Public Disclosure Authorized

43

ESP Discussion Paper Series

17676

Scientific Information and Literature

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September 1994

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Human Resources Development and Operations Policy
The World Bank

ACKNOWLEDGEMENTS

I would like to thank Lauritz Holm Nielsen for giving me the opportunity to work on scientific information and literature in the Science & Technology Program of the Education and Social Policy Department (ESP). I am also thankful to the staff of the World Bank libraries, especially the Sectoral Library, for their cooperativeness and professional services. Finally, I am grateful to Erik Thulstrup and Kin Bing Wu all colleagues from the ESP for their support and help in preparing in publishing this paper.

ABSTRACT

The paper discusses an intensive growth of scientific and technological publications and computerized databases, and the resulting challenges, problems and opportunities for individual scientists, researchers, scientific communities and countries. Trends and characteristics of traditional literature sources, especially scientific journals, books, and patents, and of computer-supported databases accessible on-line, on CD-ROM or on personal computers, are reviewed. The main strategies for achieving an efficient acquisition of scientific and technological information and the methodologies for its transfer into research and education are presented. The information and communication differences between industrial and developing countries are identified, and the main obstacles hindering the exchange, transfer and use of scientific and technological information are discussed. In the light of identified problems, the paper provides recommendations for priority actions and programs to develop/improve the acquisition and use of scientific literature, databases, information services, and to promote the transfer of knowledge into research, education and development.

FOREWORD

The last three decades have been characterized by an intensive growth of scientific and technological knowledge and information. The increased production of traditional publications, combined with the development of telecommunication and computer technologies, has resulted in the development of scientific and technological informatics as a scientific discipline, and in the emergence of an information industry.

The wealth of scientific and technological information presents both new opportunities and risks for the developing countries. The availability of information from all over the world is important for the quality and advancement of scientific research and education, and contribute for example to develpment of industrial and enhancement of agricultural production. However active participation in scientific and technological communication and exchange of knowledge is not automatic. Too many developing countries are virtually isolated from the flow of knowledge and will have to depend on others for technology transfer etc.

This paper presents the information and communication differences between the industrial and developing countries, and discusses the main obstacles hindering the exchange of scientific and technological information between low-income and high-income countries. The core of the paper gives an overview on traditional literature sources, especially scientific journals, books, and patents, as well as on computer-supported databases accessible on-line, on CD-ROM or on personal computers. Possible acquisition methods of scientific and technological information and the information-supported methodologies are discussed in relation to the specific problems in developing countries. In the light of identified problems, the paper offers recommendations for actions and programs to support the development, improvement, promotion and use of scientific and technological information in developing countries. Reducing the information and communication gap between the industrialized and the developing countries, and strengthening the transfer of knowledge, is one of the most urgent priorities in development programs.

The intention has been to provide an overview of current trends in scientific and technological literature, databases and information-supported methodologies. The paper may serve as an valuable source not only for the Bank staff working on science and technology, and higher education projects, but also for those who are involved in broader fields of education, research, communications, planning and development.

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Abbreviations

CD-ROM	Compact Disc - Read Only Memory
CDS/ISIS	Computerized Documentation System/Integrated Set of Information Systems
GIS	Geographical Information Systems
GNP	Gross National Product
PC	Personal Computer
R&D	Research and Development
RS	Retrospective Search
S&T	Science and Technology
UNESCO	United Nations Educational Scientific and Cultural Organization
UNDP	United Nations Development Program
UNIDO	United Nations Industrial Development Organization

EXECUTIVE SUMMARY

The results of scientific research are being applied much faster today than before in the development of new products and technologies. The life-time of information is becoming shorter. Information and knowledge are being treated as a scientific concept and resource or commodity with value and price. Accessibility, exchange and use of scientific and technological information have strong effects on the quality and advancement of scientific research, education, industrial and agricultural developments: they stimulate new research and prevent its duplication, provide knowledge on new materials, products and technologies, support better decision-making and planning for a sustainable development. All these are the characteristics of the **post-industrial information age**, where information and knowledge became the key components for development.

The intensive growth of scientific and technological information during the last three decades, combined with the growth of computer industry, has resulted in the development of **scientific and technological informatics** as a scientific discipline which has contributed to the prosperity of information industry. New information services and technologies have been offered to gather and process increasingly higher amounts of data from traditional and specialized scientific literature. However, the large amount of information alone does not necessary ensure a better quality of education and research. Scientists and researchers are faced with new information challenges, such as (1) the time-pressure in acquiring new information, (2) competition for priority publishing of new discoveries and inventions, (3) acquisition, selection and processing of highly specialized but dispersed, fragmented and sometimes unreliable data, and (4) effective transfer of processed information into scientific research, teaching, industrial and agricultural developments.

The main strategies for achieving an efficient acquisition of scientific and technological information and its transfer into practice utilize (1) **information-based methodologies**, such as data structuring, design of knowledge maps, pattern recognition and problem solving, and (2) **computer-supported technologies** for communication, information retrieval and data processing.

Traditional sources of S&T information include (1) **scientific journals**, which are still the major source of new findings in fundamental research. The strongest and most prestigious and influential S&T journals are published in English and come primarily from American and European publishing houses. Scientists from developing countries contribute less than 5% of their articles. (2) **Patents** bring the information on scientific discoveries, inventions and improvements in strategic fundamental research, applied science and technology. They are an indispensable source of information for applied research and industrial development. (3) **Scientific books**, although not as timely as journals, provide a few years older but more comprehensive and better structured knowledge. (4) **Proceedings** from S&T conferences, seminars and workshops, (5) **standards**, (6) technical and research **reports**, (7) **dissertations**, (8) **trade literature** and (9) special **maps** are important sources of data in any S&T information study. Access to traditional sources of scientific and technological information is the basic prerequisite for any research project or educational process. For an in-depth information coverage of a specific scientific field, all available types of scientific publications have to be acquired and analyzed. Limitations to only a few information sources may lead to gaps in acquired information, serious losses of the whole information sets, costly duplication/repetition of research, or unnecessary authorship/intellectual property conflicts.

Secondary literature sources provide bibliographic data on primary literature and often include an abstract or at least key words describing the main theme of a document. The large-volume indexes and abstract books are being rapidly replaced by computer-supported databases.

The last twenty years have been characterized by a rapid growth of **computers, communication and database industries**. Database records have grown from 1975 to 1991 by a factor of 87, number of databases by 26, database producers by 15 and vendors by a factor 14. Geographically, the largest producer of computerized databases remains the USA, followed by Western Europe, Asia, Australia, South America, Eastern Europe and Africa. Science, technology and engineering databases hold 19% of all commercial databases. Together with health/life sciences (9%) and multidisciplinary academic databases (4%) they are the main competitor to the strongest database group - business databases (33%).

The largest **on-line bibliographic databases** on S&T already contain several millions of records. They are either multidisciplinary or they cover specialized scientific disciplines, such as chemistry, biological sciences, medical research, physics, electronics and computer science, pharmaceutical research, agriculture, food production and processing, technology and engineering, environment and pollution, and biotechology. Other types of **textual on-line S&T databases** include data on patents, business and trade, different regulations, or contain directory-type information on academic and research institutions, manufacturers, suppliers, information services, natural resources and microbial culture collections. **Specialized factual databases** in natural sciences are designed for a direct support to research, and contain highly specific information, such as physical and chemical properties of materials, molecular structures, sequences of proteins and nucleic acids, or genetic maps.

An alternative to on-line databases are **CD-ROM products**. They seem to be of particular interest to monodisciplinary research groups (who only depend on one or a few databases), to academic research and educational institutions (repetitive processing of a CD-ROM database by students and research trainees does not result in additional costs), and institutions from developing countries (CD-ROM can operate in harsh environmental conditions, does not require telecommunications links, can be portable and can serve multiple workstations).

Another possibility are **specialized bibliographic and factual databases on mini or micro computers**, built by the researchers, S&T information specialists or students, who analyze primary literature in their field of work. Building and/or processing of databases on specialized scientific topics can improve the research efficiency and contribute to higher quality of S&T education in schools and universities.

The increasing amount of scientific and technological information presents both new **opportunities and risks for the developing countries**. The possibilities to access and use the scientific and technological information from all over the world can speed-up the country development, shorten the transition period and contribute to better industrial and agricultural planning and performance. However, remaining outside the scientific and technological communication and exchange of knowledge may lead to an information isolation, a deeper underdevelopment and dependency on foreign resources.

There are severe information and communication **differences between industrial and developing countries**. The gap is visible not only in higher illiteracy rates, lower spending on science and research, fewer scientists and engineers and insufficient telecommunication infrastructure, but also in lower production of literature, especially scientific books and journals, and very low participation of scientists from developing countries in the international exchange of knowledge.

The **exchange of scientific and technological information** between developing and developed countries is hindered by several obstacles, such as (1) cultural differences, (2) educational problems in developing countries, including high illiteracy, lack of scientists, technologists and information specialists, (3) the language barrier, (4) technological problems, e.g. insufficient infrastructure, lack of compatibility of equipment and software, maintenance problems, (5) inappropriate selection of priorities in foreign information aid programs, (6) organizational problems and complicated bureaucratic procedures in developing countries, (7) lack of information on different possibilities for cooperation and information exchange, (8) high cost of S&T information services and lack of funds.

Reducing or bridging the information and communication gap between the industrialized and developing countries should be one of the urgent priorities in the programs for more balanced world development. The **recommended actions and programs** to support the development, improvement, promotion and use of S&T literature and information services in developing countries include:

(1) Definition of the information needs for all target groups,
(2) Introduction of S&T informatics to regional and national information policies and development plans,
(3) Improvement of technical environments for S&T information acquisition, processing and distribution,
(4) Provision of reliable funding sources,
(5) Coordination of activities between local, national and international organizations,
(6) Cooperation between foreign consultants and local scientists and information specialists in all S&T information projects and programs for developing countries,
(7) Stronger participation of scientists from developing countries in international scientific communication and publishing (by providing training in scientific writing, advise/help in achieving high quality standards, and promotion of scientific articles from developing countries in internationally recognized S&T journals),
(8) User-oriented training and assistance in design, building and updating of information systems for the local needs,
(9) Increased sustainability of information systems in developing countries,
(10) Establishment/strengthening of S&T information networks among individuals and/or institutions in industrialized and developing countries,
(11) Organization of specialized pre-service and continuous in-service education in S&T informatics for different groups of information professionals and end-users,
(12) Introduction of S&T information services and methodologies in all areas of scientific research, industrial development, transfer of technological know-how, planning, decision-making and education,
(13) Advise and help in the transfer of knowledge (know-how) in all imports of technologies, processes and materials,

(14) Replacement of school teaching practices, which emphasize memorizing of data, with more information-based teaching for the development of skills for searching, processing and using S&T information,
(15) Support for efficient literacy programs in countries with high illiteracy rates,
(16) Development and promotion of S&T terminology, information processing and scientific publishing in indigenous languages,
(17) Introduction of training courses in S&T English and/or other main languages used in S&T communication to the university studies,
(18) Establishment/improvement of local production of basic consumables, such as paper, toners, inks, cables, diskettes,
(19) Simplification of rigid bureaucratic procedures which hinder a more efficient acquisition of S&T information and technologies,
(20) Improvement of the social status of S&T information specialists.

The age of information

Information as a resource

While the poorest regions of the world are still struggling to fulfill their basic human needs, several societies in the developed world have already transcended the classical industrial phase and entered the **post-industrial information age**, where information and knowledge have become essential resources and commodities. Information is now being treated as a scientific concept. Scientists interpret nature as matter, energy and information. Economists regard information as a resource equal of land, capital and labor. Information can be collected, stored, maintained, retrieved, processed, applied, bought and sold - all for a price. Today, scientific progress is transformed much faster than before into new products and technologies - which increases the value and price of information, and at the same time shortens its life-time. What students learn in school at present, may become obsolete in five to ten years. With the rapidly changing processes and technologies, the necessary working skills may have to be upgraded or replaced several times in someone's professional life. In an information-based economy, acquiring skills for collecting, processing and using information are becoming just as important as gaining the specific knowledge in a specialized professional field. Policies for education, training, science and technology became the vital information age policies. Information has an equally important role for economic, scientific, technological, industrial, as well as for rural, social and cultural development.

Scientific and technological information

Scientific research relies heavily on the ability to communicate -- gather reliable data, have access to information, collaborate on research projects, participate in meetings, conferences, seminars and scientific discussions, and to disseminate the results. The accessibility, exchange and use of **scientific and technological information** (S&T information) have a direct influence on the quality and prosperity of education, fundamental and applied research, industrial developments and technological innovations. In the past, science was characterized by objective observation, powerful methods and techniques, and the ability for prediction. Today, these characteristics are upgraded by the transfer of results into production and decision making processes. The traditional information sources - scientific papers, books, conference proceedings and dissertations - are thus supplemented with patents, standards, research reports, technical papers and know-how offers.

Access to and proper use of the information about new achievements in S&T has several **positive effects** in both industrialized and developing countries. S&T information can:

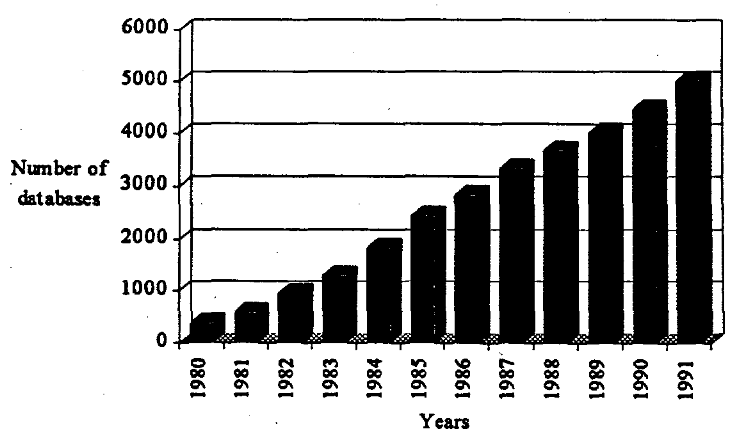
(1) stimulate new research and development and bring fresh approaches to the existing projects,
(2) help prevent duplication of research,
(3) provide knowledge on new promising technologies, materials and products,
(4) enable the recognition of developmental trends,

(5) support better decision making in the selection and in adoption of foreign technologies and products, and
(6) help in better planning for local industrial development, utilization of raw materials, expansion of trade and selection of economic partners.

The rapid growth of information in science and technology

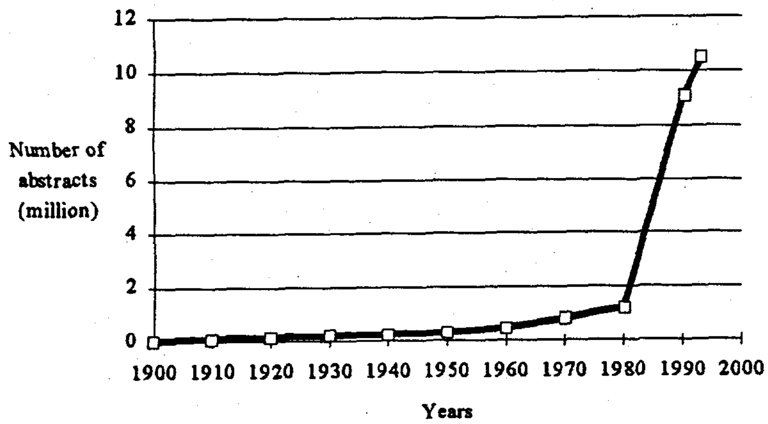
The last three decades have been characterized by an **intensive growth of publications** in most S&T disciplines, primarily as a result of more intensive fundamental research, highly competitive applied and industrial research, and a substantial increase in the number of research institutions and researchers, both in industrial and developing countries. The rate of diversification and specialization in scientific and technological fields has increased. In addition to traditional scientific disciplines, new fields with an exponential growth of information are emerging. Specialization in science and technology leads into the production of large amounts of highly specialized publications, resulting in high dispersion and fragmentation of information. In order to cope with large sets of data, several information firms were established, offering different information services and products: traditional and specialized publications, yearbooks, reference directories, abstracting and data structuring services, computerized bibliographic databases, full text and factual databases, or complete information systems. It is estimated that over 40 million technical books are already in circulation and that their number is being increased at a rate of 400 new titles each day. Another indicator illustrating the prosperity of information industry is the overall growth of the on-line accessible databases (Figure 1). In 1992, more than 5000 on-line databases have been offered by approximately 730 hosts.

Figure 1: The growth of on-line accessible databases (From Kornhauser and Boh, 1992a)



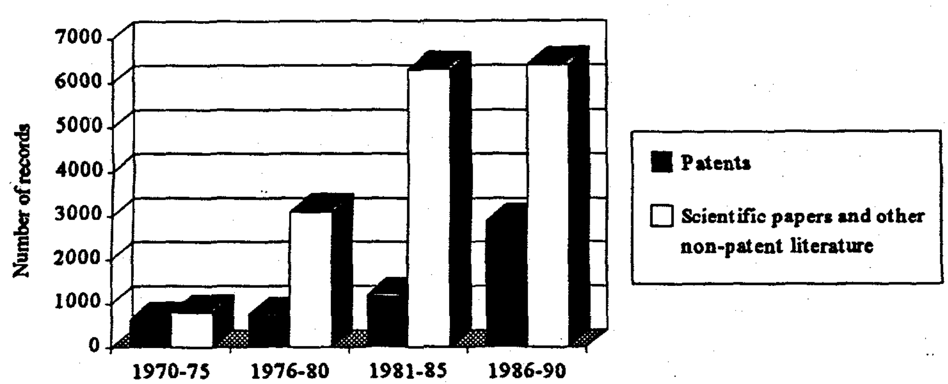
In science, chemistry is often quoted as an example of a field with exponential growth of information. The number of records in the Chemical Abstracts database increased from barely half-a million in 1980 to over 10 million at the beginning of 1990s (Figure 2).

Figure 2: Growth of Chemical Abstracts database (From Kornhauser and Boh, 1992a)



Very often the same increasing pattern of new publications can be observed in specialized scientific and technological disciplines, - both in non-patent and patent literature - as seen from an example of the microencapsulation technology (Figure 3).

Figure 3: Dynamics of information growth in a specialized scientific field: number of records on microencapsulation technology in the Chemical Abstracts Database (From Boh, 1993).



Information-supported research and education approaches

The large amount of information alone does not necessary ensure a better quality of teaching and research. On the contrary, scientists, researchers, teachers and students are faced with new **information challenges**, such as:

(1) how to participate actively in the scientific communication and transfer of information - as an user of information and as a producer of a new knowledge,

(2) how to improve the access to all sources of information and gather sufficient amount of adequate information for a chosen research theme,

(3) how to process scientific and technological information from large amounts of similar publications, when the data seem to be disorganized, fragmented and dispersed over different scientific disciplines and over different types of publications,

(4) how to recognize and link the main parameters, establish their hierarchy, structure them and recognize the patterns of knowledge,

(5) how to design information-based research hypotheses to bridge the information gaps (the most important information may not be published in scientific papers or even in patents),

(6) how to use the structured information in teaching, learning, research, recognition of developmental trends, and for solving scientific and technological problems and every day research dilemmas.

With a rapid growth of scientific and technological data, several **methodologies** were developed to approach the above information challenges, such as structuring scientific information into systems, design of knowledge maps, recognition of patterns, and problem solving in research and education. These methods became even more powerful with the availability of large computer-supported databases and with the introduction of microcomputers in research and education.

The combination of information-based methodology and computer-supported information systems can contribute to a more effective acquisition and use of information, and to a more efficient transfer of fundamental knowledge into education, applied research and production practice. To achieve this, the following **strategies** can be used:

(1) To acquire more complete and adequate information, and to avoid delays in transfer:
- Design target-oriented search profiles for processing international bibliographic databases
- Select the most relevant databases for retrospective searches
- Build a permanent updating mechanism in selected domains (SDI - Selective Dissemination of Information)
- Establish a reliable mechanism for the acquisition of primary literature

(2) To store, process and retrieve large amounts of acquired data:
- Build small specialized bibliographic and factual databases on personal computers for the needs of specific long-term research projects or educational programs

(3) To link fragmented information and recognize structures of knowledge:
- Perform in-depth information analyses of scientific literature to recognize the main parameters, their relations and hierarchy
- Structure the information to recognize patterns of knowledge

(4) To process large, incomplete or vague sets of data:
- Apply the concept of information density

(5) To design information-based research hypotheses (or to develop well structured educational materials):

- Combine results of the above phases

(6) To evaluate and optimize a research hypothesis (or an educational product):
- Test a research hypothesis with experimental research work
- Acquire and analyze additional information on missing/questionable fragments
- Solve the remaining problems by following the same steps

(7) To upgrade the research hypothesis (generation of new scientific and technological knowledge):
- Creatively interlink the known (structured) information with fundamental scientific knowledge, research intuition and experimental research work.

The following example of an **information-supported research strategy** (Table 1) combines computer-supported information methods with experimental laboratory work for the development of a new product or technological process. The flowchart is designed in phases, which successively end up in higher levels of information processing, enabling a continual following and evaluation of phase results in solving a given research problem. Each level consists of three blocks: (a) preparatory work and/or introductory studies, (b) selection, study and application of appropriate methodology, and (c) phase results as a target of one level and at the same time a start to a progressively higher level.

Table 1: An example of an information-supported research strategy: introductory studies, main methodological steps and the phase results (Adapted from Boh, 1991; Boh and Kornhauser, 1992).

Phases	PREPARATORY WORK and/or INTRODUCTORY STUDIES	METHODOLOGICAL STEPS	PHASE RESULTS
1	Discussing a research/developmental problem: scientists, researchers, potential industrial producers, users of final products	PROBLEM DEFINITION	Defined problem - draft research plan with tasks, timelines and expected outcomes
2	Consulting an S&T information specialist	DESIGN AND OPTIMIZATION OF A SEARCH PROFILE FOR BIBLIOGRAPHIC DATABASE PROCESSING	Optimized profiles for the retrospective searches (RS) and for the constant updating with new publications - Selective Dissemination of Information (SDI)

Cont. Table 1

Phases	PREPARATORY WORK and/or INTRODUCTORY STUDIES	METHODOLOGICAL STEPS	PHASE RESULTS
3	Consulting an S&T information specialist	SELECTION OF APPROPRIATE DATABASES	Searches on on-line and/or CD-ROM databases: bibliographic data, abstracts, definition of developmental trends
4	Collecting primary documents (articles from scientific papers, books, patents, technical reports, dissertations, conference proceedings, gray literature);	ANALYSIS OF PRIMARY LITERATURE WITH SIMULTANEOUS DEFINITION OF KEY WORDS; ENTERING DATA INTO A SPECIALIZED BIBLIOGRÁPHIC DATABASE ON A MICROCOMPUTER	Specialized database on PC containing bibliographic data on all collected primary documents, and precise, well structured key words or abstracts
5	Methodology of structuring information for recognition of parameters, their hierarchy, relations and patterns of knowledge	STRUCTURING DATA INTO A TREE- OR MODULAR STRUCTURE: DEFINITION OF MAIN PARAMETERS, THEIR HIERARCHICAL ORDER, AND RELATIONS BETWEEN THEM	A tree (or modular) structure of the research field: from general towards detailed branches, leading to specific products, processes or properties. (Can be used as a basis for a factual database.)
6	In-depth analysis of publications: gathering and analyzing selected factual data	SELECTING A PRIORITY BRANCH: BUILDING A HIGHLY-SPECIFIC AND TARGET-ORIENTED FACTUAL DATABASE ON PC	A factual database (or a system of databases) on the chosen narrow field, such as a specific technology, group of materials, family of products.
7	Definition of main parameters, their relations, and sorting keys for computer-supported processing	PROCESSING OF A FACTUAL DATABASE: SORTING, ANALYSIS, STRUCTURING, COMPARISONS, OVERLAPPING, CALCULATING DENSITY OF INFORMATION	Sorted printouts, such as lists of raw materials, their physical and/or chemical characteristics, technological processes, process variables, market products, producers and suppliers, etc.
8	Concept of information density: applications for segments with large, incomplete and vague information	DESIGNING A RESEARCH HYPOTHESIS (e.g. for laboratory work): LINKING FRAGMENTS WITH HIGH INFORMATION DENSITY INTO A HYPOTHETICAL SKELETON	A basic skeleton of a research hypothesis (e.g. process backbone, synthesis flowchart, research procedure, composition of a product formulation, structure of a complex compound)

Cont. Table 1

Phases	PREPARATORY WORK and/or INTRODUCTORY STUDIES	METHODOLOGICAL STEPS	PHASE RESULTS
9	Technical knowledge and experiences for setting-up the laboratory procedure (or another form of experimental work)	TESTING AN INFORMATION-BASED RESEARCH HYPOTHESIS WITH LABORATORY (or FIELD) WORK; EXPERIMENTAL OPTIMIZATION OF PARAMETERS	Verified and optimized research hypothesis
10	Target-oriented database searches: obtaining additional information on missing fragments. Additional in-depth studies of fundamental concepts needed for upgrading the research hypothesis	UPGRADING INFORMATION STRUCTURES WITH NEW KNOWLEDGE : INTERLINKING OF INFORMATION METHODS, TARGET-ORIENTED FUNDAMENTAL KNOWLEDGE, RESEARCH INTUITION AND EXPERIMENTAL RESEARCH WORK	Upgraded/new material, product, process or technology. Publication of results in a form of a scientific paper, patent or technical report

The importance of scientific and technological information for the developing countries

The vast amount of information available presents both **new opportunities and risks for developing countries**. The international competition in the development of new technologies (e.g. information technologies, biotechnology, environmental technologies), and new products (e.g. computers, chemicals, pesticides, pharmaceuticals, food products, ceramics, synthetic fibers), strongly depend on the availability of scientific and technological information. In order to compete in the international market and improve their quality of life, developing countries need to have **access to scientific and technological information**, the **abilities to process information** and **use the results and knowledge** for their development. The successful implementation of S&T information systems and services is based on the convergence of a range of disciplines, including fundamental science, computer science, informatics, library science, communications, publishing and management.

Low- and Middle-income countries have to participate actively in the international exchange of S&T information - not only as observers and users, but also as active **contributors of new knowledge**. At present, developing countries contribute only about 5 percent of the new S&T publications worldwide, which does not only illustrate the deepening information gap between the two parts of the world, but also shows the extent to which low-income economies depend on industrialized countries for information and technology transfer. The dependency is being maintained by technology transfer firms in order to keep their leading position and increase the profits, and by the developing countries themselves. A study on S&T information and technology transfer (Lundu et al., 1989) demonstrates how the transfer of finished products, which appeal more to third world consumers, usually overshadows the technological information and know-how. Many third world decision makers see no direct use of S&T information, research and development, and believe that there is no moral, economic or technical justification for developing countries to "reinvent the wheel". The same authors see a serious danger in this phenomenon, realizing that ignorance or lack of information are the major causes of underdevelopment. Import of technology without a proper information source results in dependency and, consequently, in underdevelopment and alienation. The only way out from dependency and underdevelopment seem to be in attaching a greater value to S&T information as a strategic resource. However, the acquisition of S&T information from industrialized countries has to be **carefully planned, relevant to local needs** and **cost-effective** in relation to the limited financial resources available in low-income economies.

The widening gap between industrial and developing countries

It has been a long-standing tradition to divide the world into two parts: industrialized countries and developing countries. The differences between low-, middle- and high-income economies are visible in their **basic indicators**, such as GNP (Figure 4), population (Figure 5), and adult illiteracy (Figure 6), as well as in the characteristics of **research and development** (R&D). Typically, developing countries allocate a much lower percentage of their nominally smaller GNP to R&D – an average of 0.64% (1990) in comparison with 2.92% for developed countries (Figure 7), – and have almost 6 times less scientists and engineers working in research and development in total, or close to 20 times less per million of population (Figures 8 and 9). Geographically, North America has by far the highest concentration of science and technology manpower, followed by Europe, Latin America, Asia and Africa (Figure 10).

Similarly, there are distinct differences in the **communication profile** (Table 2). In 1960, 85.8% of all books were published in the industrialized countries, which at that time represented 41.6% of total world population. With the increase in population growth, the developing countries reached a population share of 76.9% in 1990, and only 28.7% in the book production (Figures 11 and 12). In regions with high adult illiteracy, dissemination of information and informal education by radio broadcasting play an important role. However, in the developing countries there is only one radio receiver per 5-6 persons, compared to over 1 radio set per person in the industrialized world (Figure 13).

Table 2: Communication profile: differences between industrial and developing countries (UNDP, 1993).

	Daily newspaper circulation per 1,000 people, 1988-90	Book titles published per 100,000 people, 1988-90	Radios per 1,000 people, 1990	Televisions per 1,000 people, 1990	Telephones per 1,000 people. 1986-88	Average number of people served by one post office, 1986-88
Industrial countries	348	61	1130	545	590	4,200
Developing countries	50	6	180	55	28	16,330

Figure 4: GNP per capita in US$, 1991 (Data source: The World Bank, 1993)

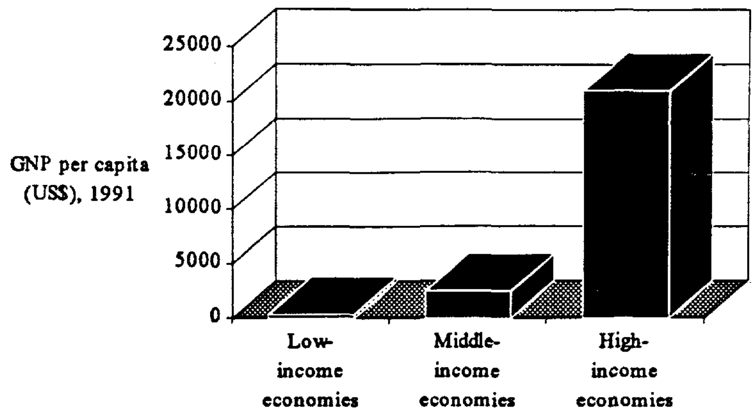


Figure 5: Share of population between low-, middle- and high-income economies, 1991 (Data source: The World Bank, 1993)

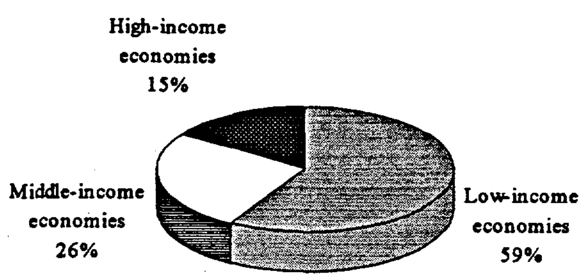


Figure 6: Adult illiteracy rates in low-, middle- and high-income economies (Data source: The World Bank, 1993)

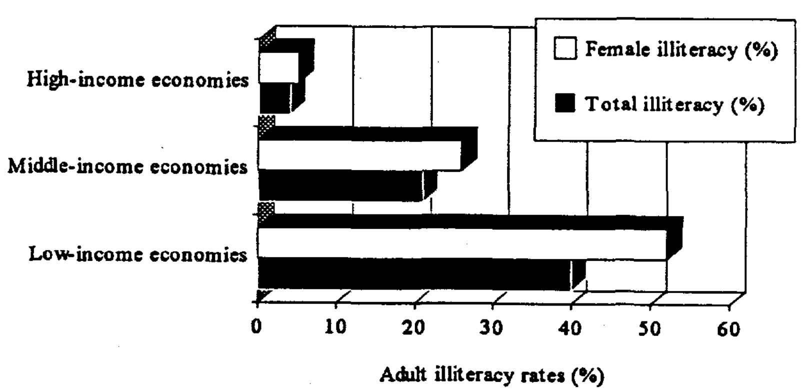


Figure 7: Expenditure for research and development (Data source: Unesco, 1992)

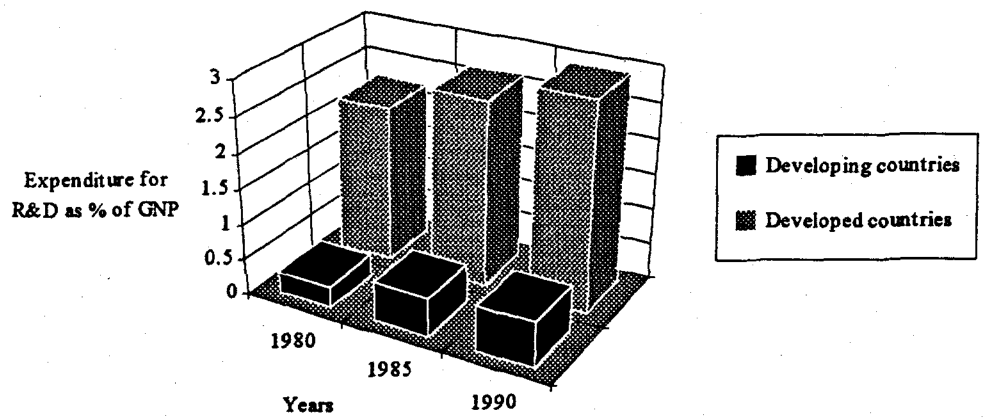


Figure 8: Total number of scientists and engineers working on research and development (Data source: Unesco, 1992)

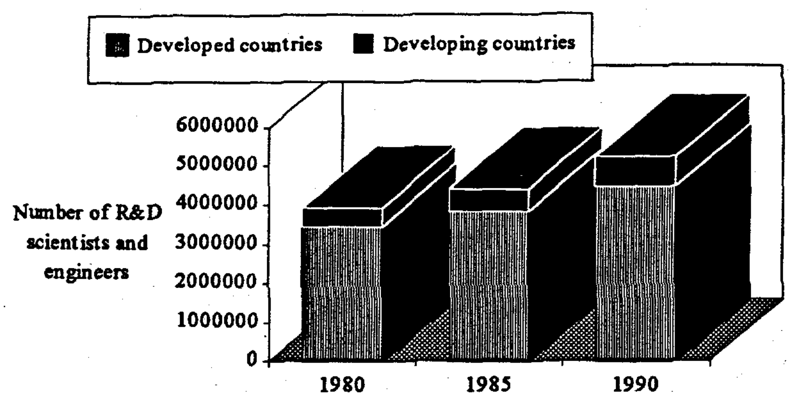


Figure 9: Number of R&D scientists and engineers per million of population (Data source: Unesco, 1992)

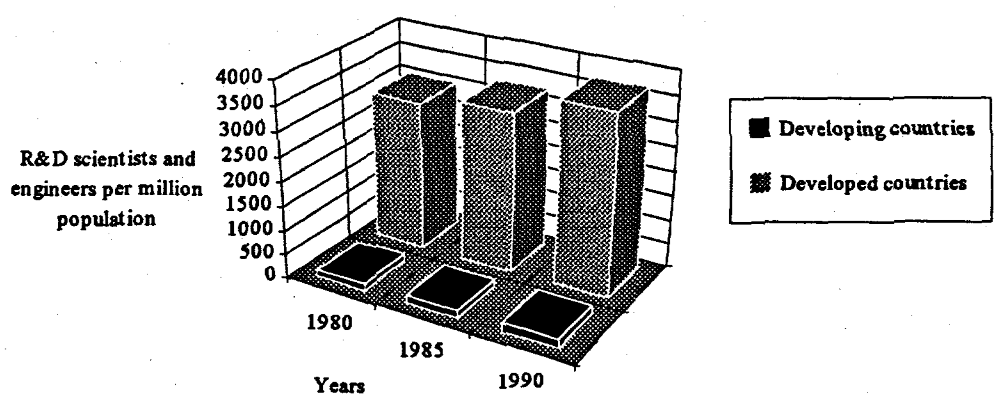


Figure 10: The geographical differences in science and technology manpower density (From Thulstrup, 1992)

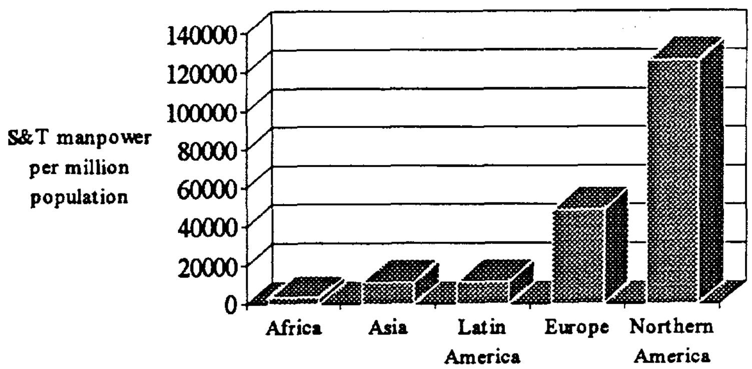


Figure 11: Percentage distribution of population and book production between developed and developing countries (Data source: Unesco, 1992)

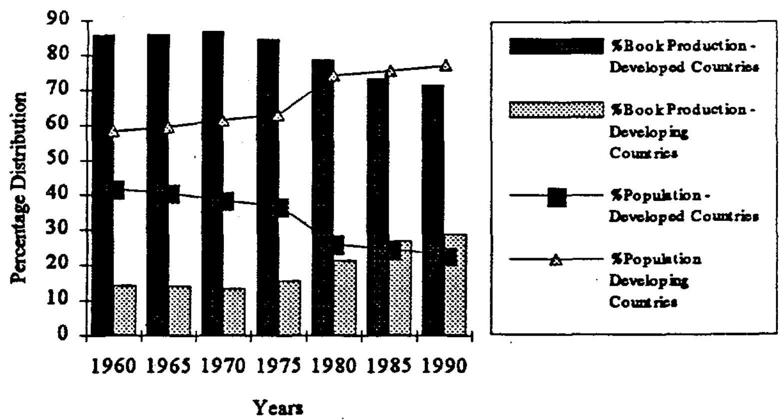


Figure 12: Number of book titles per million inhabitants (Data source: Unesco, 1992)

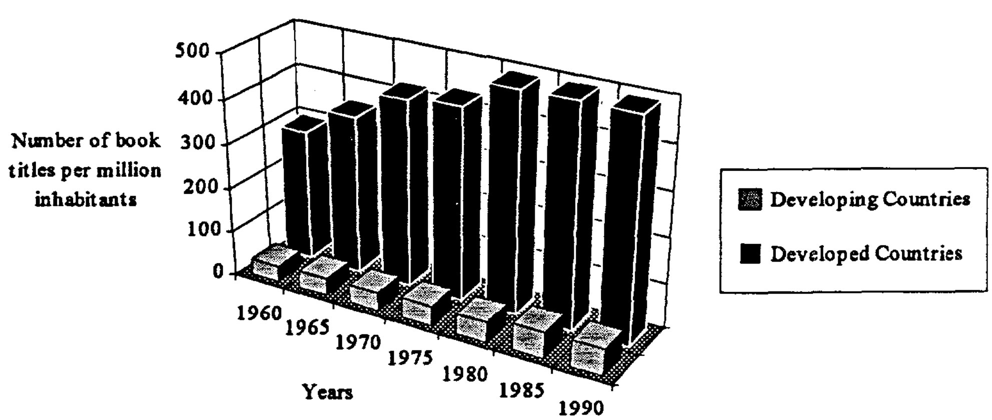
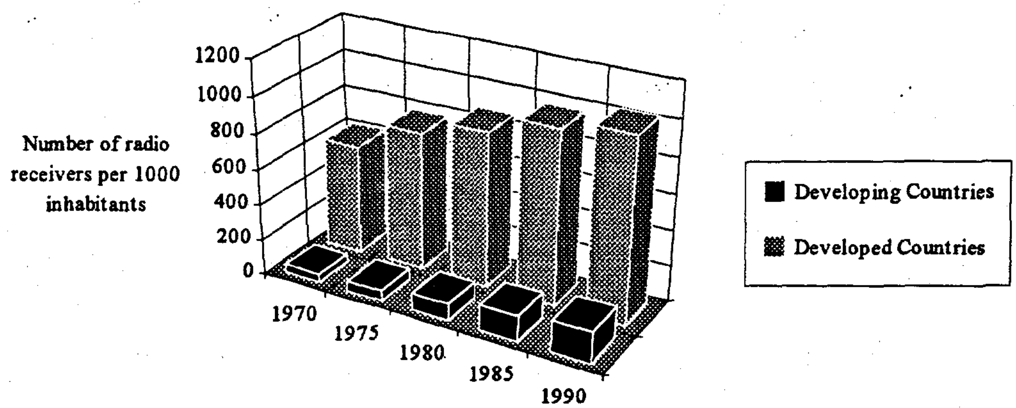


Figure 13: Number of radio receivers per 1,000 inhabitants (Data source: Unesco, 1992)



Why is the international communication in science and technology so difficult?

The exchange of information, especially in the field of science and technology, is hindered by several obstacles. The following issues have been identified by different authors, trying to analyze and understand the main problems related to S&T information exchange, and to search for possible constructive solutions:

The cultural, scientific and technological differences

There is a deep **cultural, scientific and technological gap** between industrialized and developing countries, which results in several misconceptions and problems. The following problems and complaints are most often discussed in literature:

From the viewpoint of industrialized countries:

(1) High illiteracy rates, poor education of indigenous people in developing countries, and persuasiveness of traditional cultures and traditional values seem to make the introduction of modern science and technology and the exchange of information very difficult.

(2) Lack or incompatibility of basic equipment and technologies (computers, telecommunications, software), together with undertrained staff, organizational problems and long bureaucratic procedures, cause long delays and many difficulties in the implementation of information projects.

(3) Many developing nations lack the scientific and technological terminology to express the scientific concepts and ideas in their mother tongue. In such cases, science and technology represent an alien culture to indigenous people. Insufficient knowledge of English and/or other languages used in the scientific literature sets another serious barrier in the transfer of S&T information.

From the viewpoint of developing countries:

(1) The scientific and technological information provided by donor countries is not adapted enough to the needs and priorities of developing countries. Science and technology publications sent to developing countries may sometimes be inappropriate (e.g. space research has little relevance to a rural community; nuclear power issues are not the first priority to village dwellers using cow dung as a fuel).

(2) Scientists in industrial countries sometimes try to assist their colleagues from the developing countries by contributing back issues of scientific journals and other publications. Some publishers and scientific associations donate overrun copies of their journals and reports. Such donation programs may result in relatively large quantities of inappropriate and obsolete publications, which take up the library space and lead visitors and potential donors

to think that the library is well-stocked, while there is still a lack of current, high-value target-oriented S&T publications.

(3) Information aid programs are often carried out solely by consultants from industrialized countries, without the involvement of local researchers, information specialists and administrators. Because of such strategies, much of the local knowledge is disregarded or lost.

(4) Some of the bilateral programs are directing resources towards the individual goals of a few researchers and their organizations in developing countries rather than towards the support of national and regional research and development needs.

To **reduce the existing information gap**, scientists from developing countries propose the following actions: (1) identification of the priorities and needs in developing countries, (2) recognition of the interdependence of the developed and developing worlds, especially in the production, utilization and transfer of technology and knowledge, (3) increasing the use of local experts in information processing and use of all indigenous groups as a source of information and knowledge, (4) education and training in S&T informatics - both for information providers and users, (5) searching for most suitable media, such as radio, publications and video to disseminate S&T information on most critical needs of developing countries (e.g. farming methods, health, sanitation, environmental protection) to all recipients, including rural or distant communities, (6) establishing effective information networks to capture and distribute the information and knowledge produced locally by scientists, technologists, government officials and primary producers, especially farmers, (7) supporting indigenous publishing programs and information systems serving local communities, (8) supporting pilot projects that demonstrate the use and costs of different information technologies and techniques (e.g. on-line and CD-ROM databases, desktop publishing, electronic mail, computer conferencing), (9) supporting software development and adaptation, designing, building and using specialized (local) databases.

High adult illiteracy rates

Illiteracy rates in several countries exceed 50 percent of adult population, and may in some cases run as high as 90 percent, especially for the female population (Figure 14). Illiteracy does not strictly correlate to the GNP of the country. However, the highest percentages of illiterates are found in the lowest income economies, and the proportion of illiterate adults decreases with an increase of GNP (Figure 15).

Some authors, addressing the problem of information isolation in rural areas of developing countries, have suggested as a solution the establishment of a strong network of rural libraries. The other group of information specialists, paying more attention to illiteracy issues, is skeptic about the introduction of written materials. In cases where the majority of rural dwellers are illiterate, they cannot directly benefit from publications in a foreign language. To overcome this problem, radio broadcasting in the indigenous language has been proposed as a fast and effective S&T dissemination tool in high-illiteracy communities. Nowadays, most of the households or at least villages in low-and middle-income economies own a radio set.

Figure 14: Examples of countries with high illiteracy rates (Data source: The World Bank, 1993)

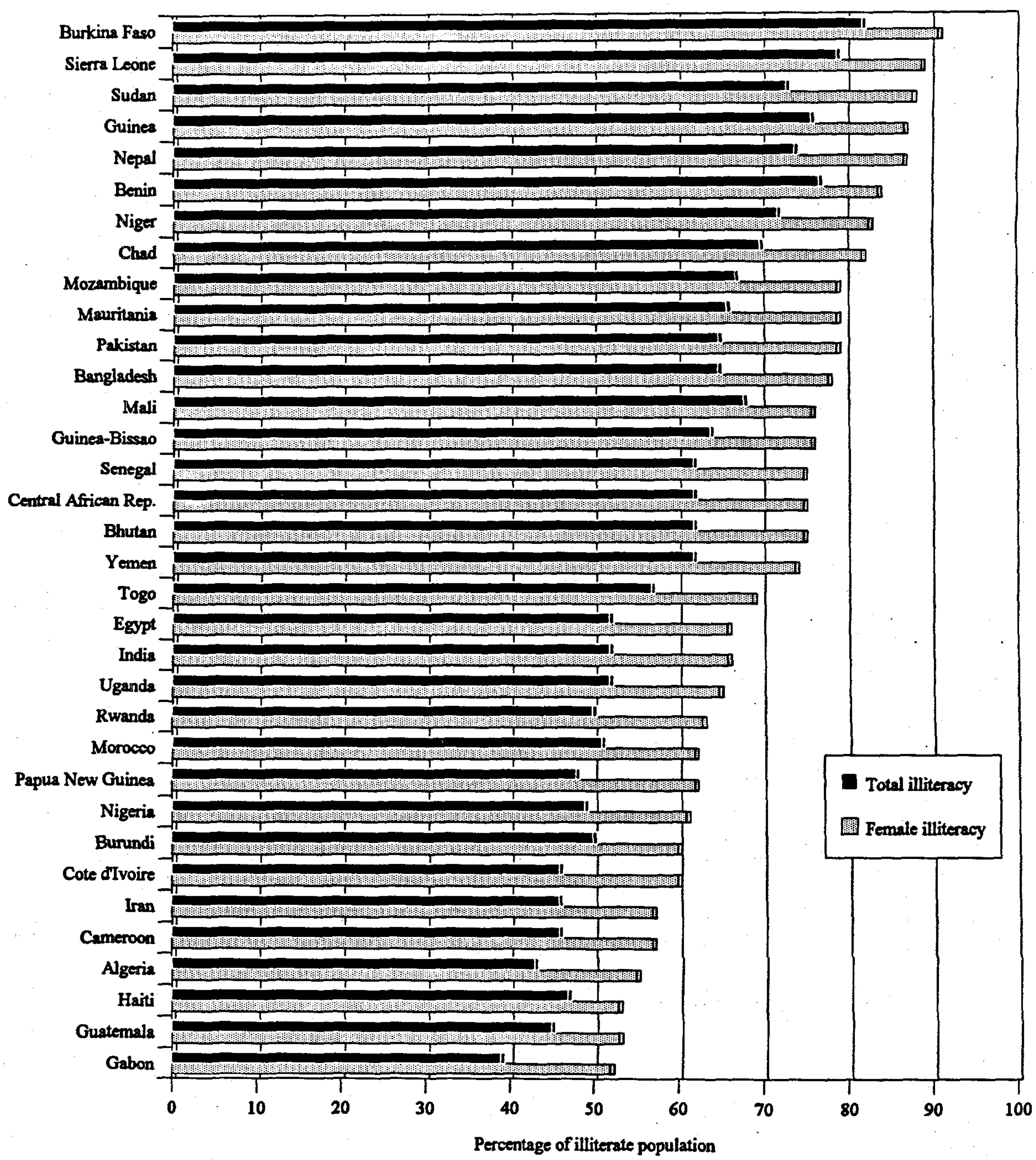
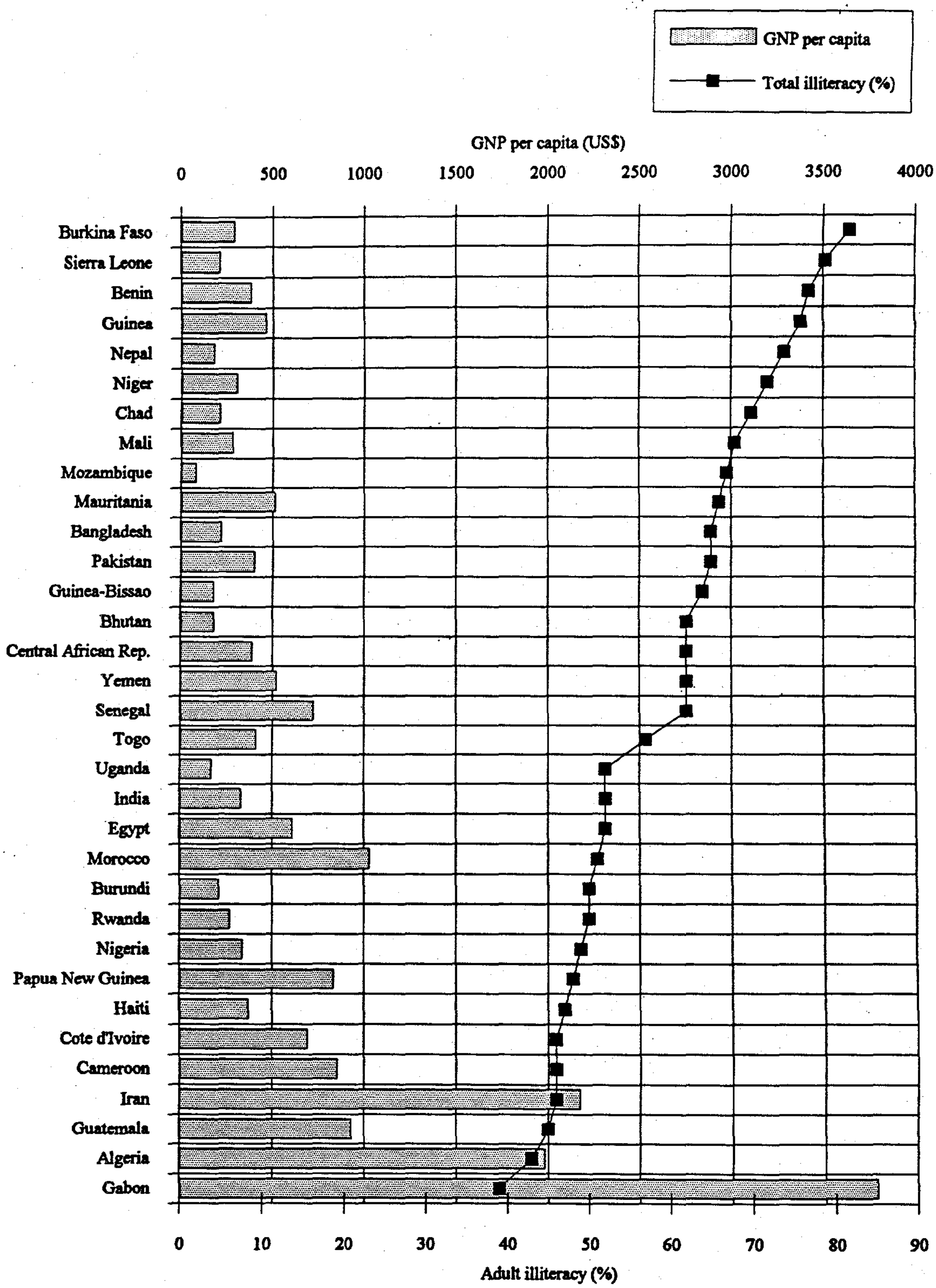


Figure 15: The relationship between adult illiteracy and GNP per capita: examples of countries with high illiteracy rates (Data source: The World Bank, 1993)



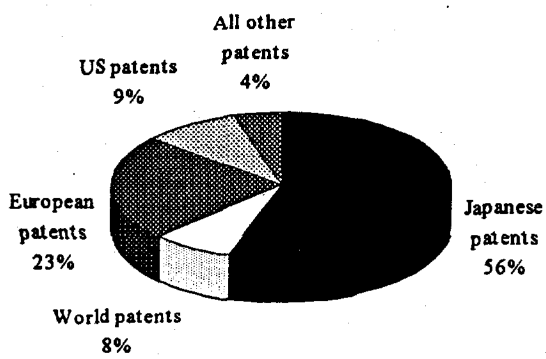
The foreign language barrier

In young or small nations, anxious to establish their identity, the country policy often emphasizes the use, spread and development of **local languages** in all fields, including education, research and S&T publishing. The positive effects of these policies are the development of scientific vocabularies in local languages, larger quantities of locally available S&T literature, and easier/wider use of scientific publications by local researchers, students and general public. However, a strong focus on local language may result in poorer foreign language skills, underuse of foreign scientific literature, smaller participation of local scientists on the international S&T information market, which all lead to an information isolation.

Although there is an undeniable pressure to **publish scientific and technological findings in English**, the number of languages in which scientific research results are published is steadily increasing and already exceeds sixty. This pressure may affect different languages unequally. Statistics show an increasing trend of English articles in German scientific journals, while the trend in Japanese journals is decreasing (Thorp, et al., 1988). Similarly, different scientific fields and different document types show different trends. Findings of **fundamental scientific research and medical research** are most often published in English. Exchange of fundamental S&T information and writing in a *lingua franca* are promoted by the research quality evaluation system, which is to a large extent based on a number of scientific quotations. On the other hand, the results of **strategic fundamental and applied research, technological inventions and industrial improvements** are patented first, and may only later be published in another form. A priority patent is normally applied in a domestic country and in a country official language. The invention may therefore be additionally protected or hidden by the language barrier. The system of patent equivalents (patent applications from same patent family, applied in different countries) breaks a language barrier and provides patent literature in different languages. However, several firms, especially Japanese, prefer to patent their inventions only in their homeland. This phenomenon of re-introducing a language barrier is becoming more pronounced in highly competitive scientific and technological fields, as illustrated on an example of microencapsulation. Among the applications of this technology, pressure-sensitive carbonless copying papers represent the most successful commercial product (Figure 16).

There are a number of ways in which language barrier problem may be improved. Several international scientific databases provide English abstracts of non-English scientific literature (e.g. JAPIO for patents and JICST-E for scientific papers published in Japan). However, for an in-depth study abstracts are not sufficient. Strong industrial research groups often have information specialists for the translation and analysis of patents, technical reports and strategic S&T papers in Japanese, Chinese, Arabic, German, French, Italian, Spanish and Portuguese languages.

Figure 16: Illustration of a language barrier: a large proportion of Japanese patents on microencapsulation technology (From Boh, 1993).



Absence of an enabling technological environment

Because of the large amount and rapid growth of S&T information, the effective acquisition, processing, dissemination and use of information cannot be achieved without the minimum **technological infrastructure.** In this respect, the developing countries are facing severe problems, such as (1) lack of computers and communication networks, (2) lack of easy to use and affordable software, (3) incompatibility of systems, (4) lack of adequate environment for hi-tech equipment, (5) lower life-time of equipment and materials because of the extreme climatic conditions, (6) insufficient and/or improper maintenance, (7) difficulties in purchasing basic consumables and spare parts for the acquired hardware. The introduction and/or improvement of technological infrastructure for the development and use of S&T information systems requires (a) national policies that encourage growth of the information sector, and (b) training programs for specialists in technologies, computers and informatics, courses for technicians and maintenance personnel, as well as suitable education programs for managers and decision-makers.

Insufficient training in S&T informatics

Several developing countries have already made a considerable progress in acquiring new information technologies, but did not pay sufficient attention to an adequate personnel and end-user education. An organized **training in S&T informatics** is needed for different groups of professionals, including S&T information specialists, librarians, researchers, university professors and school teachers, students in different S&T fields, government officials and policy makers, industrial managers, professional science journalists and science books writers. Unfortunately, the existing educational system in most cases does not pay sufficient attention to S&T information -- students are not trained to be aware of the value of information. Traditional teaching is still based on memorizing facts from lectures and prescribed textbooks, and does not aim at the development of skills for searching and collecting different information sources, analyzing, comparing and structuring data, and using information in a creative way. The S&T informatics is underrepresented even in the high-level informatics programs, which are usually focused around librarian science, information technologies, management and administration, financing, economics, investment, development, legislation and law, and only rarely include informatics for natural and human resources, environmental issues, science, research and technology. For an effective participation in a S&T research team, the S&T information specialist need to acquire education in both, **specialized scientific field** (e.g. chemistry, medicine, biology, physics, engineering) and in **information science**, including statistics, information technologies, information retrieval and procurement, data analysis and processing, special information methodologies, applications programming, S&T databases and information systems design and use. A good model to achieve a profound science/informatics interdisciplinary knowledge seems to be a combination of undergraduate studies in science and technology, followed by graduate information science Ms. or Ph.D. programs.

Lack of information

Potential users of S&T information are not sufficiently informed on the available information resources and different possibilities for data processing. There is a lack of information about:

(1) **Where to find information**. Which local and international institutions provide S&T information, which are the available libraries, information centers, information exchange networks, database hosts, and what are their activities and programs.

(2) **Which information sources** (scientific periodicals, specialized literature, on-line and CD-ROM databases) are available and most appropriate for the specific S&T fields.

(3) **How to obtain, process and use S&T information**. What are the procedures for data gathering and acquisition of publications, what are the most appropriate hardware and software packages for information processing, what are the methodologies and techniques for data structuring, searching for patterns of knowledge and designing of research hypotheses.

High cost of S&T information, lack of funds

Several middle-income countries encounter lack of hard currency to upgrade and maintain telecommunication systems, to buy modern equipment, especially hardware and software, and to use information services, such as computerized international databases. In addition to these problems, low-income economies report on an acute shortage of funds to procure and distribute the basic sources of information, such as CD-ROM products, books, scientific journals, and even paper, toners and ink.

Scientific literature: a basic source of S&T information

Access to traditional sources of scientific and technological information is the basic prerequisite for any information support to a research project or educational process. For an in-depth information coverage of a specific scientific field, all available types of scientific publications have to be acquired and analyzed, such as scientific journals, books, conference proceedings, patents, standards, technical and research reports, dissertations, trade literature and special maps. Limitations to only a few information sources may lead not only to gaps in acquired information, but also to serious losses of the whole information sets, costly duplication/repetition of research and unnecessary authorship/intellectual property conflicts.

The following chapter summarizes the basic characteristics, issues, trends and opportunities for acquiring and using traditional sources of scientific and technological information.

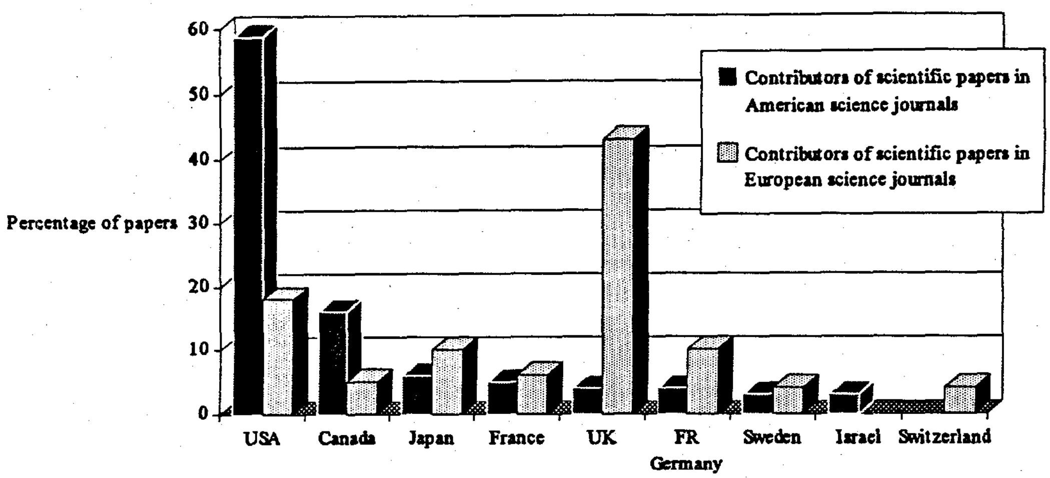
Scientific journals

S&T journals bring the latest findings of fundamental scientific and medical research, results of experiments and tests, descriptions of new research and technological procedures, new methodological approaches, information on new materials and technologies, and overviews on specific S&T topics and disciplines. Scientific journals remain the major source of scientific information. According to Altbach (1988), there are more than 100,000 scientific and scholarly journals in the world, reflecting a substantial financial investment as well as the core of a worldwide network communications.

While the largest part of scientific journals is published for **national** academic communities and with limited circulation within the country, there are relatively few top **international scientific publications** which dominate the market and are of primary importance, have highest prestige and greatest influence on research. English serves as a major international language for S&T communication, therefore almost all of the top scientific publications with wide circulation are in English. Using English as the main language in important scientific journals has an obvious advantage - easier communication and a wider subscription base. However, it may result in several consequences for non-English speaking nations. Authors whose native language is not English, encounter problems with translation and editing of their manuscripts. Some authors from developing countries feel that the major scientific journals are dominated by the research paradigms of the major English-speaking academic communities, which only hardly accept contributions written from other perspectives.

The strongest and most prestigious S&T journals come from the **American** and **European** publishing houses. An examination of 40 important journals, equally balanced between life and physical sciences (20 European and 20 American), has shown a different representation of authors from industrialized countries, and an absence of top scientific contributions from the developing countries (Figure 17).

Figure 17: Distribution of main contributors to scientific papers in selected American and European scientific journals (From Stankus, 1990).



However, an analysis of scientific papers output, based on Science Citation Index (Stankus, 1990), shows a 3-5% growth rates for USA and the Western European countries, and a strong break-through (33-45%) of **Asian fast-developing countries**: Singapore, Taiwan, Hong Kong and S. Korea (Figure 18). Another study, based on the Science Citation Index, is comparing the number of scientific papers per million of population and the number of citations per paper for the selected industrialized countries (Thulstrup, 1992). The native English speaking countries (USA, UK and Canada) are not directly compared with other countries, since the Science Citation Index is slightly biased towards English language journals. In spite of this, some **smaller European countries** have a higher productivity of scientific papers and higher citation rates per paper, which reflects a productive research and a good quality of scientific publications.

Figure 18: Average annual growth rates of scientific papers output for USA, selected European and Asian countries (From Stankus, 1990, based on the Science Citation Index)

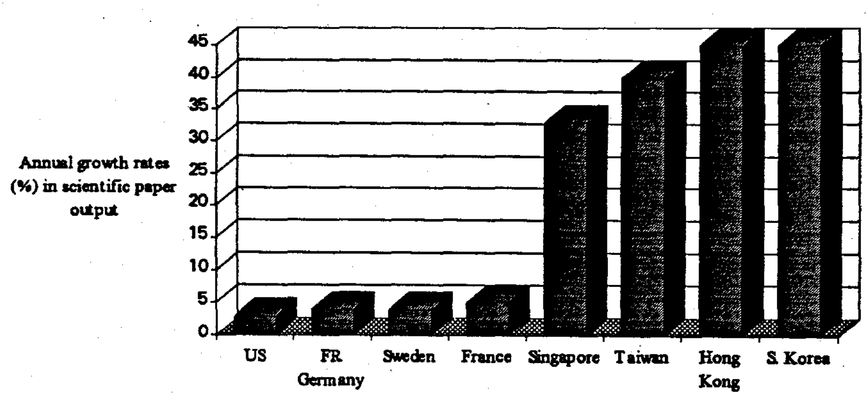
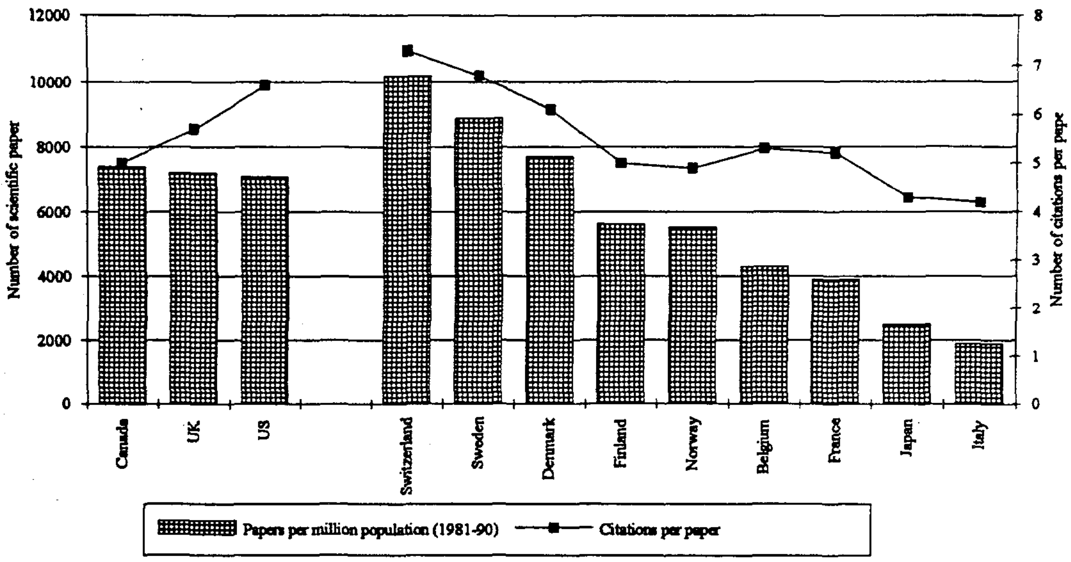


Figure 19: A comparison of research paper productivity and citations per paper for selected English speaking and other industrialized countries (From Thulstrup, 1992, based on the Science Citation Index)



As a competitive balance to numerous American S&T journals, the number of science journals that focus explicitly on European research is increasing (Stankus, 1990). Almost all **Eurojournals** are based in Western Europe and often have predecessors in single-nation journals. This is an advantage over entirely new journals, which have to build an academic respectability and develop a network of reviewers and subscribers. Some Eurojournals are endorsed by European research societies, the others are based at European multinational research centers. Eurojournals are often affiliated with strong publishing houses such as Pergamon, Springer-Verlag, and Elsevier. They cover different specialized scientific fields - especially life sciences - and seem not to be competing among themselves.

Japan is publishing several quality scientific journals - some in Japanese and some in English. However, the analysis of numerous articles and citations, performed by several firms and universities, show that with a few exceptions, the Japanese themselves still place primary emphasis on publishing in highly cited American and European scientific journals. An examination of 4000 papers in 40 important natural science journals places the Japanese researchers as the third most frequent contributors of scientific papers (see Figure 17).

Apart from Japan, a number of rapidly developing **Asian countries** are becoming serious scientific and economic competitors of the United States and Western Europe. The international publishing trends of Hong Kong, China, Singapore, Korea and Taiwan show very intensive growth rates of scientific papers (see Figure 18). The effect is most pronounced in research and development of new high technologies, such as electronics, computers and biotechnology.

Canadian scientific journals are of high quality and have a relatively wide subscription base, therefore they are attractive for publishing. In comparison with American and Eurojournals, they do not achieve as high impact factors, but they seem to be a practical surpass between the highest ranking and individual national society journals.

Another important group in the hierarchy of publications are **regional scientific journals,** published in major non-English languages, such as Spanish for Latin American region, and French in Francophone Africa, and scientific journals from larger developing countries using English as the main language of scientific publishing, such as India, Kenya and Nigeria. Scientific journals published in Chinese, Japanese, Russian and German languages may have high quality standards and a relatively large subscription base, but because of the language barrier they are limited almost exclusively to the mother countries.

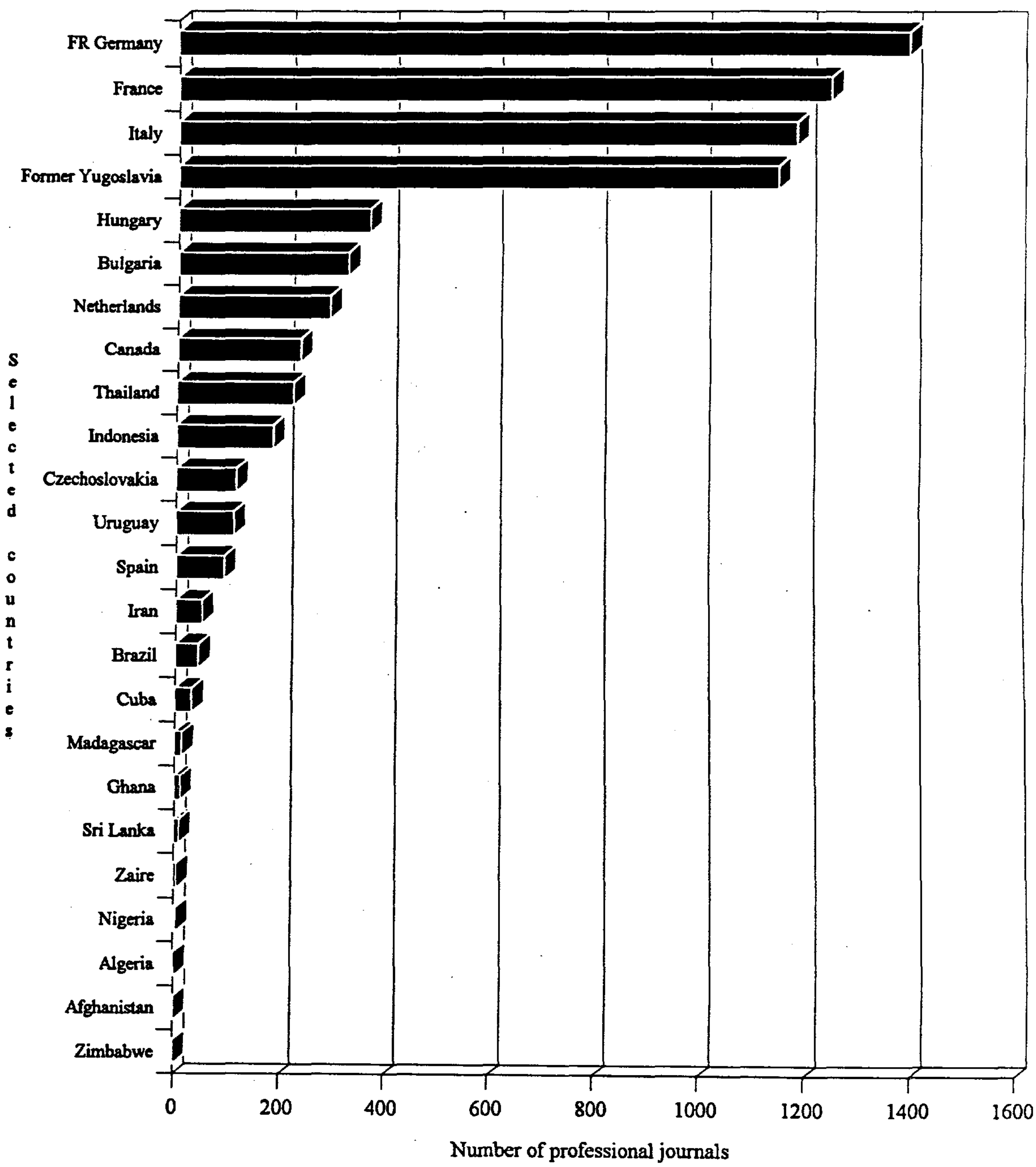
The number of **national professional journals** differs substantially from country to country (Figure 20) reflecting the differences in GNP, status of S&T in a society, and the variety of national languages. However, a high number of national scientific papers does not necessary mean an advantage, especially if they appear infrequently, have long publication times, limited circulation, weak editorial systems and if they use local languages, which may result in insufficient exposure of the work elsewhere. In such cases, the possibility of transforming the small research journals into a limited number of larger, subject specialized and better quality journals has to be promoted (Thulstrup, 1990).

From the viewpoint of **economics**, scientific journals follow the pattern of small enterprises which collect funds from subscribers and other fees, and spend for editing, printing and distribution. They require relatively little capital, are labor-intensive, and most often provide little (if any) remuneration for editors and authors of articles. For most scientific journals, libraries constitute the bulk of the buyers. Library subscriptions charges are typically much higher than subscriptions for individuals (as the library copies are used by many readers), therefore libraries provide a kind of subsidy to scientific journals.

The **economics of publishing** differs from country to country, depending on labor and printing costs. Industrialized countries use several ways to finance journals: in many cases scientific journals are published by private publishers (large publishing houses), earning good profits from them. Others may be sponsored/subsidized by strong scientific organizations and academic institutions. Scientific journals in developing countries are often sponsored by academic and governmental institutions and sold at subsidized prices. Especially in the case of small journals, the survival rates are fairly low.

New technological innovations have different impacts on S&T journals. The **bibliographic databases** offer much better overview on publications, and enable quicker and better selection of appropriate publications. However, the selection of sources they cover may be biased towards English language publications and the literature from industrialized countries, omitting several potentially important contributions from smaller nations and developing countries. Not being included in international bibliographic databases in practice means remaining outside the main stream of scientific communication. **Computer assisted publishing** can significantly reduce the cost of production and shorten the lag time between the discovery or invention, and publishing. Desktop publishing offers better survival chances for scientific journals with limited audiences. Laser printers and photo-offset printing enable better quality images. The introduction of computers permits easier and more effective record keeping. On the other hand, the **widespread use of photocopying** seems to be a serious threat to scientific publishing, especially to the scientific journals with limited circulation, which depend on each subscriber. Legal protection by copyright laws is in practice very often violated by unauthorized photocopying, which seem to be attractive for individual researchers, particularly in the scientific communities which do not have an easy access to international journals, but may in a long-term run seriously damage the system of scientific publishing.

Figure 20: Production of national professional journals in selected countries (Data source: Unesco, 1992)



S&T journals published in developing countries are faced with several **problems and difficulties**, such as: (1) entering the international scientific library market, dominated by the publications in the industrialized nations, (2) attracting the recognized authors - even the best local scientists prefer to publish in prestigious international journals, (3) getting a constant and quantitatively sufficient input of new articles, (4) reaching and maintaining the international quality standards in terms of scientific contents and editing, (5) meeting the international standards regarding quality of printing, paper and durability of journals, (6) establishing a stable income base, printing facilities and distribution mechanisms to offer a regular supply of new issues according to the planned timetable.

For the users, S&T journals are among the most expensive serials, and most of them come from strong-currency countries. Many small research and educational institutions feel that high cost of science journals represents a disproportionate part of the budget. In a study on scientific journals, Stankus (1990) proves this thinking as inappropriate and short-sided, as the scientific minority that use science journals may be critically important for the scientific, technological and medical future of the majority. A comparative analysis of the reading habits of student population has shown that access to a good assortment of science journals supports better education and results in a better professional performance of researchers and scientists.

Books

Different types of books relevant to S&T include (1) monographs covering very narrow scientific topics, broader scientific and technological fields, or multidisciplinary issues, (2) S&T encyclopedias, (3) technical manuals, (4) statistical yearbooks, (5) S&T textbooks for different educational levels, and (6) S&T books for the general public.

Compared to scientific papers and patents, which usually compete for the priority on new research and development, the books provide a few years **older but more comprehensive and better structured information**. The amount of S&T books published in a country reflects the status of S&T, productivity of research, information needs of the educational system, and a variety of national languages (Figures 21 and 22). Most of the countries publish a larger proportion of applied S&T than fundamental science books. However, in some countries, the ratio is strongly shifted towards the fundamental science books. This may reflect the isolation of science to a limited group of scientists, low interest for applications of S&T, and lack of "science for all" approaches in the education.

Proceedings from S&T events

Scientific and technological contributions from the international, regional or national S&T events are usually published in a form of proceedings, containing abstracts and/or full text papers of presented lectures and posters. S&T events include conferences, symposia, seminars, workshops and regular meetings of S&T societies. Proceedings from a big international conference may be published as a series of several volumes, and the time difference between the presentation and publishing may take more than one year. However, the information in proceedings from smaller events can be very new, especially with the desktop publishing or ready-to-copy written contributions. Proceedings from S&T events may therefore be regarded as a valuable **source of new information**.

Figure 21: The number of scientific book titles, published in the selected countries: most cases 1990 or the last year data available (Data source: Unesco, 1992)

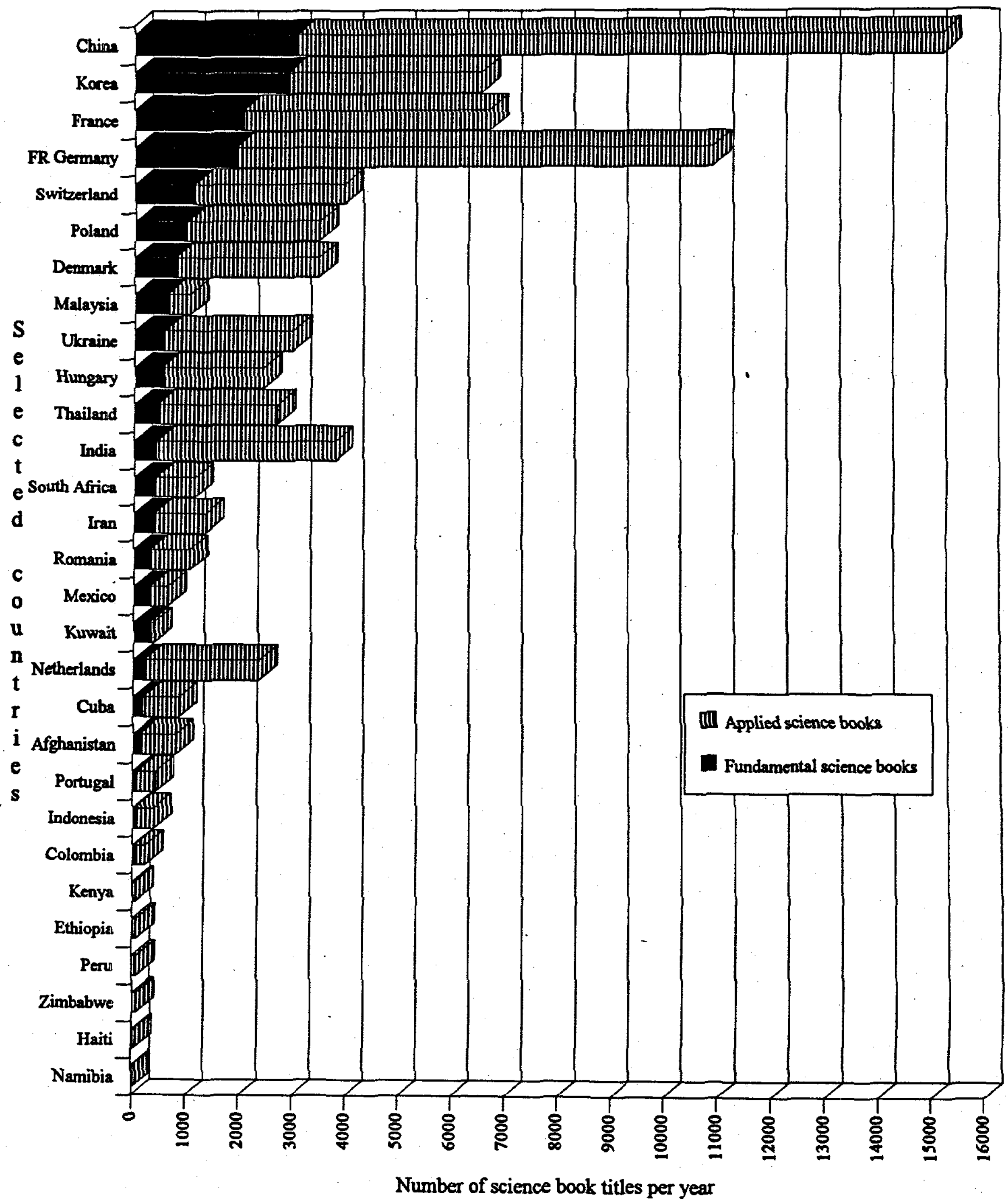
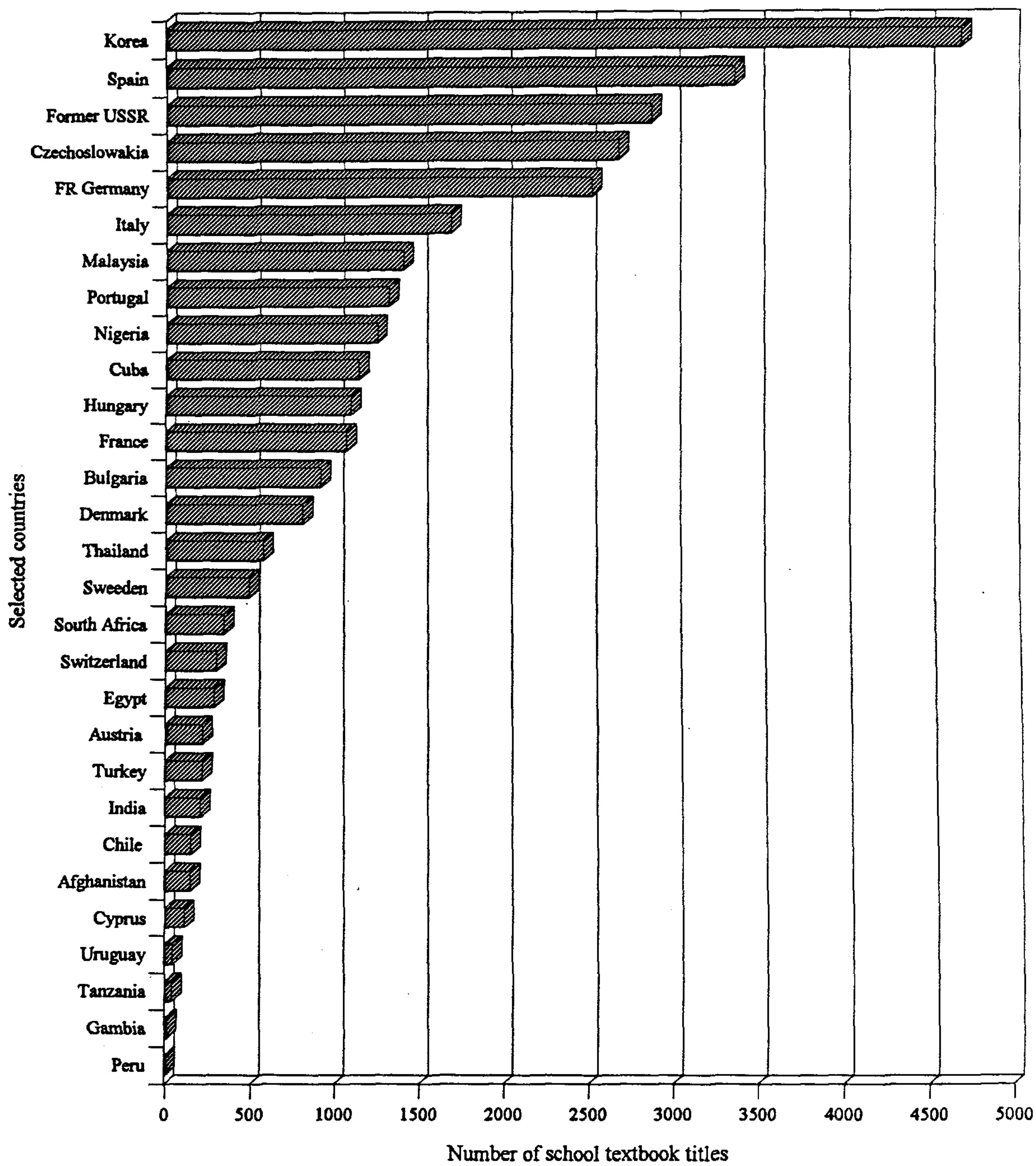


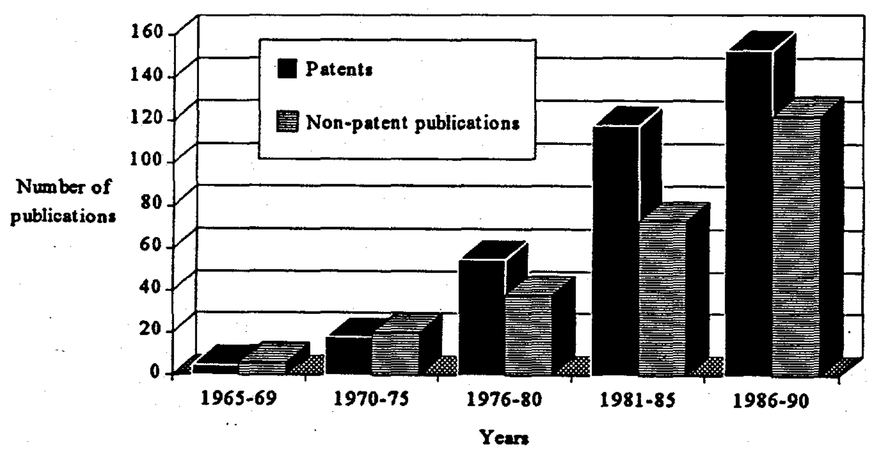
Figure 22: The number of textbook titles, published in the selected countries: most cases 1990 or the last year data available (Data source: Unesco, 1992)



Patents

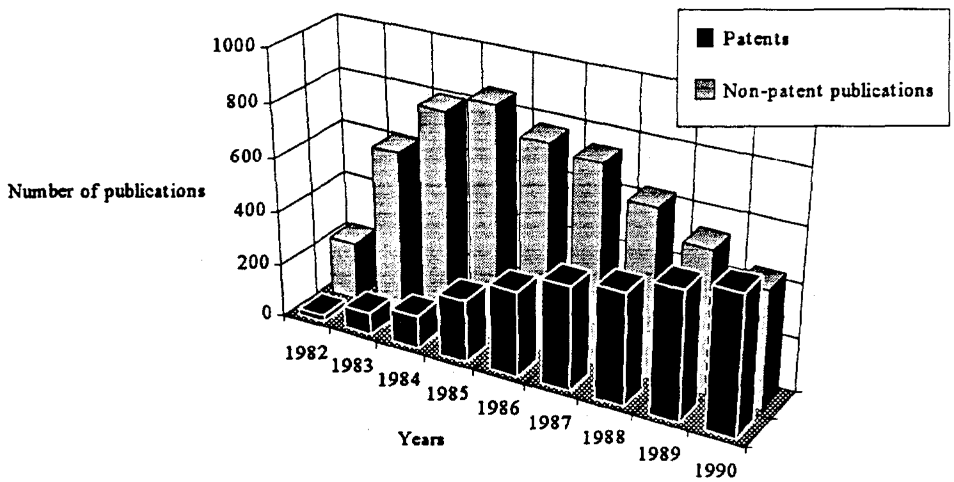
The scientific discoveries, inventions and improvements in strategic fundamental research, applied scientific disciplines, and technologies that are of high industrial importance, are patented first and may only later be published in scientific journals. In such fields, the patent literature is prevailing over scientific papers and other non-patent literature, as illustrated on the example of interfacial polymerization microencapsulation, which is one of the specialized technologies in chemical, pharmaceutical and paper industries (Figure 23). In such cases, a strong orientation exclusively towards scientific papers and books, which is still present in many scientific communities, obviously leaves out the most important source of information for a developmental researcher.

Figure 23: Cumulative growth of patent and non-patent literature for an industrially important technology: interfacial polymerization microencapsulation (From Boh and Kornhauser, 1992b).



Analysis of trends in patents versus non-patent literature for a specific discipline is a good **indicator of research intensity and orientation.** Absence or low number of patents usually indicates a fundamental stage of research, still far from economically important applications. Rapid growth in patents reflects an intensive research for development of new products and technologies. In the last stage, when technologies are in use and products on the market, the research aims primarily at industrial improvements, which are patented, while the number of scientific papers drops. Figure 24 illustrates the dynamics of patent and non-patent literature growth during the research and development cycle of monoclonal antibodies: from basic molecular biology to biotechnology, pharmaceutical and medical applications.

Figure 24: Dynamics of patent and non-patent literature during the research and development cycle of monoclonal antibodies (From Boh, Kornhauser and Musar, 1992)



Patents can also be taken as an **indicator of country research characteristics** (Figures 25 - 29). Low-income countries with weak research base submit only a few patents per year (Figure 25). In middle- and high-income economies the number of patents additionally depends on the orientation of research: S&T research in Japan, which is the world leading country in a number of patent applications per year, supports the transfer of S&T achievements into practice for the development of new materials, technologies and products.

Not all the patent applications become granted patents, and not all of the patents are really used in practice. Patents in S&T are written in a specific language and in a specific style to protect the invention, but at the same time try to hide or mask the essential data. This makes patent literature more difficult to read than books and scientific papers. In propulsive S&T fields with large amounts of patents, each of them covers only a specialized segment. Information seem to be disorganized, dispersed and fragmented, which renders more difficult the recognition of parameters and relations between them. To be able to use patent literature, science and technology students and researchers need to master specific information approaches, such as structuring data into systems, concept mapping and recognizing patterns of knowledge. **Patent information processing and writing patents should become an integral part of university studies in science and technology.**

Figure 25: Examples of countries with less than 100 patent applications per year (Data source: United Nations, 1992).

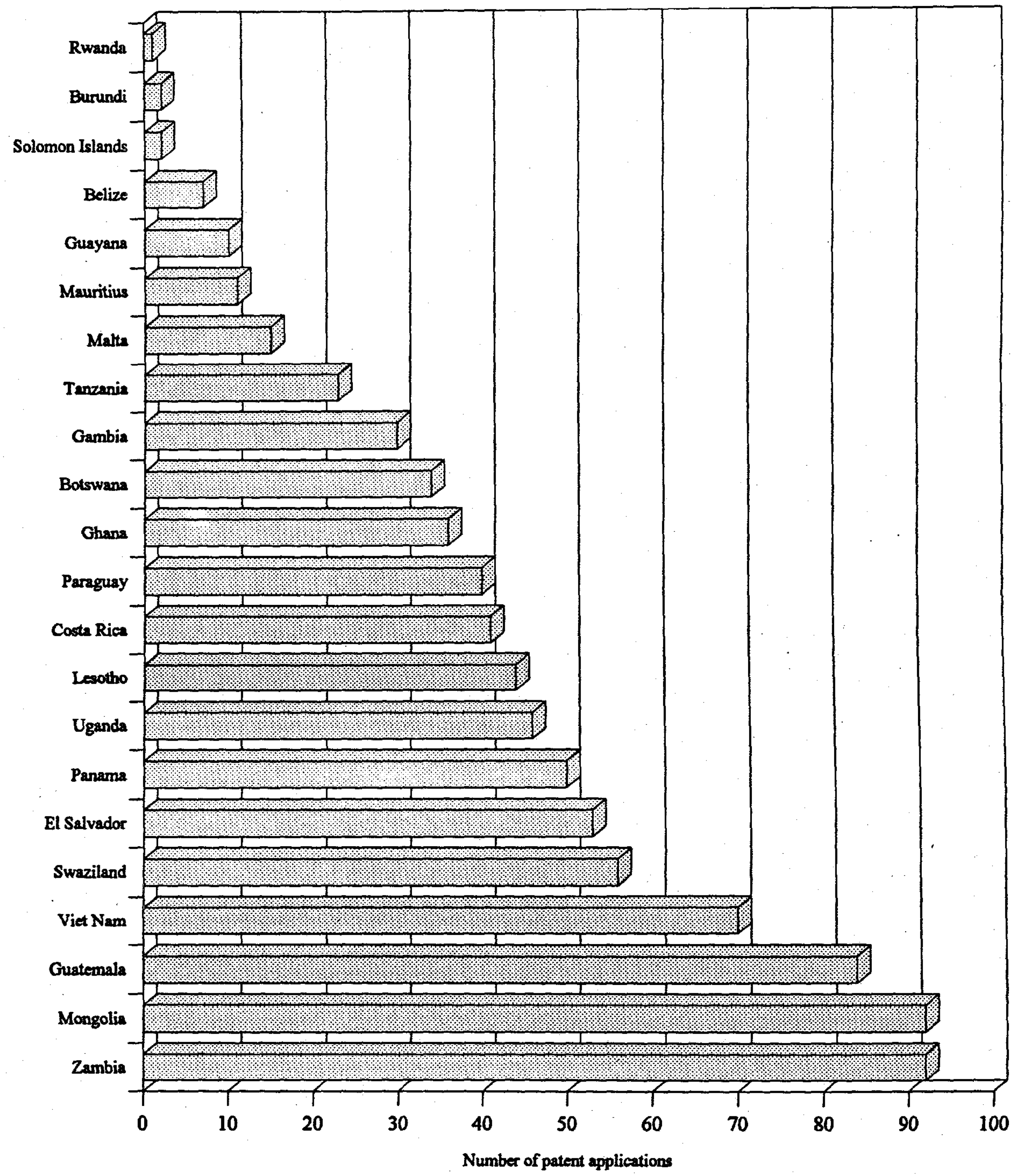


Figure 26: Examples of countries with 100 to 1,000 patent applications per year (Data source: United Nations, 1992).

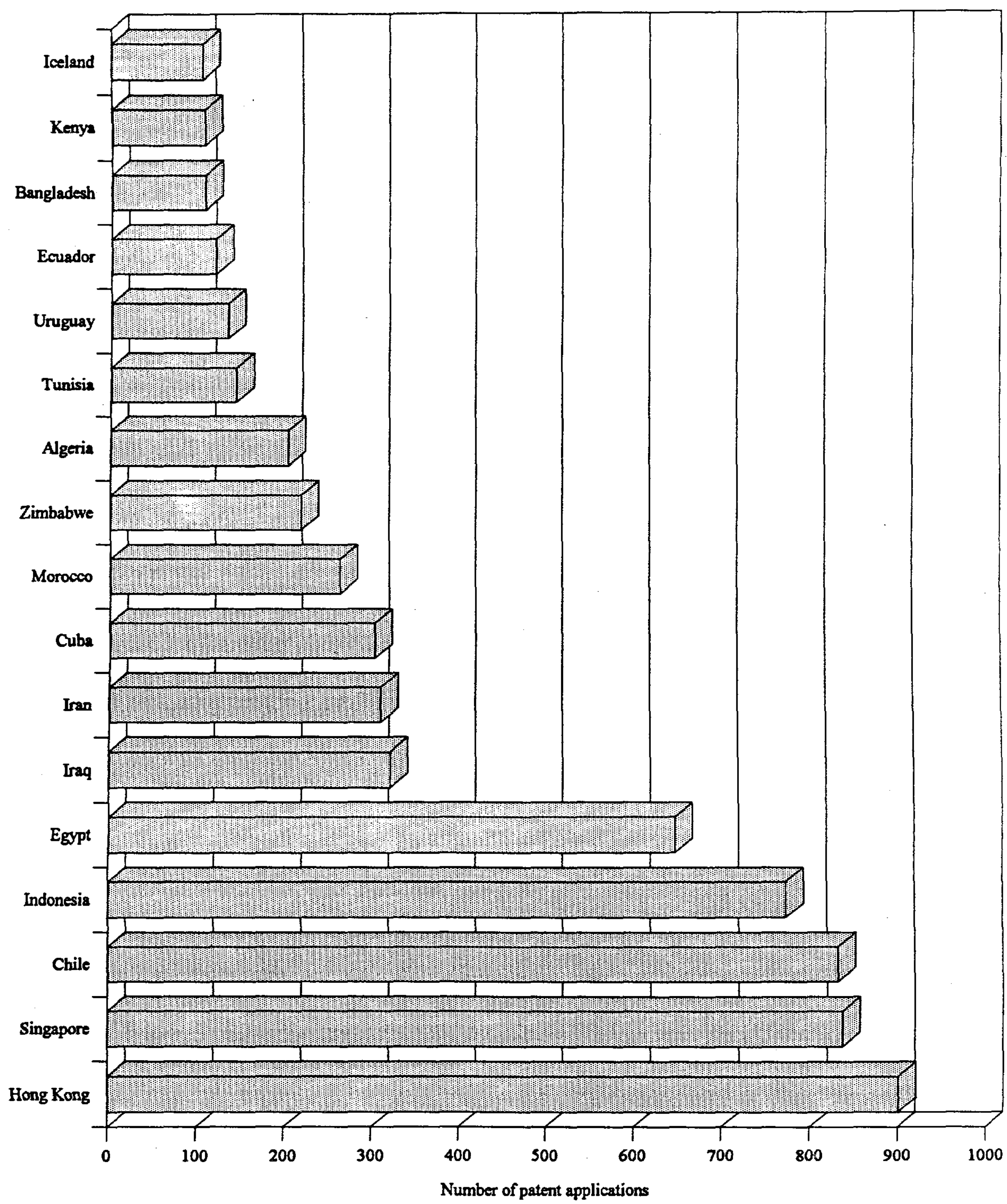


Figure 27: Examples of countries with 1,000 to 10,000 patent applications per year (Data source: United Nations, 1992).

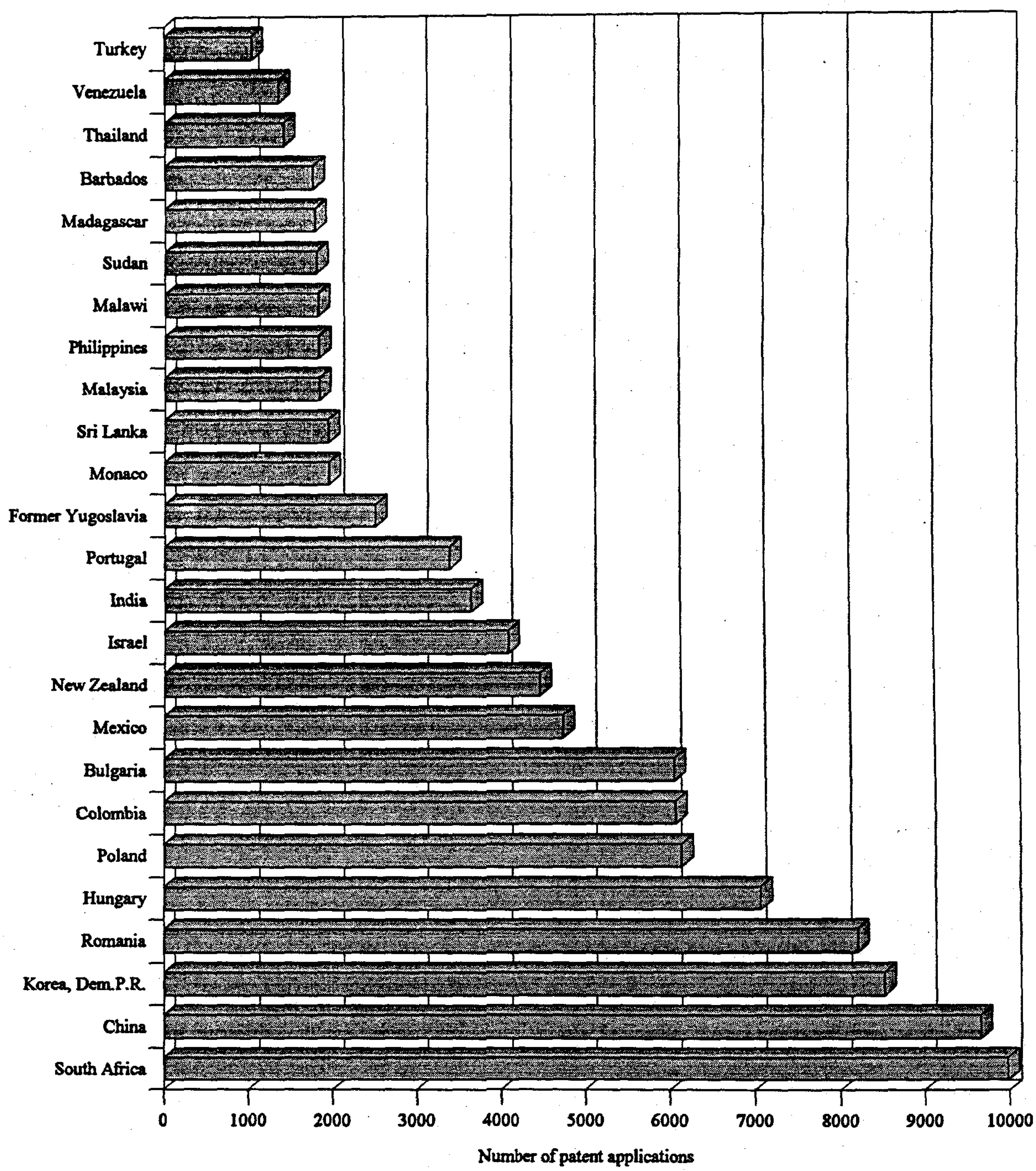


Figure 28: Examples of countries with 10,000 to 100,000 patent applications per year (Data source: United Nations, 1992).

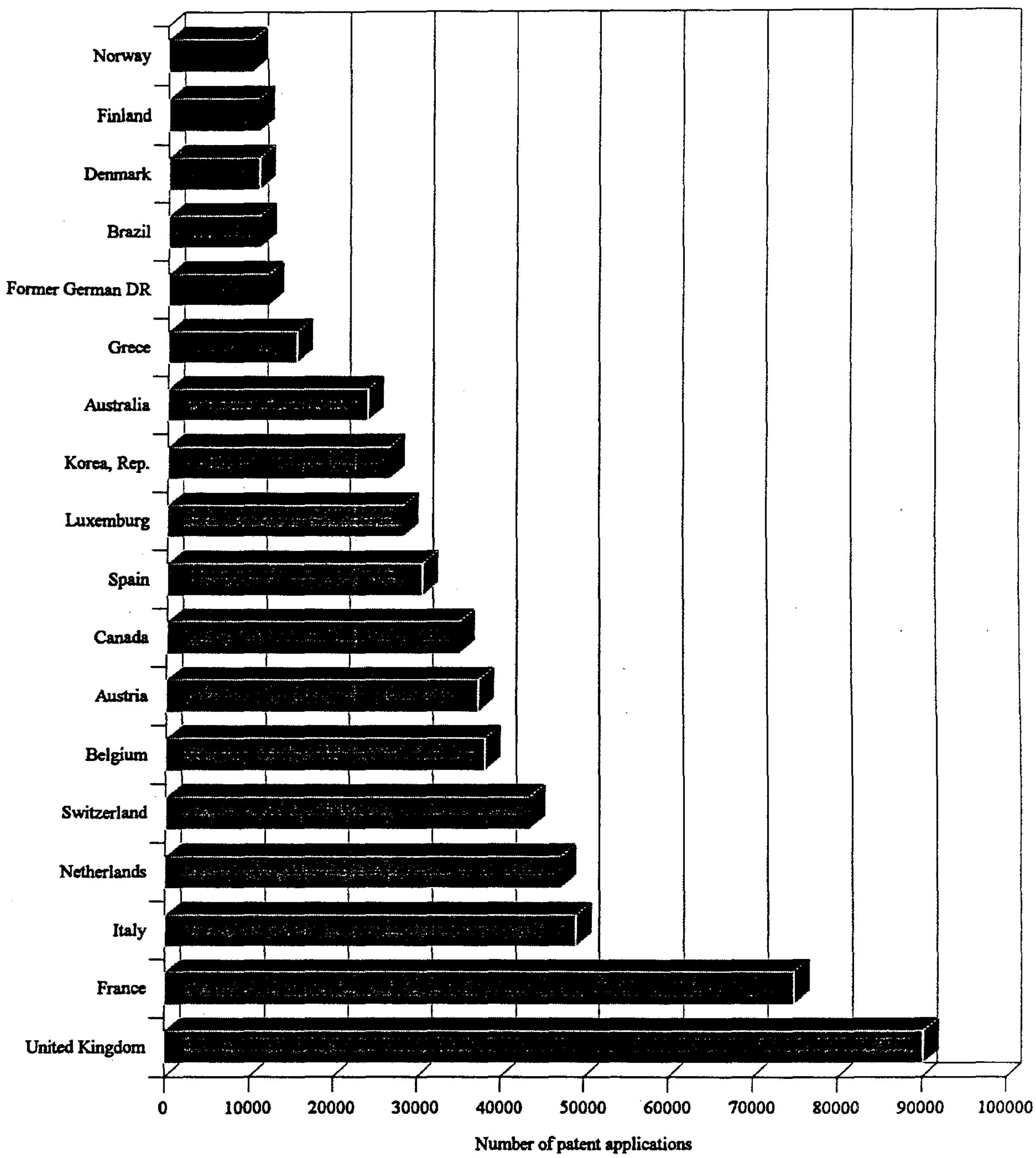
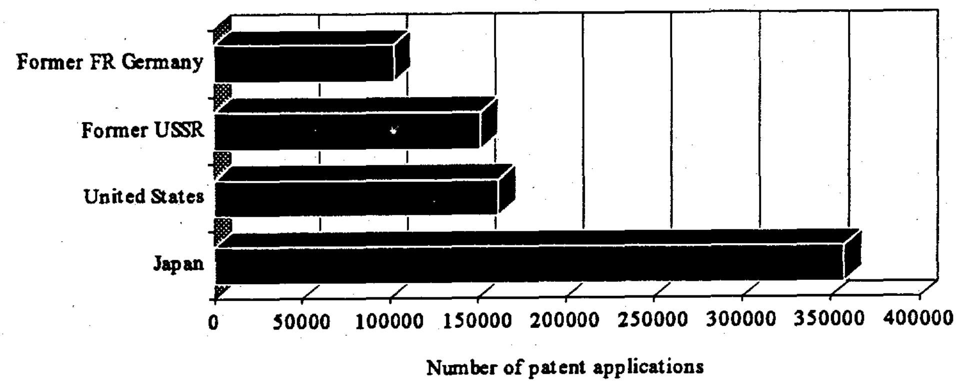


Figure 29: The patent mega-powers with more than 100,000 patent applications per year (Data source: United Nations, 1992).



Standards

International and local standards describe the appropriate or acceptable characteristics of scientific and technological innovations, products and technologies. They are an indispensable information source for applied research and industrial development departments, both for developing/exporting and for adopting/importing different products and technological know-how.

Technical and research reports

Among the most important gray literature documents (not officially published, but can circulate in scientific and technical organizations) are the reports of scientific and technical research groups from the universities, research institutes, industrial laboratories, large international organizations and non-governmental organizations working on S&T fields. The on-line available bibliographic database of the National Technical Information Service (NTIS) covers scientific research and engineering reports from the American government-sponsored projects.

Dissertations

One of the important sources of theses is University Microfilms International, which makes available the majority of doctoral theses of American universities. Theses of British origin can be obtained through the British Theses Service. Dissertations in chemistry are partly included in the Chemical Abstracts database. Dissertations from local universities in most developing countries are available on a title-to-title exchange basis.

Commercial publications (trade literature)

Marketing and advertising materials, market analyses, and know-how offers provide technical and commercial information on products, equipment, and raw materials from specific manufacturers. For a S&T researcher they can be a rich source of ideas for new applications, and a valuable assistance in the recognition of scientific, applied, developmental and commercial trends.

Maps

Maps are essential tools in several scientific disciplines, such as geography, geology, biology, agriculture, forestry and environmental science. A modern alternative to classical maps are the geographic information systems (GIS), using the computerized approaches to collect, store, process, retrieve and display spatially the information that has been referenced to its geographic location. The accessibility of GIS, special topographic maps and areal photographs for the public depends on the country policy. In many cases, special permission has to be obtained for purchase and store these materials.

Secondary literature sources

Secondary literature sources provide bibliographic data on the primary literature (journals, books, patents, standards, conference proceedings, dissertations, research reports, technical studies), and often include an abstract of at least key words describing the main theme of a document. In addition of abstract books, the publishers usually provide various cumulative indexes, such as key words, authors, patent numbers and chemical compounds registry numbers. However, the large-volume books of abstracts and indexes are being rapidly replaced by bibilographic databases, available on-line or on CD-ROM.

Other traditional sources in S&T communication

Audiovisuals

Audiovisual communication is used for special purposes, especially in the research of natural phenomena, human behavior, medical research, agriculture and forestry, environmental science, introduction of new scientific and research methods, and in the technological improvements. On a lower level, audiovisuals can be used to communicate basic S&T knowledge in the communities with high illiteracy rates.

Verbal exchange of information

Formal verbal communication on S&T can be organized as international or national S&T conferences, symposia, workshops, round tables, formal discussions, lectures and scientific radio programs. Informal ways include internal meetings and discussions on research, presentations of research results, S&T advising and consulting, and communication between individual scientists.

Direct data sources

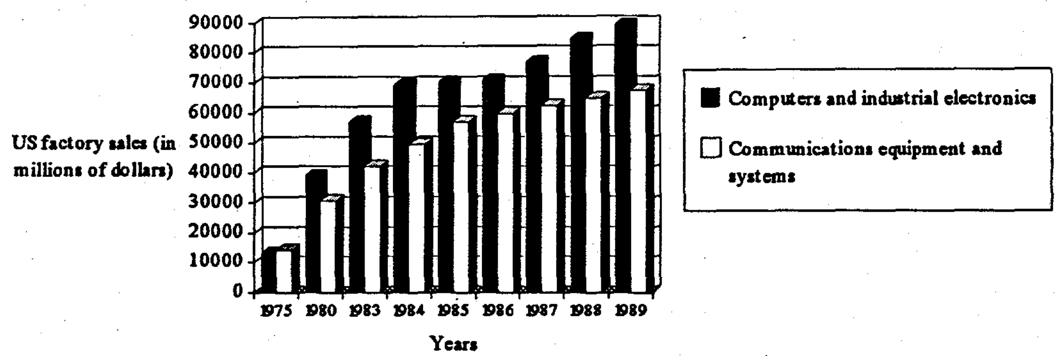
New S&T data are obtained directly from observations, measurements, tests and experiments under natural or controlled conditions.

Computer-supported databases

The database industry

In the middle of the century, many S&T disciplines have become overcrowded by accumulating knowledge. Because of the rapid growth of S&T publications, the traditional approaches of gathering information and its processing became too slow and inefficient. The simultaneous development of computer industry (Figure 30) offered a suitable environment for the development of large **international computer-supported databases.**

Figure 30: Growth of computer and communication equipment industry in the USA (Data source: Electronic Industries Association)

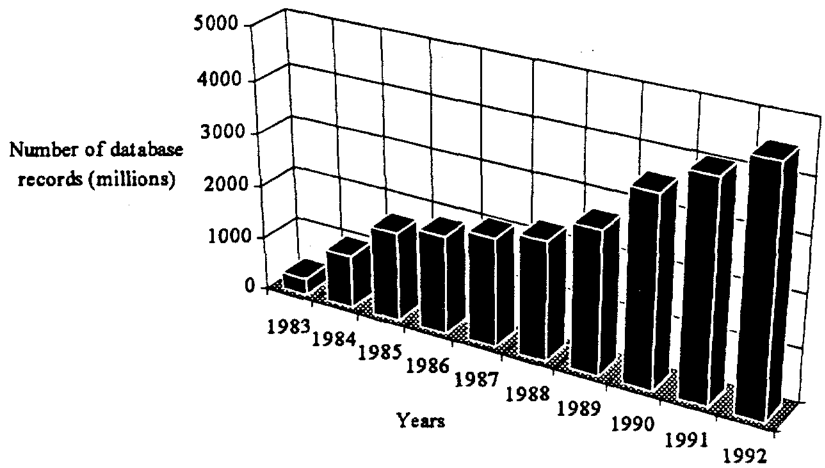


Information on databases, their main coverage, vendors, media and availability is provided by different directory producers. The first general directory of databases in North America "Computer-Readable Databases" was published in 1976 by the American Society for Information Science, followed by several similar publications in the next 15 years. Recently, the Gale Directory of Databases became the most comprehensive database review. It was first published in January 1993 after the merger of three large database directories - CRD (A Directory and Data Sourcebook), DOD (Directory of Online Databases), and DPD (Directory of Portable Databases). The Gale Directory covers on-line, CD-ROM, diskette, magnetic tape, handheld and batch access database products.

The growth of the **database industry** can be observed from the increase in the database records (Figure 31), number of databases, database producers and vendors (hosts) - Figure 32. According to a study by Williams (1993), between the years 1975-1991 the database industry has grown enormously:

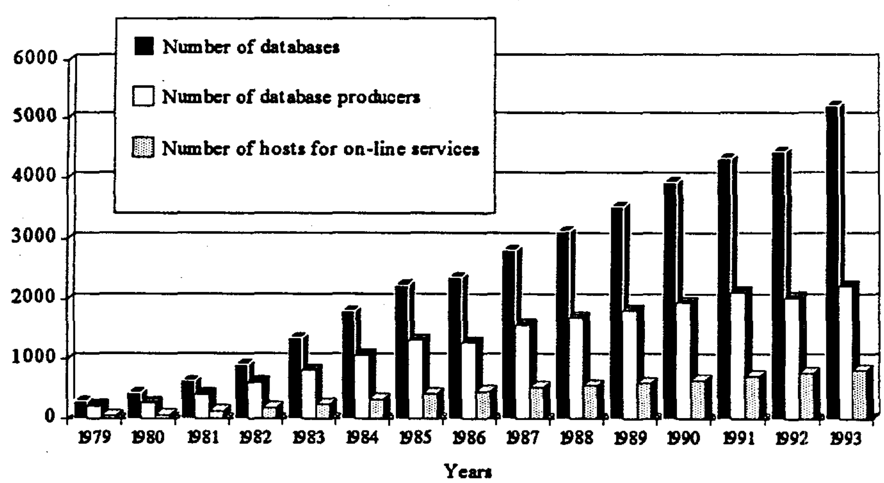
- database records by a factor of 87 (from 52 million to 4.527 billion),
- the number of databases by a factor of 26 (from 301 to 7907),
- database producers by a factor of 15 (from 200 to 3007), and
- the number of hosts by a factor of 13.7 (from 105 to 1438).

Figure 31: Growth of records in computer-supported databases (Data source: Gale Directory of Databases, Williams, 1993)



Database producers (publishers) can offer their databases in an electronic and/or hard copy form. Most of them are responsible for the database design, construction and updating, but usually prefer to offer their databases for lease or licence to **database vendors (hosts)**. Hosts provide additional value-added processing (such as database loading, special search software, on-line document ordering), distribute CD-ROM databases to the users, and offer on-line or batch search services to the marketplace - on a fee basis. The number of vendors (hosts) has grown at the slowest pace because they can offer services from several (up to several hundreds) databases. The database industry is still growing in terms of number and types of databases, as well as in use and revenues.

Figure 32: Growth of database industry: databases, producers and hosts (Data source: Gale Directory of Databases, 1993)



The average **size of databases** is increasing. Ten of the most largest databases already have more than 100 million records, and 288 other databases have already exceeded 1 million records, each record having an average of 200 to 2000 words (Gale Directory of Databases, 1993).

According to a **geographical survey** by Williams (1993), the only regions with more than 1000 databases are the North America (4768 databases) and Western Europe (1838 databases). The Asian and Middle East producers (25 databases) come from China, India and Israel. The Far East database producing countries (171 databases) are Hong Kong, Philippines, Japan, Singapore and Thailand. Australia contributed 161, East Europe 12 and Africa 7 databases (Figure 33) . On the country level, the world largest database producer remains the USA, and its leading position (in comparison with all other countries together) seems to be even stronger than ever before, as seen from the growth of the database entries in Figure 34 (some entries represent families of databases and sets of subfiles rather than single databases). The other strong database producers are UK (652), Canada (455), France (315), Germany (280), Australia (168) and Japan (161). At present, databases are produced in 18 different languages.

Figure 33: The geographical distribution of databases (Data source: Gale Directory of Databases, Williams, 1993)

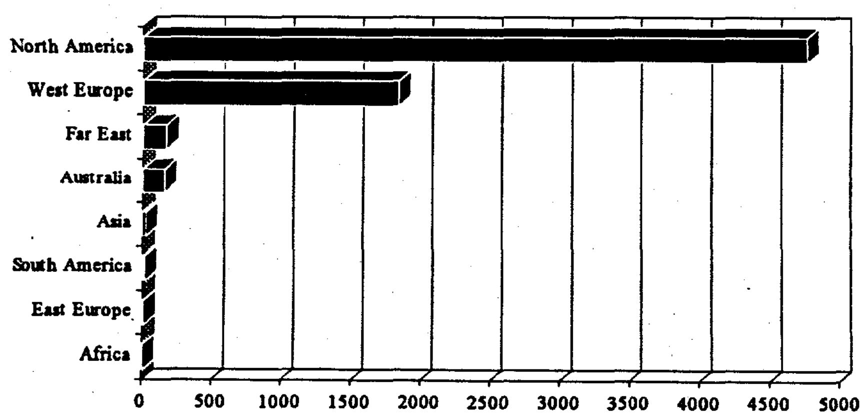
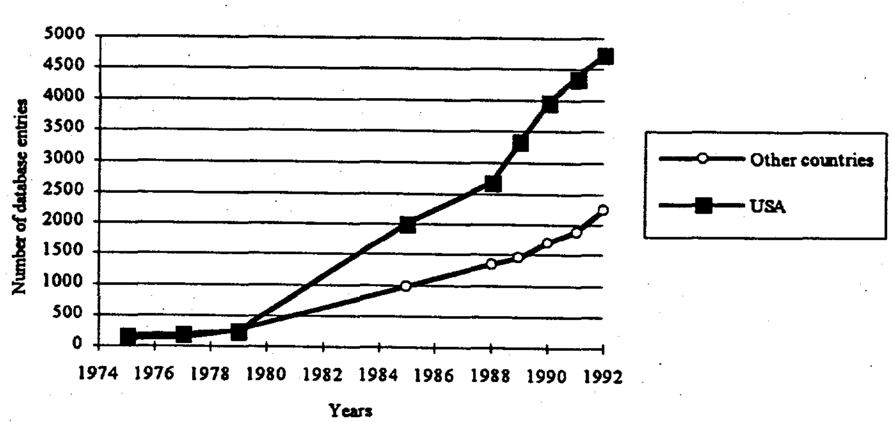
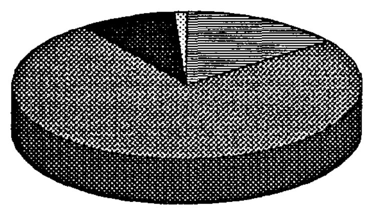


Figure 34: The growth of database entries in the USA and other countries (Data source: Gale Directory of Databases, Williams, 1993)



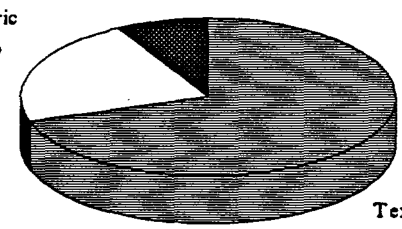
At the beginning of database industry, the largest part of databases were produced by the government (56% in 1977). The academic and industrial producers had an equal share (each 22% in 1977). In 1992, already three quarters of all databases were commercial and/or industrial (Figure 35).

Figure 35: The 1992 percentage distribution of databases by producer (Data source: Williams, 1993)



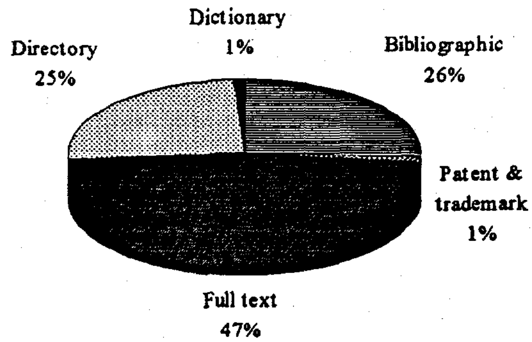
There are different possibilities to **classify the databases**. One of the most often used methods is the classification by **form of data**: words (textual databases), numbers (numeric databases), images (video databases) or sounds (audio databases). In 1992, the word-oriented databases represented 70% of all databases, followed by numeric (22%) and all others - image, audio, electronic services and software databases (8%) - Figure 36.

Figure 36: Main classes of databases by form of data (Data source: Gale Directory of Databases, Williams, 1993).



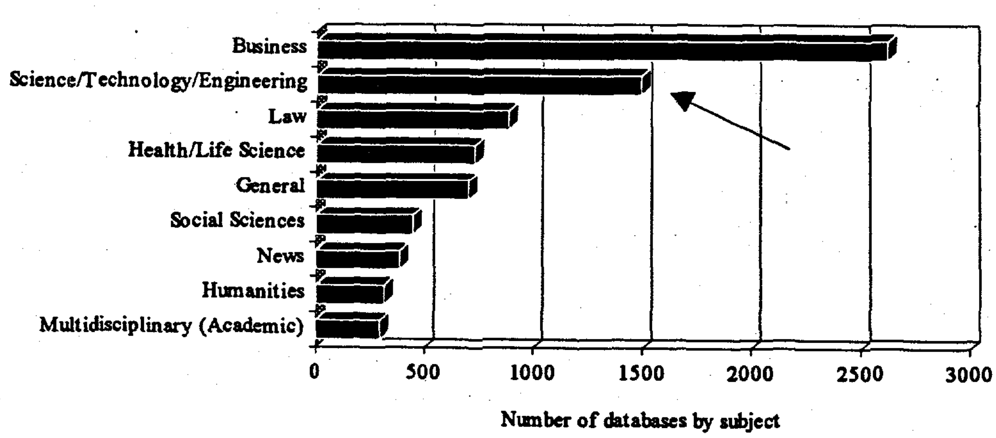
Textual databases can be subdivided into bibliographic, patent/trademark, directory, dictionary and full-text databases (Figure 37). The main sub-categories of numeric databases are transactional, statistical, time series, and properties. Image and audio databases are the newest category, and become publicly accessible only after the mid-1980s. With the rapid expansion of CD-ROM and hypertext systems, these databases are predicted to grow considerably in the next decade.

Figure 37: The subtypes of textual databases (Data source: Gale Directory of Databases, Williams, 1993)



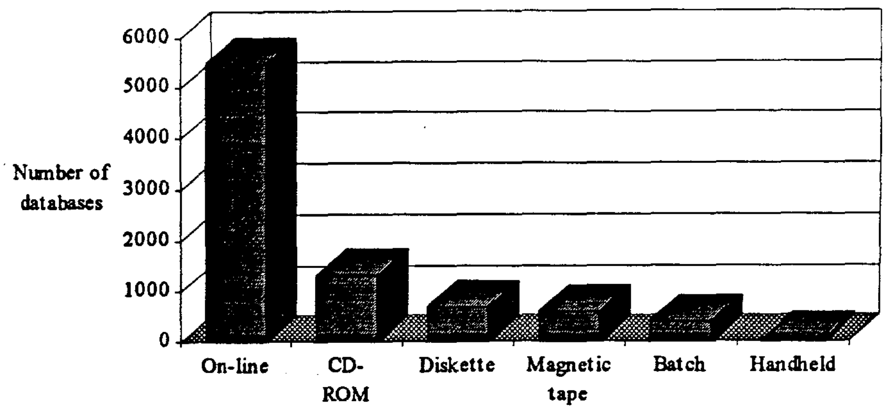
Another categorization is according to the **subject area**. According to Williams (1993), business databases remain the most numerous and hold 33% of the total commercial databases. In 1992, the science, technology and engineering databases had a share of 19%, health/life sciences 9%, and the multidisciplinary academic databases 4%, which totals at 32% and practically reaches the business databases (Figure 38).

Figure 38: Distribution of databases according to the main subject areas (Data source: Williams, 1993)



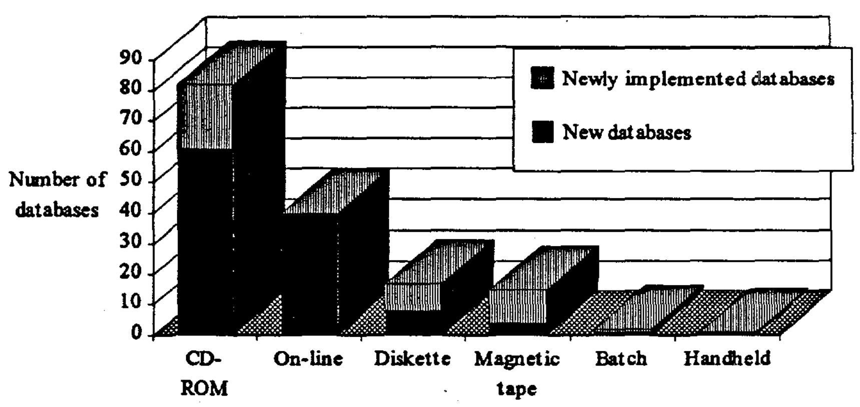
The third categorization of databases is according to the **medium for access or distribution**. According to the Gale statistics, there were 4519 On-line, 1088 CD-ROM, 320 batch, 557 diskette, 481 magnetic tape and 33 handheld databases offered by different vendors in 1992 (Figure 39).

Figure 39: Distribution of databases by different media (a database may be offered on several media) (Data source: Williams, 1993).



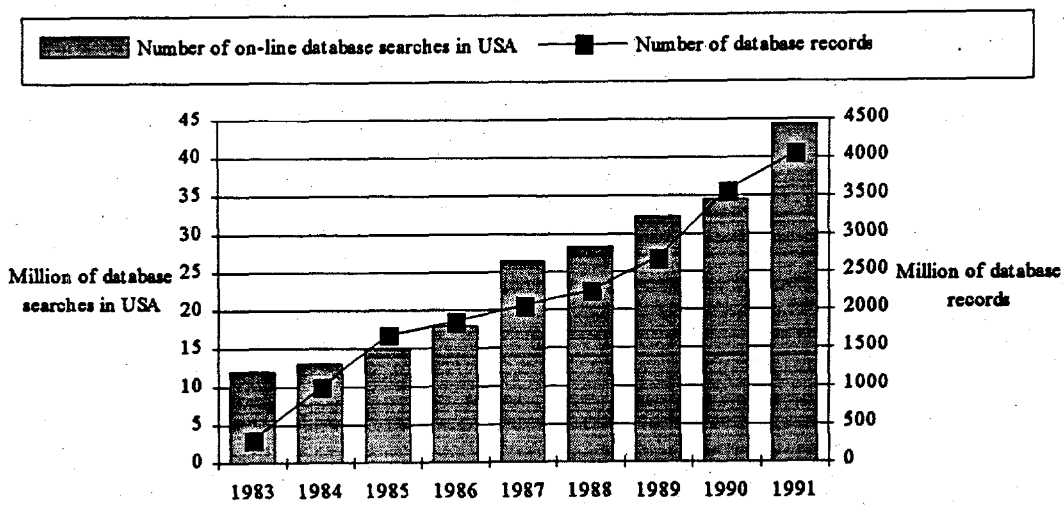
For the field of Science, technology and medicine, the Gale Directory 1993 lists 157 new databases in the last six months, of which 73% were totally new database products and 27% were new publications of the existing databases in the same or new medium (Figure 40).

Figure 40: Distribution of new and newly implemented science, technology and medicine database products by medium - the last six month period, Gale Directory of Databases, 1993 (Williams and Smith, 1993)



With the rapid growth of databases, there was a concern about the use of **stored information**. Statistics show that the number of searches follows parallely the growth of databases (Figure 41). No complete data are available for the whole world, but the on-line use for databases on the major host systems in the USA increased from 750,000 searches in 1974 to 44.4 million searches in 1992 - without taking into account the transactional databases and consumer service systems, which would make the number of searches even larger (Williams, 1993).

Figure 41: The growth of on-line database searches in the USA in comparison with the increases in database records (Data source: Gale Directory of Databases, Williams, 1993)



The **database market** is dynamic - it still grows every year and there are no signs of leveling off. One of the most important changes in the database world during the last decade are the CD-ROM databases, which are greatly increasing in production, sales and use. They are particularly well accepted in academic research institutions and as a support to university teaching, where the cost of on-line searches has often been a barrier to access. According to the new observations (Williams, 1993), this has already resulted in a decrease of the on-line searching of those databases, that are also distributed on CD-ROM, particularly on databases well used in academia, such as ERIC, PsycINFO, NTIS, and Medline.

On-line databases

Chemistry, as a scientific discipline with enormous amount of data on chemical compounds, their synthesis and applications, was among the first scientific fields to introduce a comprehensive **computerized bibliographic on-line database**. The Chemical Abstracts Service (CAS), Columbus, Ohio, established by the American Chemical Society, has a reputation of the world leading center of chemical information. The Chemical Abstracts (CA) database is available since 1967 and covers the important world literature from the fields of chemistry and chemical engineering, including over 1200 chemical journals, patents from 27 countries and 2 international organizations (European and World patents), numerous books, research reports, dissertations and conference proceedings. At the end of 1990 the database reached 10 million records. Every two weeks it is updated with 15 to 20 thousand new records. At the end of 1992 the CA register of chemical compounds included data on 17 million chemical substances. Similar information processing institutions established on-line databases for other scientific disciplines, such as:

- **medical research** (MEDLINE, 1966, 7 million records, and EMBASE, 1974, 4 million records),
- **biological sciences** (BIOSIS, 1969, 7.7 million records; Zoological Record Online, 1978, 1.3 million records),
- **physics, electronics and computer science** (INSPEC, 1969, with 4 million records),

- **pharmaceutical research** (International Pharmaceutical Abstracts, 1970, 0.17 million records, and Pharmaceutical News Index, 1974, 0.3 million records),
- **agriculture** (AGRICOLA, 1970, and AGRIS International, 1975, 1.3 million records, CAB Abstracts, 1972, 2.8 million records),
- **food production and processing** (FSTA - Food Science and Technology Abstracts, 1969, 0.4 million records),
- **technology and engineering** in chemistry and life sciences (COMPENDEX PLUS, 1970, 2.5 million records, and CEA - Chemical Engineering Abstracts, 1971, 0.1 million records),
- **environment and pollution** (Aqualine, 1960, 0.13 million records; Pollution Abstracts, 1970, 0.175 million records; ENVIROLINE, 1971, 0.15 million records; ENVIROBIB - Environmental Bibliography, 1973, 0.4 million records; Toxline, 1981, 1.6 million records)
- **biotechnology** (BIOTECHNOLOGY ABSTRACTS, Derwent Publications, 1982, 0.12 million records, and CBA - Current Biotechnology Abstracts, 1983).

In addition, some databases have been developed, covering **broader field of science and technology**, such as SCISEARCH - Science Citation Index, 1974, 10.7 million records; PASCAL, 1973, 3.8 million records. Science Citation Index, which covers the majority of important scientific journals, has been extensively used for bibliometric analyses (e.g. publication and citation counts), such as readability of scientific journals (see Hatley et al., 1988; Todorov et al., 1988), aging of scientific literature (Bottle et al., 1987; Stinson et al., 1987), tracing the scientific collaboration between different research groups or countries (Luukkonen, et al., 1991), searching for most cited scientists (Science Watch, 1992), and for evaluating the scientific quality and S&T research performance (Coward, 1991, 1990; King, 1987, Narin et al., 1975, Thulstrup, 1990, 1992).

In the 1960s, two major **patent databases** were established, both covering a large spectrum of patents, including those on S&T inventions: WORLD PATENTS INDEX (Derwent Publications Ltd., 1963, 6 million records), and INPADOC (International Patent Documentation Center, 1968, 18 million patent citations).

The first comprehensive **business database** PTS PROMT - Predicates Overview of Markets and Technology, offered in 1972 (now 2 million records), was followed by several discipline-specialized commercial databases in 1980s, such as BioCommerce Abstracts and Directory (established by BioCommerce Data Ltd. in 1981), AGRIBUSINESS USA (Agribusiness, 1985), and BIOBUSINESS (Biosis Inc., 1985).

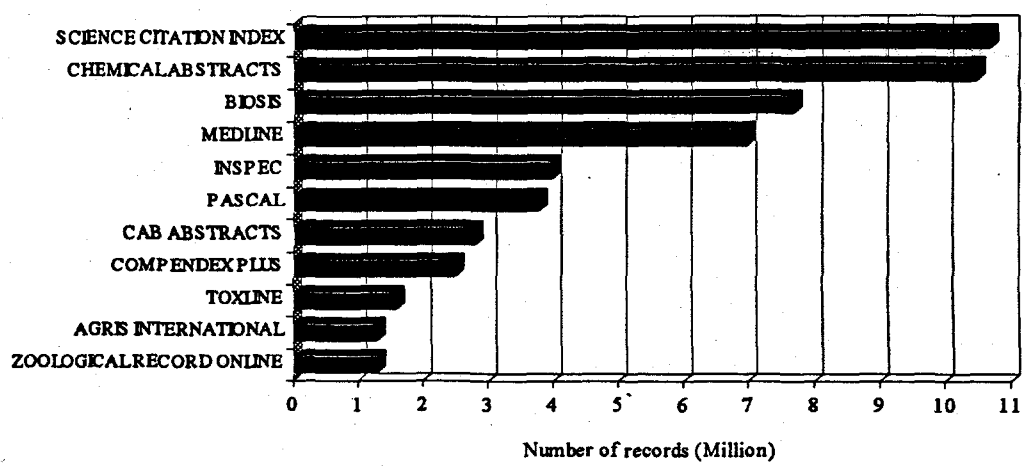
DIOGENES database, 1976, 0.5 million records, offers the information relating Food and Drug Administration **regulations about substances and devices**, including chemicals, pharmaceuticals and medical devices.

Data on **manufacturers and suppliers** of chemicals, reagents, equipment, machinery and instruments in life sciences can be obtained from the permanently updated directory-type databases, such as BIOQUIP (bio-chemicals and instruments), DEQUIP (technical equipment in biotechnology and chemical engineering), and PESTMAN (pesticides and their suppliers). A special sub-branch in this group represent databases on microbial, cell and tissue **culture collections**, which are usually directly linked to depositories of microorganisms for scientific research and industrial applications in dairy industry, breweries, pharmaceutical fermentations, waste treatment and bioremediation, and for other biotechnologies (e.g. MSD - Microbial Strains Database, MIRDAB - Microbial Resources Databank, MiCIS - Microbial Culture Information Service, and MINE - Microbial Information Network Europe).

The last wave of **factual databases in natural sciences** are the narrow specialized data collections with an advanced software support for graphic presentations, molecular structure searches, comparisons of analytical data and recognition of macromolecular sequence similarities.

Examples include (1) **molecular structure databases** (PROTEIN DATABANK - crystallographic data and macromolecular structures of proteins; CARB BANK - molecular structures of carbohydrates), (2) **protein and peptide sequences databases** (PSD - Protein Sequence Database, PIR - Protein Identification Resource, and Amino Acid Sequences of Proteins Database), (3) **nucleic acid sequences** (GENBANK, Nucleic Acid Data Library, Nucleotide Sequence Bank, Nucleic acid Sequence Database, DNA Databank of Japan), and (4) **genetic maps** (HGML - Human Gene Mapping Library).

Figure 42: Examples of some largest on-line databases on science and technology (data from Kornhauser and Boh, 1992, Chavan, 1993, Kornhauser, 1993)



On-line abstracting and indexing databases relevant to S&T are accessible via different hosts (vendors), such as BRS Information Technologies, CompuServe, DataStar, DIALOG Information Services, DIMDI, ECHO, ESA-IRS, InfoMaster, Knowledge Index, MEAD, ORBIT Search Service, QUESTEL, STN International, and U.S. Library of Medicine. CAN/SND and STN International host numeric scientific databases. Each vendor has a specific retrieval language, including not only simple search commands and procedures, but also more sophisticated search features, e.g. proximity operators, field index specification, multi-file searching features, and new possibilities for statistical analysis, such as ranking by frequency or occurrence of terms in records. Therefore, a close **cooperation of an information specialist** trained in on-line searching, **and a researcher** from a specialized scientific discipline is essential for an effective on-line search.

The main **problems related to the use of international on-line databases in developing countries** are: (1) insufficient technological base for on-line connections and searches (e.g. lack of national telecommunications networks to link users to overseas databases, poor telephone lines), and (2) the cost (charges for telephone line, host and database entrance, database connecting/processing time, printing of hits). The regular use of international databases seem to be very costly for most universities and academic research institutions in developing countries. One of the potential solutions is the university-industry cooperation, where the industry, recognizing the economic interest in a specific research project, covers or at least contributes to the expenses of international database processing.

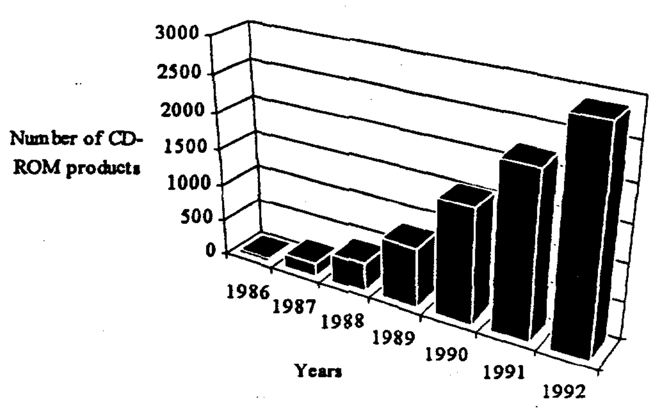
Databases on CD-ROM

As an alternative to on-line databases, many information centers offer **databases in the form of CD-ROM**. They are appropriate especially for the monodisciplinary research groups, who depend primarily on one or a few databases. The **main advantages of CD-ROM** are (1) local availability of databases, (2) known fixed costs for hardware and a CD-ROM database, but no additional costs for database processing - therefore they are of particular value for very frequent users, and as a teaching tool for students, trainees and novice researchers, (3) CD-ROM can serve multiple workstations, (3) potential use in conjunction with other information technologies (incorporation of text, graphics, moving images and sound). With increased production and competition resulting in lower prices, CD-ROM is becoming affordable for the developing countries.

According to Wright (1990) and White (1992), CD-ROM technology has grown in developing countries in faster rates than in industrialized countries, mostly because it seems **custom-made for the problems faced by developing countries**: (1) it can operate in harsh environmental conditions, such as heat, humidity, dust and unstable power supply - the optical disc do not deteriorate in the tropical environment, nor suffer from mold or mildew, it is robust and the data is permanent, (2) it eliminates the need for difficult/costly telecommunication links, (3) it can be portable or battery-operated, (4) has a relatively low capital cost for the equipment, (5) the discs are small and light enough to be easily send via airmail. The main drawback of CD-ROM is the need to update the master disk database at regular intervals, and the cost of remastering.

The **CD-ROM database market** still grows every year and there are no signs of leveling off. The first edition of CD-ROM Directory in 1986 contained only 48 CD-ROM titles and 48 companies involved in the industry, while the 7th edition in 1992 listed 2012 CD-ROM products of 2601 companies and organizations from 67 countries (Figure 43). The majority of CD-ROM products come from the USA, Europe and Japan. While there are only a few titles coming from Africa and Asia, the growing number of distribution networks indicates a much greater interest within these areas in the CD-ROM technology itself.

Figure 43: The growth of CD-ROM products (Data sources: Finlay and Mitchell, 1991; Rega, 1993)



The number of CD-ROM databases with high relevance to S&T in industrialized and developing countries increases each year. Of particular interest to developing countries is the appearance of full text S&T literature on CD-ROM (e.g. CD-ROM Kirk-Othmer Encyclopedia of Chemical technology, Oxford Textbook of Medicine, Dictionary of Natural Products). CD-ROM imaging is expected to replace the microfiche and microfilm technology in the future, providing high quality reproductions and user-friendly searching of back issues of scientific journals, reports, patents and legal documents.

Reflecting the developing technologies within the CD-ROM industry, the CD-ROM directory at the beginning of 1992 contained a section devoted to **multimedia CD** titles, comprising nearly 20% of all titles, showing a similar rate of growth to that of the CD-ROM industry in its infancy. If this trend is maintained, the multimedia industry may soon become a major participant on the CD-ROM consumer market (Finlay and, Mitchell, 1991).

According to market analysis by Williams (1993), the CD-ROM databases are increasing in production, sales and use. They are particularly well accepted in **academic research** institutions and as a support to **university teaching**, where the cost of on-line searches has often been a barrier to access. This has already resulted in a decrease of the on-line searching of those databases that are also distributed on CD-ROM, particularly on databases well used in academia, such as ERIC, PsycINFO, NTIS, and Medline. Due to the economic decisions of database producers, some of the important databases, such as Chemical Abstracts, are not likely to be offered on CD-ROM, and will remain accessible only on-line or in a printed form.

Specialized databases on personal computers

The third possibility of computerized information storage and retrieval are **specialized databases on mini or personal computers**, built by the researchers or S&T information specialists, who study and analyze primary documentation in their field of work. Several industrial and some academic research groups build bibliographic and factual databases of their own. Building and processing of these databases can greatly support research efficiency, contribute to the sustainability of university-industry projects, and improve the quality of S&T education at a high-school and university levels.

One of the efficient **software packages** for the design and processing of textual databases is the Unesco CDS/ISIS. Its main advantages are: (1) flexible design of a database: optional number and format of worksheets and printing formats, almost unlimited number of fields and optional field length, possibility of introducing repeatable fields, division of fields into subfields; (2) variable field length - occupying less disk space, (3) optional selection of fields and sub-fields for searching (4) several searching possibilities: fast searching in an inverted file (possible techniques: each word, strings of words, or only selected/marked words), full-text searching, searching and counting frequency of empty/occupied fields and sub-fields (may be used for the determination of information density), searching in one field or in several fields at the same time; (5) possibility for preparing and storing complex search profiles, (6) automatic generation of search terms dictionary, (7) sorting and indexing for the preparation of optional sorted printouts and indexes, (7) optional printout formatting, (8) changing conditions for database processing in a premade database. CDS/ISIS (last version 3.0) has been used for bibliographic and textual factographic databases by academic and research institutions, libraries, and schools worldwide, especially in the developing countries (for examples see Chaudhury and Shukla, 1988; Goyal and Kumar, 1990; Hopkinson, 1989-1992; Ngwira, 1991; NRC, 1989; Suraniranat et al., 1991; Wongkoltoot and Indee, 1992).

The following examples of records illustrate the possibilities of designing specialized S&T databases on PC for the specific needs of long-term research projects. Both examples are taken from a university-industry project on microencapsulation technology and applications: University of Ljubljana and Aero Graphic, Printing and Paper Industry, Slovenia.

Record 1: Example of a record for a patent description from specialized bibliographic database on microencapsulation (Boh, 1991). The key words were determined on the basis of patent analysis by researchers themselves and therefore reflect the recognition of the main parameters (which are often hidden in a patent), are more specific and better structured than the key words in less specialized international on-line databases.

Record No.:	001622
Document type:	PATENT
Authors:	FUKUO, H., ONOGUCHI, T.
Title:	MICROCAPSULE MANUFACTURE
Firm:	SAKURA COLOR PRODUCTS
Patent No.:	US 4753759, 880628
Patent applications:	US 892783, 860801 JP 137825, 850626 JP 236176, 851021
Patent classification:	B01J13/02
Publication year:	1988
Language:	ENG
Internal number:	5294
Descriptors:	MICROCAPSULES POLYMERIZATION IN SITU UREA-MELAMINE-FORMALDEHYDE WALL UREA-FORMALDEHYDE WALL MELAMINE-FORMALDEHYDE WALL MODIFYING AGENTS ACRYLIC ACID-METHACRYLIC ACID COPOLYMERS ACRYLIC ACID-ITACONIC ACID COPOLYMER ENCAPSULATION ACCELERATING AGENTS POLYHYDRIC PHENOLS EMULSION STABILIZING AGENTS POLYANIONIC MACROMOLECULES SOLVENTS ALCOHOLS ESTERS KETONES ETHERS FATTY ACIDS ACID AMIDES HYDROCARBONS APPLICATION FIELDS PRESSURE-SENSITIVE COPYING PAPERS LEUCO DYES TEMPERATURE INDICATORS THERMO-CHANGEABLE COLORS PERFUMES

Record 2: Example of a record from a highly specialized factual database, containing qualitative and quantitative data on interfacial polymerization microencapsulation procedures in water-in-oil emulsions (Boh, 1991). The database was built as an information support for the design of a research hypothesis for the development/upgrading of an industrially applicable technological process .

Record No.:	000199
1. Wall polymer:	AMINO ACID-ACID CHLORIDE
2. Solvent (hydrophilic):	WATER
4. Wall component (hydrophilic):	L-LYSINE, 30 ml of 0.53 M in sodium carbonate solution
5. Additives (hydrophilic):	SODIUM CARBONATE, 0.67 M in water
6. Solvent (hydrophobic):	CYCLOHEXANE : CHLOROFORM 3:1, 100 ml
7. Emulsifier (hydrophobic):	SORBITAN TRIOLEATE, 10 percent (v/v) in 100 ml of hydrophobic solvent mixture
8. Wall component (hydrophobic):	TEREPHTHALOYL DICHLORIDE, 100 ml of 0.8 ml of hydrophobic solvent mixture
10. Emulsification:	Emulsion W/O, stirring 20 min.
11. Polymerization:	interfacial polymerization, 20 min.
13. Deactivation:	dilution with 100 ml of hydrophobic solvent mixture
14. Post-treatment:	washing 3 times with cyclohexane on a centrifuge, dispersion into deionized water containing dispersing agent, washing with deionized water, dialysis against deionized water for 2 weeks
15. Microcapsule separation:	centrifugation
17. Properties of microcapsules:	negatively charged microcapsule wall
18. Application field:	MEDICINE AND PHARMACY
19. Annotation:	adsorption of fibrinogen to microcapsules, disintegration studies
20. Reference source:	Internal No. in the bibliographic database: 5386 - Example pp. 133-4

Further examples of database and information processing with practical applications in scientific research and development are given in PHREE Background Paper Series, PHREE/92/67: University-Industry Cooperation Under Constraints. Experience of the International Center for Chemical Studies, Ljubljana, Slovenia (Kornhauser, A., 1992a). See also Kornhauser, 1992b; and Boh, 1991, 1992.

Acquisition of S&T information

Users of S&T information

Since different users have different information needs, no single information system can serve a broad spectrum of users. Targeting the intended audience is an essential first step in the acquisition of appropriate S&T information, its processing, distribution and use. Examples of different **S&T user groups** include: (1) professors and students at the universities, colleges, specialized science schools, regular secondary and primary schools, (2) researchers from universities, industrial research units, private researchers, (3) professionals from S&T related fields (medicine, health and nutrition, agriculture, forestry, food processing, environmental protection, engineering), (4) government officials working in S&T related fields (5) professionals in industrial and commercial enterprises, (6) journalists, (7) farm extension workers, community leaders and staff from non-governmental organizations, (8) farmers, industrial workers, (9) consumers.

The information dissemination mechanisms have to be adapted to the characteristics of the target groups. To succeed in the highly competitive research and development fields, industrial researchers need fast and efficient technology-based approaches, such as computerized information systems, relational databases, on-line and CD-ROM databases, powerful statistical and graphical packages, and desktop publishing. At the community level of developing countries, less sophisticated and less formal mechanisms of exchanging information are often much more effective -- such as scientific literature in indigenous languages, TV and radio programs, extension services and demonstrations.

The main **types of institutions involved in the acquisition of S&T information** include: (1) academic information centers and university S&T libraries, (2) information centers and libraries at research institutes, (3) technical, industrial and commercial libraries and information centers in the industries, (4) libraries of international organizations working on S&T related disciplines, (5) governmental libraries, (5) school libraries, (6) libraries and information centers of S&T related non-governmental organizations.

Acquisition methods

Direct purchase

The most common acquisition system for books and periodicals is the direct purchase from local bookshops, local publishers, regional offices of overseas publishers or purchase from abroad. Periodicals are received through membership programs (membership fees to professional organizations) and by subscriptions. There are three main **procurement channels** for foreign S&T literature: (1) direct import by individuals, libraries, information centers, research and educational institutions, (2) import through local book dealers or subscription agents, and (3) import through government or semi-government agencies. In most cases, the governments of developing countries are liberal with regard to import of literature and do not introduce any limitations, while in specific cases there are different restrictions regarding the content and subjects (political, religious, moral prohibitions), origin countries (economical, political, scientific and cultural embargo) or financial limitations (amount of foreign exchange).

The practices of **selecting S&T literature** differ from country to country. The main sources for the selection of S&T publications are (1) publishers announcements and catalogues, (2) book reviews in journals, (3) bibliographic databases, (4) prescribed or recommended lists designed by governmental or international bodies, (5) book exhibitions, (6) visits to bookstores, and (7) books sent by booksellers on approval. The selection is done by scientists, researchers or teachers alone, by librarians and information specialists, or by governmental committees, taking into account the limitations of allocated funds and foreign exchange.

Donations

Some international and bilateral agencies, research groups or individual researchers donate books and scientific journals to researchers and libraries in developing countries. In several low-income countries with temporary or long-lasting financial problems, which usually result in severe restrictions in the acquisition of S&T publications, such donation programs have become the major source of new S&T reading materials. However, donation programs may have hidden limitations. Donated publications may be out of date or out of relevance for the recipient country, therefore donation is usually not the most satisfactory way of transferring S&T information and technology to the developing countries.

Grants

Grants seem to be a much more appropriate way of helping low-income economies. With grants, the donor institution offers a specific amount of foreign exchange to be used exclusively for the purchase of S&T literature. The selection and choice of the most appropriate and needed publications within the identified research field is left to the recipient.

Legal deposit

The national reference libraries have a legal right to warehousing of all locally published documents, including S&T publications. In additions, these institutions often deposit the reports and other documents from the main international organizations and national governments.

Exchange and interlibrary lending

The sharing of library resources through various library cooperative programs can ensure more economical acquisition, larger quantity and better utilization of scientific literature . Several libraries in developing and industrialized countries have exchange arrangements with other libraries and international organizations, especially for research and technical reports, proceedings from local and international meetings, dissertations, technical publications, scientific papers and newsletters. However, research and technical reports, dissertations and local newspapers are often written in local languages, which may be a problem in offering publications for exchange. The countrywide interlibrary lending facilities may include additional services, such as exchange of books, patents and standards, circulation of scientific journals, and photocopying services. In some cases, scientific libraries compile catalogues of science books and periodicals available in different institutions of the country.

Problems in acquisition of S&T information in developing countries

Authors from developing countries report on different problems related to the acquisition of scientific literature:

(1) **Lack of national policies** on (1) literature collection development, (2) national S&T information services, (3) scientific literature publishing, (4) acquisition and use of S&T information materials.

(2) **Low budget and lack of foreign exchange** for new S&T materials - several developing countries report on a decrease in a number of journal subscriptions and scientific books purchased each year, especially because of the steep rises in their prices and meager budgets for their acquisition.

(3) **Lack of locally available publications** - as a result of underdeveloped local publishing industry and lack of scientific writers.

(4) **Restrictions** in literature import intricate import and customs procedures.

(5) **Distribution problems** - some experiences of developing countries show that it takes between three and six months to receive book orders from local and foreign dealers, and that up to 40 percent of journals are lost in transit due to postal misdelivery. Finding no alternative, some institutions try to overcome this problem by appointing foreign agents to collect and send the materials, for which they charge additional 10 percent plus postage costs.

(6) **Unbalanced subject coverage** - poor representation of newer subjects and disciplines such as computer science, biotechnology, genetic engineering, new materials and energy sources, and environmental science.

(7) **Gaps in collections**, particularly in periodicals.

(8) **Poor coverage** or even absence of patent literature, standards, research and technical reports, commercial publications and other specialized sources.

(9) **Low level S&T information services** as a result of (a) insufficient knowledge about literature acquisition possibilities and procedural details, (b) lack of cooperation among libraries, (c) lack of reference and bibliographical sources, indexing and abstracting services, (d) limited access to international databases, (e) insufficient/too slow development of local bibliographic databases, (f) lack of computers, software and trained personnel.

Improving the access to and use of S&T information in developing countries

Recommended actions

Reducing or bridging the information and communication gap between the industrialized and developing countries is one of the most urgent priorities and one of the most difficult tasks in the present programs and efforts for a more balanced world development.

The following **actions and programs** can support the development, improvement, promotion and use of S&T literature and information services in developing countries:

(1) Define the **information needs** of different regions, countries, nations, scientific and technological institutions, and professional groups.

(2) Introduce S&T informatics in regional and national **information policies** and development plans.

(3) Establish reliable **technical environments** for the introduction of S&T information services (improve telecommunication systems, maintenance services, compatibility of equipment and software).

(4) Assure **stable fundings** for the acquisition and distribution of scientific literature and databases of particular interest and relevance to the users.

(5) Improve the **coordination of activities** between the local and national institutions, international organizations, bilateral/multilateral foreign aid and donor programs, and S&T research projects to (a) exclude unnecessary duplication of publications, databases, and information technologies, (b) achieve a better coverage of different S&T disciplines and a greater variety of information sources, (c) facilitate planning for a more efficient acquisition, distribution and use of available resources, (d) provide adequate education and training of personnel, and (e) ensure a more stable financing.

(6) **Include local scientists and information specialists** in all S&T information projects and programs for developing countries.

(7) Promote the **active participation** of S&T specialists from developing countries in the international S&T communication and exchange of knowledge: (a) provide training in scientific writing, (2) advise/help in achieving high quality standards, (3) facilitate the promotion of scientific articles from developing countries in internationally recognized S&T journals.

(8) Provide training and assistance in design, building and updating of **user-oriented information systems** adapted to local needs.

(9) Increase the **sustainability of information systems** by (a) promoting reliability, professionalism, and efficiency of information services, (b) ensuring a stable income generation (charging for services, grants, memberships), and (c) introducing adequate marketing and promotion of information services.

(10) Organize **S&T information networks** among individuals and/or institutions in the fields of: (a) S&T information services - for acquisition and processing of information, (b) dissemination of information on available information services, technologies, software, equipment, training opportunities and new S&T related projects, (c) technical assistance for systems design, development and trouble-shooting, (d) education and training in building and use of databases and information systems, data processing methodologies, new hardware and software products.

(11) Provide specialized **pre-service training** and continuous **in-service education** in S&T informatics for different groups of (a) information professionals - librarians, computer specialists, S&T informatics specialists, and (b) end-users - scientists, researchers, industrial engineers and technicians, managers, economists and lawyers in S&T firms, governmental officials responsible for R&D, S&T journalists, teachers, students, and other professionals involved in S&T related projects.

(12) Promote the **use of S&T information services and methodologies** in all areas of scientific research, industrial development, transfer of technological know-how, planning, decision-making and education in order to (a) acquire more complete and adequate information, (b) enable fast and efficient processing of data, (c) facilitate the transfer of fundamental knowledge into development and production practice.

(13) Avoid the import or adoption of technologies, processes and materials without a simultaneous **transfer of knowledge (know-how)**.

(14) Change the **school teaching practices**, which emphasize memorizing of data, to more information-based teaching, aiming at the development of skills for searching, processing and using S&T information.

(15) Introduce and/or strengthen efficient **literacy programs** in countries with high illiteracy rates.

(16) Encourage the use of **S&T terminology in local languages**, provide assistance with native-language information processing, and promote scientific publishing and scientific journalism in indigenous languages.

(17) Provide basic **training in English** and/or other languages used in science communication with special emphasis on S&T terminology.

(18) Support effective **local production** of basic consumables, such as paper, toners, inks, cables, diskettes, and facilitate access to necessary spare-parts.

(19) Improve the rigid **bureaucratic procedures** which hinder a more efficient S&T information planning and management, budgetary changes, efficient provision and maintenance of equipment, acquisition and distribution of publications and databases, sharing of resources, staff allocation, interaction with users, and education programs.

(20) Improve the **social status** of S&T information specialists.

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