agro-based research institutions. Besides the continued support for increasing productivity in the major commodities, there was a significant shift to more downstream applications-oriented research in the processing of agricultural output and by-products. This approach included research into possible end use product development as well as potential commercialization and

marketing. The shift to downstream research was emphasized, especially in product development of wood-based and food processing industries. Similarly, research efforts in palm oil contributed to meeting consumer preferences, thus raising the demand for palm oil and palm oil products in the international fats and oils market. Research in the rubber sector further assisted in upgrading the technologies on yield improvements as well as product development of rubber, rubber wood and rubber wastes. Research in the fisheries sector concentrated on developing better techniques for breeding prawns and freshwater fish, many of which have been successfully applied. In the livestock sector, research activities were carried out primarily to control livestock diseases as well as improve animal breeding and nutrition.

6.11 Universities complemented the research efforts of the various agro-based R&D institutions. Areas of research included plant and animal biotechnology, agricultural mechanization, pest and disease management, and agro-waste management and utilization.

R&D in the Industrial Sector

6.12 In comparison to agriculture, R&D activities in the industrial sector had not received equal emphasis mainly due to the narrow base of the sector itself and due to technological and manpower constraints. Nevertheless, during the Fifth Plan, a greater number of R&D projects were undertaken, particularly in areas such as micro-electronics, information technology, automated manufacturing technology, nuclear technology and material sciences, with the objective of introducing and disseminating new ideas for product development.

6.13 In the field of industrial R&D, public sector institutions and the universities conducted basic and applied research not only in the conventional technologies but also in new areas of technology such as material sciences, artificial intelligence and information technology. Increasing emphasis was placed on developing technologies having potential applications in innovative high technology products, both for the local and export markets. In micro-electronics and information technology, promising R&D results have benefited the computers, telecommunications and software industry. In the area of manufacturing technology, significant progress was made in developing and utilizing a number of advanced technologies.

6.14 Advanced techniques for mould and die using computer-aided design (CAD) and computer-aided engineering (CAE) were developed and successfully applied. Low-cost small machineries for food processing

and production were designed and fabricated, particularly for small-and medium-scale industries (SMIs). In nuclear technology, the development of tracer technology using radioisotopes enhanced process and product development in a number of industries. In the area of material sciences, considerable progress was made in ceramic, metal and plastic technology development which benefited local industries.

R&D in the Strategic Sector

6.15 Areas of research covered under the strategic sector include the basic sciences, resource management, emerging and future technologies, techno-economics and the social sciences. Recognizing the importance of basic sciences in augmenting knowledge and developing new technologies, a significant proportion of resources was allocated for its development. In view of the emphasis on conserving natural resources and protecting the environment, increased funds were made available for programmes such as environmental impact assessments, disposal of solid and toxic wastes, as well as water, air and noise pollution. Significant results have emerged from research activities in specific areas such as liquid natural rubber, coastal and highway erosion, remote sensing and electro-optics. It is encouraging to note that certain findings by local scientists are ready for the applied or development stage.

R&D in the Medical Sector

6.16 During the Fifth Plan, R&D activities in the medical sector were significantly enhanced. The focus was on problem-oriented research directed at finding ways to fill gaps between knowledge and its applications in solving persistent health concerns. Notable success included the development of a new animal model for the testing of potential drugs against filariasis and the identification of microbial agents as alternatives to insecticides in the battle against the mosquito. In addition, new technologies, such as the rapid diagnostic kit for dengue fever, and the development and production of reagents for diagnosis of endocrine diseases were introduced. Various aspects of bio-medical sciences also received increased research allocations.

Private Sector Participation in R&D and Technology Development

6.17 Although up-to-date information on R&D expenditure as well as the extent of technology development in the private sector is not readily available, a R&D expenditure survey by the Government in 1990

indicated a low level of R&D expenditure and technological innovation among domestic firms. This general trend was further supported by the preliminary findings of a recent Federation of Malaysian Manufacturers (FMM) Manufacturing Survey, 1989/90. Among others, the survey highlighted extensive reliance by the private sector on foreign sources of technology, while in-house R&D activities were not significant. Domestic adaptions and modifications of externally-sourced technologies in the form of new and improved products and processes were not substantial. This is in contrast to the experiences of many NIEs when they were at Malaysia's current level of economic development.

6.18 Notwithstanding this general trend, the private sector contributed to the expansion of research activities and technological innovations in specific areas. Significant progress was made in telecommunications where extensive product diversification and innovation created prospects not only for the domestic market but more importantly for the export market. The plantation sector expanded its R&D activities, providing added emphasis to tissue culture, biotechnology, marketing and end-use research to generate increased downstream agro-based product development activities.

6.19 Given that private sector research and technology development is relatively low in the country, the Government launched the Industrial Technical Assistance Fund (ITAF) to provide matching grants to support product development and design schemes as well as quality and productivity improvement schemes, especially for the SMIs. This was in addition to available fiscal and financial incentives. Further, the country's first technology park was established to promote greater private sector participation in technology development and encourage new technology-based start-up companies.

Technology Imports

6.20 In view of the country's small technology base, the utilization of imported technologies continued to play a significant role in accelerating industrial expansion during the Fifth Plan. The inflow of technology, as indicated by the number of contractual agreements approved by the Government, increased notably during the Fifth Plan period, as shown in *Tables 6-1* and *6-2*. However, this indicator is reflective of only those agreements required under the Industrial Coordination Act (ICA), 1975, or the Promotion of Investment Act (PIA), 1986, or when specifically required under any Foreign Investment Committee (FIC) rulings.

TABLE 6-1

TECHNOLOGY IMPORTS BY TYPE OF AGREEMENT, 1985-90
(number)

	Type of Agreement	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*[1]	*5MP*
1.	Joint Venture	9	19	11	11	15	16	72
2.	Technical Assistance	46	47	50	64	64	73	298
3.	Know-how	5	3	3	3	13	11	33
4.	Licences and Patents	14	27	22	37	35	15	136
5.	Management	6	10	5	7	12	5	39
6.	Services	1	1	1	2	12	5	21
7.	Trade Mark	5	6	8	7	18	19	58
8.	Turnkey and Engineering	0	1	0	1	1	1	4
9.	Supply and Purchase	1	0	1	0	6	2	9
10.	Sales, Marketing/Distribution	7	7	7	10	6	5	35
11.	Others	2	2	2	8	16	4	32
	Total	**96**	**123**	**110**	**150**	**198**	**156**	**737**

Note:

[1] There were less technology transfer agreements in 1990, though the number of approved manufacturing licences was substantial. This is because many of these projects are expected to come on stream only during the Sixth Plan years, and the relevant technology transfer agreements are expected to be submitted for approval much later.

6.21 While recognizing the need for technology imports to achieve rapid industrial growth, the Government initiated measures to ensure that there was more effective transfer from foreign technology suppliers with the view to further enhancing domestic technological capabilities. This included the formulation of new policy guidelines on royalty payments. The major thrust of the guidelines was to ensure that balanced mutual benefits were obtained both by the receiver and supplier of technology. In addition, steps were taken to strengthen the technical capability of the institutions involved in the processing, evaluation, selection and enforcement of technology transfer agreements.

TABLE 6-2

TECHNOLOGY IMPORTS BY INDUSTRY GROUP, 1985-90
(number)

	Industry Group	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*[1]	*5MP*
1.	Food	10	8	8	16	21	14	67
2.	Textiles & Wearing Apparel	1	7	2	6	4	8	27
3.	Leather & Leather Goods	0	0	0	1	0	1	2
4.	Wood & Wood Products including Furnitures	0	4	1	0	0	6	11
5.	Paper & Paper Products, Printing & Publishing	3	4	1	3	0	4	12
6.	Chemical & Chemical Products including Pharmaceutical	16	15	18	29	27	24	113
7.	Petroleum & Coal	0	0	0	6	2	0	8
8.	Rubber & Rubber Products	4	13	8	22	18	8	69
9.	Plastic & Plastic Products	0	4	0	2	6	5	17
10.	Non-metallic Mineral Products	7	7	12	4	10	7	40
11.	Basic Metal	1	1	2	0	6	4	13
12.	Fabricated Metal Products	9	22	21	17	7	4	71
13.	Manufacture of Machinery	0	0	0	0	7	6	13
14.	Electrical & Electronic Products	20	12	29	37	40	41	159
15.	Transport Equipment	20	15	4	1	15	18	53
16.	Hotel and Tourism	4	4	1	2	6	3	16
17.	Agriculture	0	0	1	1	7	0	9
18.	Miscellaneous	1	7	2	3	22	3	37
	Total	**96**	**123**	**110**	**150**	**198**	**156**	**737**

Note:

[1] See Table 6-1.

6.22 Despite various measures to facilitate technology transfer from abroad, technological innovation among Malaysian firms, particularly the SMIs, was still relatively low in many respects. Innovation activities were largely geared towards incremental improvements or marginal adaptations to meet local needs rather than the design and development of new products and processes. The lack of indigenous capacity and ability for technological development indicates the need to strengthen domestic consultancy, design and engineering capabilities.

Scientific and Technological Manpower

6.23 In line with rapid technological changes anticipated in the economy, the capacity of the public education and training institutions was expanded to meet the increasing demand for high level and specialized skills, particularly engineers and technicians as well as R&D personnel. However, despite the high rate of expansion in the output of high-and middle-level S&T-related manpower from institutions of higher learning, the imbalance in the type and number of manpower produced and required by the nation continued to be a problem.

TABLE 6-3

R&D MANPOWER IN PUBLIC AND PRIVATE SECTORS, 1989
(number)

Qualification	*Public*	*Private*	*Total*
Ph.D	1,254	35	1,289
Masters	2,181	66	2,247
B.Sc	1,679	322	2,001
Sub-total	5,114	423	5,537
Others[1]	6,656	1,412	8,068
Total	**11,770**	**1,835**	**13,605**

Note:
[1] Includes sub-professionals, technicians and other supporting staff.

6.24 The findings of a R&D manpower survey conducted by the Government indicated that a total of 13,605 personnel, either full-or part-time, were involved in R&D activities in 1989, as shown in *Tables 6-3* and *6-4*. Of the total, 5,537 were research scientists and the rest were supporting staff. The public sector represented the largest source of R&D manpower in the country, a substantial portion of whom were engaged in agriculture research. A large proportion of the R&D personnel in the public sector were in basic or upstream research compared with that in applied or developmental research. This has contributed to the consequent low impact of R&D on industry. The R&D personnel in the private sector was too small to stimulate significant indigenous market-driven research.

TABLE 6-4

R&D MANPOWER BY SPECIALIZATION AND QUALIFICATION, 1989
(number)

Specialization	*Ph.D*		*Masters*		*B.Sc*		*Total*
	Public	*Private*	*Public*	*Private*	*Public*	*Private*	
Engineering[1]	142	7	486	18	585	115	1,353
Computer[2]	33	0	138	1	40	30	242
Medical[3]	87	0	134	0	112	0	333
Agriculture[4]	347	19	528	15	210	43	1,162
Basic[5]	491	9	484	32	482	134	1,632
Others	154	0	411	0	250	0	815
Sub-total	1,254	35	2,181	66	1,679	322	5,537
Total	**1,289**		**2,247**		**2,001**		

Notes:

[1] Engineering proper, such as chemical, civil, mechanical, electrical engineering and specialized fields such as metallurgy and textile technology.

[2] System analysis, information science, electronic data processing, computer programming and other allied subjects.

[3] Anatomy, biochemistry, dentistry, microbiology, medicine, obstetrics, optometry, osteopathy, physiotheraphy, public health and other allied subjects.

[4] Agronomy, animal husbandry, fisheries, forestry, horticulture, veterinary medicine and other allied subjects.

[5] Biology, botany, chemistry, entomology, geology, mathematics, meteorology, physical geography, physics, zoology and other allied subjects.

6.25 The ratio of research scientists to total population estimated to be around 400 per million population, was relatively low compared with Japan (6,500 per million), United Kingdom (3,200 per million), West Germany (3,000 per million) and South Korea (1,300 per million). Thus, by international standards, not only was the number of Malaysian R&D personnel small and concentrated in the public sector but its utilization for user-oriented research was also limited.

S&T Awareness, Promotion and Popularization

6.26 Activities aimed at promoting better understanding of S&T and its role in national development were organized at various levels throughout the Fifth Plan period. National science essays and poetry competitions, science fiction writings, science quizzes, inventor competitions, computer software and graphic development competitions were promoted among school children as part of the annual National Science and Technology Week. The National Science Centre, currently on a temporary site, was established with the view to popularizing and promoting S&T. In addition, a planetarium was established in Kuching by the State Government, while the planetarium in Kuala Lumpur is under construction.

III. PROSPECTS, 1991-95

6.27 The role of S&T in promoting growth as well as diversifying the development and trade base will continue to remain dominant during the Sixth Plan and beyond. Technology-oriented policy measures that will enable the nation to become more self-reliant and resilient to withstand greater challenges from the changing domestic and international economic environment will be emphasized. More intensive and concerted efforts, therefore, will be pursued towards the rapid expansion of S&T and its integration into national development. The Government will continually improve the requisite policy framework, infrastructure, incentives and supporting services. The benefits will have to be harnessed by the private sector and the society as a whole.

6.28 Indigenous technology development will be guided and fostered through activities that promote creativity, innovation and inventiveness, especially at all levels of education as well as in industry. In particular, the private sector is expected to accord priority to technology absorption, adaptation, innovation and exploitation in line with industrial and export requirements. Greater efforts will be given to reorientate upstream research to meet requirements of the market. While the domestic private

sector may not be in a position to spearhead extensive technology breakthroughs, it must nevertheless reorient itself to the changing environment. More specifically, greater emphasis will need to be accorded to raising the technology content, efficiency and productivity of Malaysian products and services to enable them to compete in international markets.

Policy Objectives and Strategies for S&T Development

6.29 Policies and strategies for potential S&T applications and development will be those that contribute to long-term sustained economic growth and socio-cultural enrichment. In principle, the nation will support the development of scientific and technological activities that build on existing strengths and capabilities and have commercial and export potential. Extensive opportunities to increase the country's competitive position in world markets by improving productivity and developing innovative products and services will be explored.

6.30 While recognizing the need to strengthen basic research, an important policy thrust will be to emphasize applied and developmental research and innovation in areas that can contribute significantly to the country's industrial development and competitiveness. This will develop local capability in product design, engineering and innovation. Equally important will be developing competence in technologies essential to both the established industries as well as targeted new industries.

6.31 Given the rapid pace of technological advancement and structural change, greater focus will be on enhancing the use of domestic technological capacity and capabilities, as well as activating and sustaining the transfer of potential technologies into productive enterprises. Many of the research outputs by the public sector institutions are highly advanced and have potentials for commercialization. In this regard, policies will be geared towards fostering entrepreneurial technology-based ventures, encouraging greater interaction amongst research institutions, industry and Government enterprises as well as making public sector R&D more market-oriented. A strategy for the intensification of commercial exploitation of research and technology will be introduced.

6.32 In order to build up endogenous capability in S&T, the learning and teaching of basic sciences and the provision of technology-oriented instruction will be emphasized at the primary, secondary and tertiary levels of education. The thrust will, therefore, be on improving scientific and technological literacy so that more people will be attracted to careers

in S&T-related fields and universities continue to produce graduates and researchers of high calibre. It will also be necessary to make available selected educational programmes in applied technologies to those already in the labour force to enable retraining, upgrading and acquisition of new practical knowledge and skills. This is in line with the objective of developing an adaptable, well-informed and skilled workforce.

6.33 Another policy objective will be to encourage the wide diffusion and use of S&T to optimize the quality of life and ensure higher standards of living for the nation, while reducing adverse effects on the environment as well as cultures and lifestyles of the people. The Government research and educational institutions as well as industry and labour will play an important role in communicating and demonstrating the benefits of S&T to the general public so that support for related policies, programmes and initiatives will be forthcoming.

6.34 Apart from improving and strengthening public and private sector R&D organization and infrastructure, the S&T policy will strive to integrate private sector research activities within the national R&D framework. The private sector will be expected to be more aggressive and adopt a more positive attitude towards R&D, and set in place an efficient infrastructure to facilitate technology assimilation, diffusion and application. In line with this, industry will be encouraged to specialize in new and promising technologies in the form of niche strategies. The latter should be the focus of opportunities in an increasingly competitive global environment. Domestic firms, particularly the larger enterprises, will be encouraged to set up their own R&D systems. Special assistance programmes will be designed and packaged for SMIs to promote industrial innovation. Improved fiscal and financial incentives as well as the provision of techno-infrastructure will be instituted to stimulate R&D and technological innovation activities in the private sector, especially among technology-intensive SMIs.

6.35 Increased funding for R&D will be required to strengthen the manpower and infrastructural facilities, with particular emphasis on the development of priority-oriented technology. The Government will provide budgetary allocations, direct matching grants, soft loans and preferential credit to accelerate innovative activities in the public and private sectors. Simultaneously, the private sector will complement public sector efforts. This is in line with the Government's aim to at least double the national R&D expenditure as a percentage of GNP, by the year 2000 from the current level of around one per cent. Special efforts will be made to improve the private sector's contribution so that by the year 2000, its share in national R&D expenditure will be at least 40 per cent.

Programmes

Diffusion and Applications of Advanced Technology

6.36 Several measures will be undertaken to ensure widespread diffusion and application of updated and advanced technology, especially in areas that are becoming more technology and information intensive. In this regard, a major vehicle will be direct foreign investment, technology licensing and trade activities. The policy on foreign investment and technology licensing will be applied strategically to ensure that the required technology will be acquired while minimizing duplicative and low-level technology. In addition, the development of overcapacity or concentration in certain technologies will be monitored. Special attention will also be given to the creation of more effective joint-ventures and linkages between domestic and foreign enterprises to enhance local technological capability.

6.37 Domestic enterprises, particularly SMIs, are expected to respond more positively to various measures by the Government to upgrade the technology level of industry and, as a consequence, to create better opportunities for product and market development. The implementation of the ITAF, which provides matching grants to enhance product development as well as technical improvements and sophistication in industries, will be made more effective by the provision of supporting business and marketing advisory services and consultancies.

6.38 Within the above context, technical services provided by relevant Government institutions to private industry, such as consultancies, extension services, technical information and technical training in specific areas, will be further intensified. Where feasible, the Government will make available the required techno-infrastructure and facilities as well as discounted rates for utilities and land within specific areas such as within a high-technology industrial estate, foundry park, quality enhancement centres and existing institutions and agencies.

6.39 As an alternative to partial grant financial assistance, the Government is developing mechanisms to provide soft loans, venture capital and other forms of assistance to encourage private firms and individuals to undertake the commercialization and marketing of technology. Collaborative or joint private-public R&D ventures involving companies, public research institutions and universities will be encouraged. In this regard, the Government will consider measures to facilitate the transfer or secondment of scientists and researchers among public sector agencies, as well as between the public and private sectors.

6.40 In order to enhance R&D and technology development, international cooperation in selected S&T areas will be established, while at the same time fully utilizing the existing technical and economic cooperation arrangements. Attempts will be made to increase the exchange of technological information as well as undertake joint research and training in specific areas of S&T. This will include mutually beneficial activities such as, the exchange of technical information on fundamental and applied research as well as exchange of researchers, scientists and technologists in selected technologies.

Increasing Quality and Design Competence

6.41 The level of quality and design competence needs to be raised substantially in order to exploit the tremendous investment and export opportunities through greater product differentiation and sophistication arising from technology, quality and design variations. Domestic enterprises will have to adopt a more positive approach towards quality improvement and management as well as acquire competence in areas such as industrial, engineering and product design. Special emphasis must be placed on in-house and on-the-job training in quality and design skills.

6.42 The Government will implement quality and design enhancement programmes that are readily accessible to industries. In order to increase design awareness and competence, the product design centre at the Standards and Industrial Research Institute of Malaysia (SIRIM) will be upgraded to form the National Product Design Centre. The Centre will provide consultancy services to industries in product design, prototyping, and product development, with special emphasis on assisting SMIs. In line with the APITD proposal on the establishment of a number of quality enhancement centres to provide design and engineering support as well as other related advisory services, the Government will provide the initial basic infrastructure for such centres. The private sector will subsequently be expected to take over these centres. In addition, courses and training programmes in public sector educational institutions will be reoriented to meet increased demand for such knowledge and know-how.

Education and Training in S&T

6.43 Recognizing that the development of human resources will ultimately determine the extent and quality of technology advancement and enrichment, the Government will place high priority on improving and strengthening the overall education and training in S&T. The thrust

will be on building a society that is educated and trained in S&T which can participate actively in socio-economic transformation. This requires a more flexible training system to respond to the changing pattern of occupational skills and a relatively higher minimum threshold of competence for all young people.

6.44 A critical constraint to overcome will be the mismatch between the supply and demand of scientific and technological manpower, both in terms of quantity and quality. A substantial portion of the shortfall will be met by the intensification of education and training efforts abroad and within the country itself. The emphasis will be on expanding domestic education and training programmes in science, engineering and technology as well as the continual updating of the S&T curricula and skills development to incorporate appropriate application-based scientific and technological knowledge. In order to provide effective support for the acquisition of competence in the new and emerging technologies as well as for upgrading traditional and conventional technologies, the universities, research agencies and tertiary level institutions will take the lead to enhance education, research and training capabilities. Programmes leading to post-graduate diplomas, masters and doctorates will be augmented, especially in S&T-related fields.

6.45 The development of S&T manpower will be fundamental in raising the level of industrial competence and competitiveness. At the enterprise level, measures will be taken to encourage them to update their knowledge of recent developments and enhance their ability to apply new and improved technologies. The Human Resource Development Fund, to be launched by the Government, will aim at developing indigenous technological capability within manufacturing enterprises. Industrial firms will make a mandatory contribution to this Fund, which will be utilized to implement relevant technology-related training programmes at approved institutes.

Support for the Science Base

6.46 In the process of accelerating S&T development, support for strengthening the science base will be continued. Measures will be taken to emphasize the key disciplines in basic sciences, such as molecular biology and genetics as well as chemistry, physics and mathematics. In this respect, universities are expected to play a major role in expanding education and knowledge in these fields. Increased resources will be made available to the universities to strengthen their research and teaching capabilities through the provision of improved facilities and the upgrading of skills in selected areas.

6.47 Improvements and adjustments to the requisite curricula will be made to keep abreast with the expansion of knowledge, know-how and applications in the mathematical, scientific and technological fields. In this regard, research into the processes of teaching and learning of S&T, at both the basic and the higher level of application, will be supported. Universities are expected to maintain close linkages with other relevant institutions and industry, in order to achieve greater focus and relevancy of the teaching and learning of mathematics and the basic sciences.

Enabling and Key Technologies

6.48 The Government has announced long-range plans for a substantial expansion of resources in new and emerging technologies to ensure focus in areas which can yield the highest economic pay-offs. Five key technology areas have been identified for building competence and for exploitation to enhance innovativeness and to further develop niche areas for domestic industries.

6.49 *Automated Manufacturing Technology* (AMT) refers to the application of advanced techniques of management and technical methods and methodologies to enhance the quality, speed and flexibility of the manufacturing environment. AMT draws upon a wide range of technologies, notably information technology and control and software engineering. Examples include CAD, CAM and computerized numerical control (CNC), industrial robots, flexible manufacturing systems, process planning and control and expert systems. AMT is applied to varying degrees in some of the larger manufacturing enterprises in Malaysia, particularly those associated with multinational companies. Most indigenous manufacturing companies, however, have yet to derive the benefits of efficiency, productivity, quality and international competitiveness that AMT can offer.

6.50 *Advanced Materials* covers a wide range of materials, including plastics, metals, ceramics and composites of these materials, where recent technological progress has shifted radically the traditional perceptions of the roles that these materials can play. Thus, for example, new structural applications of plastics and ceramics are expected, the mechanical and chemical properties of metals are being enhanced through advances in metallurgy and fabrication methods and a whole new class of electro-ceramics are seen as the key to advances in electronics and micro-electronics. Malaysia possesses a resource advantage in plastics and in certain new materials such as rare earth elements, that will be utilized to make advances in this field.

6.51 *Biotechnology* has grown in importance as a key technology of the future through recent advances in molecular biology and genetic engineering. Applications are evident in diverse areas, such as agriculture, health, food and energy. This is a field where Malaysia has acquired competence and a moderately strong knowledge base and further development, including institutional strengthening, can be expected.

6.52 *Electronics* is widely recognized as the technology which has had far reaching impact on the global economy. A wide range of specialized areas of activity are encompassed, including the design and manufacture of components, techniques of design and assembly of systems and a wide range of sophisticated applications for industry and the consumer. Micro-electronics and digital technology are two of the key areas in this field. Malaysia has acquired a measure of competence in the narrow area of assembly of electronic devices and components through the manufacturing activities of multinational companies, but has yet to acquire the required capability in the more creative aspects of design and development of innovative products and services.

6.53 *Information Technology* (IT) in its broadest sense refers to all technological elements that enable the acquisition, storage, processing, transmission and presentation of information. The primary technologies involved are micro-electronics, computers, telecommunications and software technology. It has aptly been described as the foundation of the second industrial revolution and has been targeted by virtually all industrialized and industrializing economies as a strategic competitive technology for attaining efficiency and competitiveness in world trade. Malaysia, in common with the rest of the world, is currently experiencing considerable change as a result of the impact of IT, and has demonstrated abilities in certain areas of micro-computer technology and telecommunications, although as a whole it lags behind many NIEs in these areas.

6.54 In order to enhance capability and promote R&D in these selected priority areas, the institutions responsible will draw up prioritized research activities, strategic plans and awareness projects for implementation. In essence, more comprehensive and integrated development programmes will be designed. The emphasis will extend beyond the provision of physical infrastructure and financial support for R&D and innovation. Complementary measures will include the promotion of activities related to diffusion, commercialization and marketing with a view to upgrading the technology base and creating new growth and employment opportunities.

6.55 A fundamental pre-condition for the success of such a strategic approach is that it should involve the private sector. In this regard, the Government will create a conducive environment for fostering the growth of indigenous new technology-based firms. Special incentives to promote these firms will be introduced, including enabling grants to cover start-up costs as well as assistance in market search and in mobilizing venture capital. Other measures will include Government procurement policies that will give preference to domestic products such as computers and telecommunications, relaxation of regulations to permit collaboration among high technology-based firms and setting of technical standards which favour products of domestic firms.

Commercialization of Research and Technology

6.56 The APITD had recommended self-financing targets for research institutions of 30 per cent by 1995 and 60 per cent by the year 2000. On the part of R&D institutions, it is appropriate at this juncture to take on a more explicit commercial stance in order to achieve such targets and to enhance their potential contribution to development. This will be initiated by the rationalization and reorientation of their research activities with the view to creating synergy and synthesis with the market place.

6.57 In this context, the establishment of the appropriate institutional, legal and administrative framework for the systematic assimilation, adaptation and dissemination of promising technologies will be critical. A number of measures are being studied. Under consideration is the establishment of an intermediary agency that will facilitate the commercial exploitation of potential research and technology. Other options include the formation of a commercial arm within the institute or university for the purpose of bringing potential technology to the market, or the commercialization and marketing of potential research output through technology parks and innovation centres. A comprehensive system of contract research to generate greater interaction between research institutions and industry will also be considered. Such new approaches will facilitate sale of potential technology as well as lead to joint efforts with industry in downstream technologically feasible projects.

6.58 These new approaches will also induce technology ventures and entrepreneurship for commercializing and diffusing new technologies. As a consequence, spin-off activities such as consultancies, engineering, design and other related services will emerge. However, the infrastructure for initial downstream activities, such as up-scaling,

prototyping, financing and marketing will need to be developed. Due to the high risk, uncertainty and long gestation period of the commercialization process, the Government will consider establishing special funds within existing financial institutions or in new venture capital corporations which will advance funds to enterprising firms, consortia or individual entrepreneurs on concessionary terms.

Intellectual Property Policy for Commercialization

6.59 In the efforts to commercialize potential technology and create new economic activities and job opportunities, an important aspect will be the formulation and design of an intellectual property policy and guidelines for universities and research institutions. This is part of the process of creating a favourable climate to nurture innovation, invention and the transition from laboratory to commercialization. This initiative will be geared primarily to serve public interest, promote creativity and innovation and diversify the industrial base. The policy and guidelines will provide institutions the flexibility to develop licence agreements, sponsored research contracts and related procedures that meet specific needs. Participating institutions will then need to devise intellectual property management programmes which will enable them to solicit research funds, share intellectual property rights with inventors, and play a major role in identifying and marketing intellectual property with commercial potential.

6.60 Overall, the supporting infrastructure for patents and the management of intellectual property rights also requires development. The existing administrative and enforcement machinery will be further improved to manage an increasingly sophisticated environment as more advanced technologies are developed and patented. In addition, a new range of advisory and consultancy services pertaining to intellectual property protection and the patent process, including related legal issues, patent search and translations, will be developed.

Role of Universities

6.61 As part of the strategy to enlarge the technology base, the universities are expected to play a more important role in S&T and manpower development. In order to acquire and upgrade competence in the new technologies and generate innovations, universities will be provided with resources to enhance their teaching standards as well as research and training capabilities. Opportunities for post-graduate

education and training will also be increased in order to strengthen capabilities, especially in the R&D thrust areas and the science base supporting them.

6.62 Given the existence of broad based multi-disciplinary skills, the universities are in a position to contribute significantly to overall industrial development through product development and the commercialization of new ideas. While universities have some traditional forms of collaboration with industry, new forms of interactions will be established so that they will play a more symbiotic and effective role in technology exploitation and human resource development. New forms of linkages such as the teaching company scheme, incubator schemes, and joint industry-university post-graduate and extension programmes are under various stages of preparation.

Increasing S&T Awareness

6.63 The future thrust is for S&T awareness to permeate all facets of society. In order to enhance S&T awareness, the mass media and other informal means will be extensively utilized to complement measures already initiated at the school and tertiary levels to promote general and specific education in S&T.

6.64 The S&T Week will be expanded in order to encourage wider participation at the state and district levels and cover a broader spectrum of S&T-related issues. Measures will be instituted to increase the involvement of the private sector as well as S&T associations, societies and clubs in national technology-oriented activities. In order to enhance S&T awareness, a new Science Centre will be established to coordinate efforts to popularize S&T. Towards this end, the Government has received the support of the corporate sector which will contribute towards the design, fabrication or purchase of the exhibits for the Centre.

S&T Intelligence and Information System

6.65 An important pre-requisite in building linkages and consensus for an effective management and coordination of S&T policies and programmes will be the establishment of an efficient mechanism for information gathering and dissemination. For this purpose, a National Science and Technology Intelligence and Information System will be established to enhance the availability of information on S&T developments. Such a system will facilitate the rapid and effective

dissemination of information on S&T, assist in the coordination and monitoring of R&D programmes as well as collate information and data for the formulation of relevant S&T policies, strategies and programmes.

Coordination and Management of S&T Policy

6.66 As the country seeks to accelerate technological innovation for greater economic growth, productivity and competitiveness, there will be increased emphasis on the coordination of S&T policies. In this regard, the Government will undertake to minimize fragmentation in decision making and ensure the harmonization of activities among institutions and enterprises as well as across sectors. Better coordination of S&T policies and closer integration with economic and other policies will be essentially aimed at reducing institutional complexities and diversity of S&T systems as well as at synthesizing the needs of the academia, research institutions and the private sector.

Priority Areas in R&D

6.67 The Government will provide substantial expenditure to finance direct R&D, supplemented by the private sector. While Malaysia is not expected to be in the forefront of all advanced technologies, budgetary allocations and other forms of assistance will be directed towards selective target-oriented R&D programmes that are of strategic importance and offer the best development potentials. Major research programmes will also focus on the science base that supports emerging technologies, such as engineering, electro-optics, advanced materials, telecommunications, semi-conductor technology, computer systems and software, manufacturing systems, and medical, plant and animal biotechnology. Other important areas include environment, resource management, and non-conventional energy. The socio-cultural dimension of S&T will be given more emphasis. In this regard, the impact of technology development will be studied to minimize detrimental socio-cultural effects. Towards this end, an additional IRPA Panel on social science has been established. Its future agenda includes the formulation of a master plan for social science research.

IV. ALLOCATION

6.68 The Federal Government development allocation and estimated expenditure for the period 1986-90 and the allocation for the period 1991-95 is shown in *Table 6-5*. The Government will increase direct R&D funding to research agencies and universities to about $600 million, while

$560 million will be provided for related physical infrastructural facilities and manpower development. The overall resource allocation is expected to reflect the balanced emphasis placed on basic and applied research and on industrial and agricultural R&D as well as socio-economic research.

6.69 Greater emphasis will be accorded to making R&D more relevant and effective, particularly within the context of increasing indigenous capability in downstream innovations. This will be done largely through the allocation of resources for R&D programmes and activities that will apply advances in technology to increase production, improve products and services and reduce adverse environmental impact. In particular, priority will be accorded to building up competence in industrial R&D in line with the need to diffuse, adapt and modify technology for economic development.

TABLE 6-5

DEVELOPMENT ALLOCATION FOR SCIENCE AND TECHNOLOGY, 1986-95

($ million)

Programme	*5MP*		*6MP*
	Allocation	*Expenditure*	*Allocation*
Direct R&D	**413.8**	**285.4**	**600.0**
Agriculture	*203.2*	*127.5*	*273.8*[1]
Industry	*138.1*	*98.3*	*177.7*
Medical	*33.1*	*30.6*	*59.8*
Strategic	*39.4*	*29.0*	*78.6*
Social	—	—	*10.1*
S&T Infrastructure and Development	**126.7**	**109.1**	**560.3**
Total	**540.5**	**394.5**	**1,160.3**

Note:

[1] Allocation does not include cess funds under the Rubber Research Institute of Malaysia (RRIM) and Palm Oil Research Institute of Malaysia (PORIM).

6.70 An important objective will be to assist public research agencies and universities to emphasize the efficient and productive use of S&T advances, information and R&D capabilities. Available resources will be utilized, where feasible, to augment R&D capability within local enterprises. As the public sector represents the largest source of R&D wealth in the country, more resources will be channelled towards potential programmes that promote the transfer of untapped indigenous technology from public research institutions to the private sector.

V. CONCLUSION

6.71 The important role of S&T has become critical in the light of global scientific and technological developments which has led to changes in the comparative advantage and competitiveness of economies worldwide. Although Malaysia lags behind many of NIEs in advanced technologies, it has realistic goals in building up competence in technologies relevant to its economic development. The Sixth Plan will build upon the foundation laid during the Fifth Plan to further enhance the coherence and transparency of policies, strategies and programmes evolved for S&T development. The emphasis will be on balanced growth in the science base that supports technology development and higher productivity in primary production as well as giving special emphasis to downstream market-oriented research, and higher level of technical competence in balance with technological innovation and entrepreneurship. Environmental research programmes will stress on resources management. The expansion of S&T will provide the growth impetus for the creation of sufficient resources and wealth required for the attainment of the National Development Policy objectives.