UNESCO: *why the S?*

UNESCO

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GLOSSARY

ANSTI	African Network of Scientific and Technological Institutions
ASEAN	Association of South-East Asian Nations
ASPEN	Asian Physics Education Network
CASTAFRICA	Conference on the Application of Science and Technology to the Development of Africa
CASTALAC	Conference on the Application of Science and Technology to the Development of Latin America and the Caribbean.
CASTARAB	Conference on the Application of Science and Technology to the Development of the Arab States
CASTASIA	Conference on the Application of Science and Technology to the Development of Asia
CCST	Caribbean Council for Science and Technology
CEAO	Communauté Economique de l'Afrique de l'Ouest
CERN	European Organization for Nuclear Research (European Laboratory for Particle Physics)
CLAB	Latin American Centre for Biological Sciences
CLAF	Latin American Centre for Physics
CLAMI	Latin American Centre for Mathematics and Informatics
COMAR	Major Regional Project on Research and Training leading to Integrated Management of Coastal Systems
COSTED	Committee on Science and Technology in Developing Countries
CSK	Co-operative Study of the Kuroshio
IAEA	International Atomic Energy Agency
IBRO	International Brain Research Organization
ICMS	International Centre for Mechanical Sciences
ICPAM	International Centre for Pure and Applied Mathematics
ICRO	International Cell Research Organization
ICSU	International Council of Scientific Unions

ICTP	International Centre for Theoretical Physics
IFIAS	International Federation of Institutes for Advanced Study
IGCP	International Geological Correlation Programme
IHP	International Hydrological Programme
IISEE	International Institute of Seismology and Earthquake Engineering
IOC	Intergovernmental Oceanographic Commission
IOCD	International Organization for Chemical Sciences in Development
IPAL	Integrated Project on Arid Lands
IUGS	International Union of Geological Sciences
MAB	The Man and the Biosphere Programme
MINESPOL	Conference of Ministers Responsible for Science and Technology in the European and North American Region
MIRCEN	Microbiological Resource Centre
PAMERAR	Programme for Assessment and Mitigation of Earthquake Risk in the Arab Region
RINSCA	Regional Informatics Network for South and Central Asia
SECAB	Secretaria Ejecutiva Permanente del Convenio 'Andrés Bello'
UDEAC	Union Douanière et Economique de l'Afrique Centrale
UNCSTD	United Nations Conference on Science and Technology for Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFPA	United Nations Fund for Population Activities
UNISIST	The set of methods, rules, norms and standards needed for the creation of compatible information systems and services and their interconnection to a world science information system
WESTPAC	The Western Pacific

CONTENTS

For centuries Venice, one of the world's foremost centres of art and culture, has been threatened by floods and subsidence. In 1966, Unesco launched a campaign to save Venice. What began as a cultural appeal developed into a long-term scientific investigation into the causes of this destructive phenomenon, with the aim of eventually controlling it.

INTRODUCTION

This booklet is designed to answer the question, 'What does Unesco do in science and technology?' It is meant for a broad readership that may include policy-makers in government and elsewhere, members of National Commissions of Unesco and of non-governmental agencies, the media (particularly science journalists) and the interested public.

Because of the presumed variety of its readers, and because Unesco's activities in science and technology themselves are so numerous and varied, the booklet's approach is necessarily selective. Such an approach has been taken also because it was felt that a mere catalogue of activities would make dull reading. An attempt has first been made to define what is distinctive about Unesco's science and technology programmes within the context of United Nations bodies and other international agencies, and then to give examples of the most important kinds of activities, all the while stressing why these particular types of activity have been chosen. An attempt has also been made to stress what results have been achieved by Unesco's efforts, who has benefitted from them, and in what way.

The acronym Unesco narrowly missed not having the 'S' for science, because when plans were being laid for foundation of the organization near the end of the Second World War, education was the main theme. Meeting in wartime London to consider a successor to the League of Nations' International Institute of Intellectual Co-operation, the Conference of Allied Ministers of Education had proposed a UNECO. The 'S' was added only in November 1945 by the preparatory commission that met in London to create the United Nations Educational, Scientific and Cultural Organization. The change was made in response to pressure from scientists' groups, particularly in the United Kingdom. The appointment of Sir Julian Huxley as Unesco's first Director-General assured that activities in the sciences and in technology would play an important role in Unesco, Huxley himself being not only a distinguished scientist but also an accomplished popularizer of science. (This latter talent led, incidentally, to his being awarded Unesco's own prize for science popularization, the Kalinga Prize, in 1953, after he had retired as Director-General.)

Huxley recognized the potential of science and technology for development in his first publication about Unesco, in 1946. 'The application of scientific knowledge', he wrote, 'provides our chief means for raising the level of human welfare.' At that time, however, the term 'development' was not commonly employed in the sense that it is today. Nor was promoting development the chief reason for setting up Unesco. The world was just recovering from an enormously destructive war, and those who founded Unesco believed that another such catastrophe could only be prevented through the spread of knowledge and through international co-operation. Science was seen as an ideal medium through which to encourage such co-operation. Unesco's Constitution noted that the organization had been established 'for the purpose of advancing, through the educational *and scientific* and cultural relations of the peoples of the world, the objectives of international peace and the common welfare of mankind for which the United Nations was established and which its Charter proclaims'. (Italics added.) It was, incidentally, the first time that an intergovernmental organization had been given a major responsibility for the development of international relations in science, which previously had been the province of professional organizations. Henceforth, Unesco was to work hand in hand with these organizations.

The wisdom of the early planners in including science (and technology though there is no 'T' in the acronym) in Unesco's mandate has been amply demonstrated since that time. Science and technology have become a major force in industrial countries and indispensable to the progress of developing nations. Whatever criticisms may be directed towards it in hindsight, the Green Revolution, based on the scientific development of high-yielding strains of wheat and rice and a concomitant set of well-researched farming practices, saved millions of people from starvation during the 1960s and 1970s and helped make more than one developing nation self-sufficient in agriculture. Scientifically-based medical advances have eliminated smallpox from the world and have saved millions from other scourges such as polio and diphtheria. Technological developments in communications have brought the most remote villager in touch with a wider world, and have facilitated the conduct of business and industry in areas formerly almost unreachable. States such as Singapore have made solid-state electronics virtually the engine of their development. Many other examples could be cited.

Yet the fruits of science and technology are still unevenly distributed. In 1980, only approximately 6 per cent of total research and development worldwide was carried out in developing countries. Expenditure on research and development as a percentage of Gross National Product was only 0.43 per cent in developing countries, compared with 2.24 per cent in the industrialized world. Such figures provide one convincing answer to the question, 'Why the S in Unesco?', since one of its tasks is to help redress this imbalance.

But there is another reason. In the words of *Thinking ahead, Unesco and the challenges of today and tomorrow* (a popularized version of Unesco's Medium-Term Plan for 1977-1982), 'Unesco's general mission... is to promote the development of scientific knowledge, because it has an intrinsic value.' Thus Unesco places science alongside education and culture in its mandate because, as well as being useful, it has a value of its own. This is Unesco's way of recognizing that science constitutes a seminal method of interpreting the world. Unesco is, in fact, the *only* organization within the United Nations system whose mandate includes *basic science.*

In today's world, these two reasons why Unesco is involved in science—the practical one and the cultural one—are, in the eyes of many, not considered equal. Because of the urgency and the pervasiveness of malnutrition, illness, poor housing and low standards of living, in this view the practical aspects of science and technology should take precedence, so that these powerful tools can be used to better the conditions of those who live in developing countries, who comprise the majority of mankind. This opinion is reflected in Unesco's science programmes, many—perhaps even a majority—of which have come to stress development goals.

But stressing the applications of science for solutions to human problems does not mean abandoning basic science. There are many reasons Unesco supports both. For example, experience has shown that new technologies often arise from basic scientific discoveries: Dr Cesar Milstein, immunologist and winner of Unesco's 1983 Carlos Finlay Prize for developing a technique for producing chemically pure antibodies (monoclonal antibodies) that offers great promise in the treatment and diagnosis of diseases, particularly in developing countries, has made a point of noting that it was basic research that led to his discovery.* Basic research may help promote technological innovation in other ways, too, particularly in developing countries: without a core

* In October 1984, Dr Milstein was awarded the Nobel Prize in Medicine and Physiology for the same work.

of informed fundamental researchers to keep abreast of findings in other parts of the world, to interpret trends and to suggest where future innovations might be found, such countries might easily miss opportunities to adapt new findings to their own benefit. Finally, basic research helps to inform science education: it is the major source of new ideas and concepts necessary to the vital and up-to-date teaching of science.

Unesco's science and technology programmes therefore cover both basic and applied science. Science teaching in the schools, up to secondary level, is dealt with by the Division of Science, Technology and Vocational Education in the Sector of Education (including a section on environmental education). All other aspects of science and technology, except for the programme aimed at facilitating international and technical information transfer (UNISIST), are grouped under the Science Sector. The basic sciences fall under the Division of Scientific Research and Higher Education, which includes sections on mathematics, physics and problem-oriented research; chemical and biological sciences; science in the contemporary world (science-society interactions) and informatics (computer science and technology). Science Sector activities dealing with technology, science and technology policies and terrestrial science fall under the following divisions: Science and Technology Policies; Technological Research and Higher Education (including sections on energy information systems, energy development and co-ordination, research in engineering sciences and engineering education); Ecological Sciences; Earth Sciences; Water Sciences; and Marine Sciences. The activities of the Intergovernmental Oceanographic Commission (IOC), the International Geological Correlation Programme (IGCP), the International Hydrological Programme (IHP) and the Man and Biosphere Programme (MAB) constitute concerted international scientific efforts within Unesco, each dealing with its particular field. The social sciences fall under a separate sector in Unesco.

This, then, is the organizational grouping of science and technology programmes within Unesco. The chapters that follow describe the major thrusts and some of the contents of these programmes. But first it seems useful to place Unesco's scientific activities within the context of other United Nations agencies and international bodies. This is done in the next chapter.

UNESCO'S SPECIAL CONTRIBUTION

The Specialized Agencies of the United Nations all contribute in different ways to the application of science and technology to development, and to the strengthening of research and the training of scientific and technological personnel. For example, the World Health Organization deals with human biology and epidemiology; the Food and Agriculture Organization with agricultural sciences, forestry and biological sciences related to food and nutrition; the International Telecommunications Union with communications technology, and so on.

Like these agencies, Unesco promotes scientific and technological development in developing countries, and assists in the training of specialized personnel. In addition, Unesco helps establish and operate institutions engaged in higher education, research and the provision of services in science and technology, promotes the formulation of national science policies and encourages public understanding of the impact on society of scientific and technological advances.

What distinguishes Unesco's role in this area is the breadth and depth of its interests in science and technology and their social effects. Unesco also is unique among United Nations agencies in two other respects: its responsibility (as mentioned in the Introduction) for research, education and training in the basic sciences, and for the promotion of international co-operation in these fields.

Thus while the other United Nations agencies take care of mission-oriented institutions (in agriculture, medicine, industry, communications, transport, etc.), Unesco is responsible for research and training in the basic sciences (physics, chemistry, mathematics, biology), in the applied sciences (especially natural resources and environmental sciences) and in the engineering sciences. In effect, Unesco provides much of the substrata on which the mission-oriented United Nations agencies' programmes thrive.

Unesco's activities in the basic sciences, centred in the Division of Scientific Research and Higher Education, are all designed to provide the stimulation and high scientific standards necessary for setting up research and training programmes and facilities in the basic sciences in countries that lack them.

Internationally, Unesco has played a key role in several areas. It contributed to the establishment of CERN—the European Organization for Nuclear Research—now one of the world's leading laboratories in the investigation of the nature of matter and known as the European Laboratory for Particle Physics. In co-operation with the International Atomic Energy Agency (IAEA), it operates the International Centre for Theoretical Physics (ICTP) in Trieste, Italy, which is visited by 700 developing country researchers every year. It helped found the International Centre for Pure and Applied Mathematics (ICPAM) in Nice, and both the International Brain Research Organization (IBRO) and the International Cell Research Organization (ICRO) were set up on Unesco's initiative.

Since 1973, Unesco has supported the International Centre for Mechanical Sciences (ICMS) in Udine, Italy, which trained more than 2,500 young researchers from about 70 countries between 1969 and 1980. It also supports the Centre for Heat and Mass Transfer, Belgrade, Yugoslavia, and as early as 1960 recognized the significance of computer sciences in establishing the International Computation Centre in Rome, now transformed into the Intergovernmental Bureau for Informatics (IBI).

A special kind of international activity is carried out within Unesco through an intergovernmental commission, the IOC, two intergovernmental programmes—the IHP and MAB—and the IGCP, which is a joint venture of Unesco and the International Union of Geological Sciences (IUGS). These permit truly international research activities to be undertaken across national boundaries, making possible a scale of operation unobtainable by any other means. The IHP developed from the highly successful International Hydrological Decade, which promoted world-wide research in water sciences from 1965-1974 and constituted a remarkable example of international co-operation. It now involves more than 130 Member States in its activities. Through its networks of national, regional and global research teams, it has made a significant contribution to the understanding of the processes that occur in the water cycle, assessment of surface and ground-water resources, and adoption of a more rational attitude to water use. It has also promoted national and international education and training programmes in hydrology and water resources planning and management.

The IOC's task is to promote concerted action in oceanographic research; it also functions as the co-ordinating body for all activities in marine science within the United Nations system, and besides its research activities, it provides ocean services (for example data for forecasts of ocean conditions) to scientists and to the public, and promotes education and training. The IGCP performs similar stimulating functions in geology: it involves some 4,000 geologists in more than 110 countries. It combines the advantage of non-governmental participation and guidance through its scientific partner, the IUGS, with the benefits of governmental support through Unesco. The IGCP is oriented through basic research towards the solution of such problems as the supply of petroleum and other energy sources and geological hazards such as earthquakes.

The MAB programme has been in operation since 1971. Its principal aim is to develop the basis, within the natural and social sciences, for the rational use and conservation of the living resources of the earth. It involves scientists from more than 100 countries working on more than 1,000 collaborative projects aimed at finding practical solutions for concrete problems of managment of land resources and human communities. Among other accomplishments, it has resulted in the establishment of 243 biosphere reserves in 65 different countries—protected areas for the conservation of ecosystems and the plant and animal resources they contain.

Unesco gives special emphasis to a regional approach: it has set up three regional centres in Latin America, for example, in biological sciences (Caracas, Venezuela), in mathematics and informatics (Buenos Aires, Argentina), and in physics (Rio de Janeiro, Brazil), which operate mainly through training courses and co-ordination of regional activities. These are known, respectively, as the Latin American Centre for Biological Sciences (CLAB), the Latin American Centre for Mathematics and Informatics (CLAMI) and the Latin American Centre for Physics (CLAF). Networks are a much-used method of improving co-operative research: they have been set up for physics, chemistry, cell research, brain research, the biosciences and microbiology. These are made up of institutes in various countries that have agreed to pool resources and co-operate on projects that can best be carried out on a regional scale. Their aim is to help developing countries to become better able to conduct their own research programmes according to their own plans. In Asia, for example, there is the Asian Physics Education Network (ASPEN), the Regional Informatics Network for South and Central Asia (RINSCA), and others for energy and appropriate technology.

Unesco's science programmes are based on the principle that maximum use must be made of each country's own resources, especially human resources. Emphasis is therefore laid upon upgrading the qualifications of a country's manpower, making as full use as possible of local or regional training institutions. Where countries cannot afford research or training programmes, Unesco advocates the pooling of resources on a regional or sub-regional basis.

The regional approach has been carried through also into science policy areas: seven regional ministerial conferences have been held in this field in Latin America (CASTALAC, 1965), Asia (CASTASIA I, 1968 and CASTASIA II, 1982), Europe (MINESPOL I, 1970, MINESPOL II, 1978), Africa (CASTAFRICA, 1974), and the Arab States (CASTARAB, 1976). At the time of publication, CASTALAC II was planned for 1985 and CASTARAB II for 1986.

As the sole United Nations agency engaged in science policy studies for various levels of government—and for the United Nations system itself—Unesco has helped establish new government institutions in thirteen countries. It has also extended its advisory services to subregional economic groupings of countries such as the Convenio 'Andrés Bello' (SECAB) in the Andean Region, the Communauté Economique de l'Afrique de l'Ouest (CEAO), the Union Douanière et Economique de l'Afrique Centrale (UDEAC) and the Association of South-East Asian Nations (ASEAN).

Unesco's unique position among scientific agencies results in achievements that no other body could attain. An example is the setting of international standards in relation to the chemical and physical properties of sea and water: the Practical Salinity Scale and the new Equation of the State of Seawater represent a major step towards achieving a consistent set of properties for international use. Publication by Unesco of the *Geological Atlas of the World* and other international maps, are other examples. This Atlas, a joint project of Unesco's Divisions of Earth Sciences and Marine Sciences, shows geological features of the oceans and continents, and some geophysical features of the oceans. It is an indispensable reference for teachers, research scientists, and the mining industries.

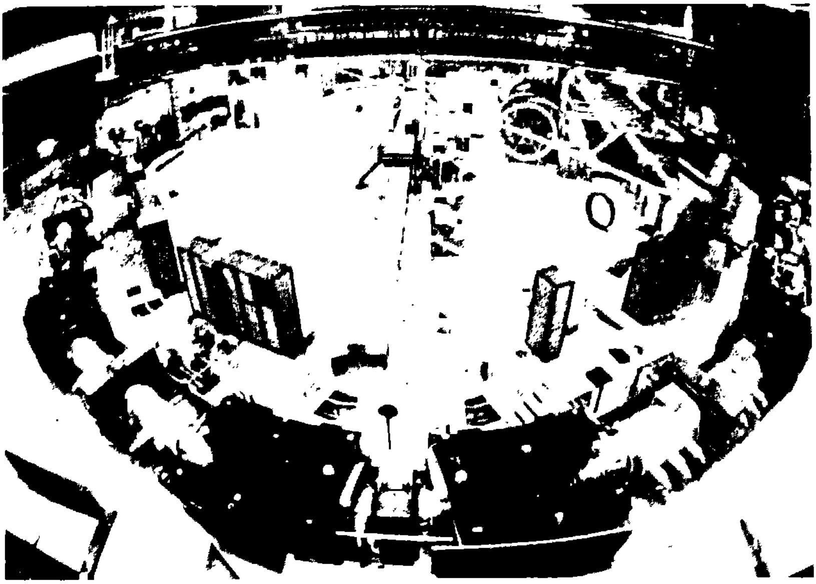
The co-operation of many countries makes possible such studies as that of the Kuroshio and adjacent regions between 1965 and 1977, in which more than forty research vessels from twelve countries participated. The Kuroshio is the most important ocean current in the Northern Pacific Ocean and exerts a profound influence on climate, shipping, fisheries and the general economy of the whole of East Asia. The Co-operative Study of the Kuroshio (CSK) provided new insight into the current's dynamics and provided information of use to fisheries in the area. It also led to a new and more comprehensive study of a much larger area of the Pacific Ocean, called WESTPAC.

Unesco's ability to marshal top scientific talent from around the world for problems of regional or global dimensions has led to its being approached for help by many organizations and governments internationally. An example is a recent (1984) study published by Unesco on earthquake risks in the Arab countries, *Programme for Assessment and Mitigation of Earthquake Risk in the Arab Region* (see page 41).

A project with similar goals was carried out by Unesco and the United Nations Development Programme (UNDP) in the Balkan region of Europe, and a report entitled *Seismic Risk Reduction in the Balkan Region* was published in 1984. This region is one of the world's most active seismic zones, where earthquakes have taken a heavy toll of life and property throughout history. Countries there sought Unesco assistance as far back as 1970, and nine years later, after a catastrophic earthquake devastated the Montenegro area of Yugoslavia and Northern Albania, further assistance was sought through a more comprehensive programme that aimed to reduce risk in the entire region. The above publication makes recommendations for continued co-operation among the countries involved.

Unesco's experience in co-ordinating large projects in fields such as oceanographic research has given the organization unique qualifications to advise on specific tasks, such as the technical specifications for oceanographic vessels. Many countries solicit advice based on such expertise when they set up their own national programmes. For example, the Government of Qatar asked Unesco to help it acquire a research vessel for use in its oceanography programme at the University of Qatar. Unesco prepared the technical specifications, handled the tendering and suggested a shipbuilder, then supervised the vessel's construction. The result was the vessel R.V. *Mukhtabar al-Bihar* handed over in 1983 at a ceremony attended by Unesco's Director-General, Amadou-Mahtar M'Bow.

The programmes and projects mentioned above give some idea of Unesco's special contribution, in the United Nations system, to international science and technology. These examples are of course only a small sampling of Unesco's overall efforts in these fields. Even when taken as a whole, Unesco's science and technology activities must necessarily constitute a selection from an entire range of possible activities. The next chapter outlines the areas Unesco has selected for its Second Medium-Term Plan (1984-1989) and how this choice was made.



The anti-proton accumulator at CERN in Switzerland, where Carlo Rubbia and Simon Van der Meer won the 1984 Nobel Prize in physics. Unesco helped to establish CERN, which celebrated its 30th anniversary in August 1984.

IDENTIFYING PROBLEMS SCIENCE CAN HELP SOLVE

It is a truism that no individual can today hope to be knowledgeable in all fields of science and technology, as Renaissance man was once supposed to be. It is equally true that no single organization can make useful contributions across the whole field of science and technology. Just as individuals must specialize, so must organizations, particularly those concerned with the use of science and technology for international development.

Unesco's recognition of this is embodied in its Second Medium-Term Plan (1984-1989). This plan, adopted by the General Conference in Paris in 1982, sets out the main lines of emphasis in Unesco's six-year plan of action and defines the areas in which Unesco concentrates in science and technology. Though based on this plan, however, Unesco's science and technology programmes are modified every two years when adjustments are made at biennial sessions of the General Conference, according to the way world problems develop, the way they are perceived, and what is known about them.

The plan itself was the result of a meticulous process of consultation based on an approach of 'planning by objectives'. The process began with an analysis of major global problems and a determination of what Unesco's contribution to their solution should be. This examination included not only scientific and technical but socio-political, legal, cultural, historical and moral and ethical aspects, and Unesco's science and technology programmes therefore emphasize interdisciplinarity. The choice of objectives to be reached through these programmes was based on a number of criteria, dictating that they should: fall within Unesco's terms of reference as defined by its Constitution; contribute directly to the solution of the problem involved; possess considerable urgency; and be in a field in which progress can be significantly accelerated by international and intergovernmental co-operation without producing wasteful duplication in the United Nations system.

Consultation with Member States and intergovernmental and international non-governmental organizations preceded the drafting of the plan. The Unesco Secretariat were asked for their views on world problems, those connected with the activities of their sector and those in their discipline. In science, an Advisory Panel on Science, Technology and Society, composed of distinguished scientists and engineers, discussed the issues involved and gave its recommendations. Meetings of the governing bodies of intergovernmental and international programmes also contributed to the plan's preparation. The draft plan was then considered and adopted by Unesco's General Conference.

The resulting plan is composed of fourteen 'Major Programmes'. Three of these embody Unesco's principal activities in science and technology: Major Programme VI, *The Sciences and Their Application to Development*; Major Programme IX, *Science, Technology and Society*; and Major Programme X, *The Human Environment and Terrestrial and Marine Resources*. Part of Major Programme VI is devoted to the social and human sciences, which are dealt with by Unesco's Sector of Social and Human Sciences.

The sciences and their application to development

As indicated in the Introduction, fundamental research is considered by Unesco to play a crucial role in the development of the natural sciences and their applications. Training is equally vital and complementary to research. They are in fact reciprocal activities, research constituting a key factor in training, and training being a preparation for research. International co-operation in both, by providing exchanges among individuals and pooling ideas, can help reduce the glaring disparities in science and technology that lie at the heart of development problems.

The objectives of this programme are therefore to encourage and promote research, training and international co-operation in the natural sciences, in technology and the engineering sciences. In addition, three key areas have been chosen for special emphasis: informatics (computer science and technology), applied microbiology and biotechnology, and renewable energy.

Two complementary approaches are adopted for this purpose. First, Unesco provides support for national efforts to create and develop scientific and technological training and research establishments. Second, Unesco strengthens and widens international co-operation in these fields so that they may grow within the region, especially among the least-developed countries.

The natural sciences

Involved in the natural sciences programme are mathematics, physics, chemistry and biology, which constitute the basis of all scientific knowledge and serve as a foundation for the engineering sciences. Progress in both teaching and research in these sciences is considered essential to creativity.

Mathematics, for example, remains as it always was a vital instrument for the development of the sciences: it is in a very real sense what the great physicist G.V. Gibbs called the language of science. It also finds direct application in a number of fields that today are highly active, such as computer technology, systems analysis, modelling techniques and simulation exercises.

Research in physics has led to exciting developments in microelectronics and telecommunications, and new knowledge about the structure of matter has helped scientists understand the behaviour of materials under extreme conditions.

Chemical research has revealed new knowledge about natural substances which are being adapted for production of new drugs and new manufacturing materials—two fields of great interest for developing countries in these days of materials and resource shortages.

Biological research holds high potential for both health and industry through recent advances in fields such as immunology, the operation of the nervous system, molecular and cell biology, applied microbiology and genetics. Such work holds out the promise, among other achievements, of self-fertilizing food crops, disease-resistant plants and inexpensive, high-volume production of synthetic hormones and enzymes, of which human insulin may be the first example.

This programme therefore aims to strengthen national research potential in the natural sciences and to improve institutional facilities. It develops university and postgraduate training programmes such as those offered at the International Centre for Theoretical Physics at Trieste, adapting them to specific needs and conditions in different countries and regions. And it broadens and strengthens international co-operation through collaborative action with other United Nations bodies and non-governmental organizations such as the International Council of Scientific Unions. Emphasis in university and postgraduate training is placed on the development of low-cost laboratory equipment and practical work manuals, the introduction into curricula of the results of recent discoveries and new concepts, laboratory technician training and curricula development.

Workshops, courses, seminars and symposia are the principal methods used by Unesco in its aim to strengthen national research potential. In the first decade of the existence of the Division of Scientific Research and Higher Education, some 10,000 individuals from developing countries received training in these ways. To take just a single year (1982), more than 2,500 participants from the following regions took courses in mathematics, physics, chemistry, biology and microbiology: Africa (about 300), the Arab States (about 250), Asia (about 700), Latin America and the Caribbean (about 400), Eastern Europe (about 700) and Western Europe (about 800). Consultancy services, grants for research and travel and fellowships are other methods by which Unesco carries out this programme. A recent innovation is the ICSU/Unesco Distinguished Fellowships in Science programme, which provides a stipend, travel and research costs for outstanding young scientists from developing countries. The idea is to establish a nucleus of bright young people capable of finding scientific and technological solutions to some of their countries' urgent economic and social problems.

Technology and the engineering sciences

This programme is designed for engineers and advanced technicians, who face daunting challenges in a technological revolution that has accompanied the scientific one. Innovations such as automation, computerization and the increasing complexity of production systems, together with the varying availability of raw materials and energy resources and their consequent price fluctuations, call for an ability to adapt to rapidly changing situations. Today's engineer-technician, moreover, must take into account the social, economic and political effects of his work in a way that his predecessors did not need to do.

The type of training such individuals must undergo has thus been changing in recent years. Efforts have been made to produce personnel who are not only technically competent but who have the judgement necessary to plan and manage projects and who are capable of finding solutions best suited to local conditions.

Today's engineers must also be equipped to deal with the new technologies that are arising from discoveries in microbiology and genetics, alternate energy sources, informatics and electronics. And they must be prepared to take account of restraints and requirements linked to environmental protection, resource protection and changes in the values society attaches to the quality of life.

Unesco's programmes in this area are therefore keyed to such needs. They aim to improve educational institutions and their facilities and to strengthen their potential for research and technological adaptation; to adapt training programmes for engineers and technicians to socio-economic needs, new sociological trends and the new requiremens of these professions; and to develop international co-operation in these fields.

They do this by contributing to national efforts, and by promoting joint ventures between Member States and non-governmental organizations. Special attention is paid to rehabilitating and adapting traditional technologies, increasing the use of technological innovations in rural development, and encouraging public participation in solving problems through technology. Stress is laid on improving relations between technological research institutions and industry, and on providing or improving national technological facilities, such as instrumentation and quality control.

Key areas in science and technology

Recent developments in computer technology, biotechnology and energy use are expected to bring about radical changes in peoples' ways of life. The combined advances in computer technology and microelectronics seem likely to result in developing countries losing outlets for their products because they will be less competitive. Computerized techniques bring the threat of unemployment to countries where there are adequate supplies of labour but not of capital. Yet these technologies also offer great benefits for countries able to exploit them, for example in data processing, communications, manufacturing and quality control.

Applied microbiology and biotechnology offer the possibility of producing in new ways a great number of substances and compounds essential to human life and welfare. Improved fermentation processes with a high yield, improved fertilization techniques, cheap production of biogas for cooking and heating fuel, and biotechnological production of foodstuffs: all these offer distinct benefits to developing countries. So, too, do renewable forms of energy such as sunlight, which are sometimes more effective and accessible than conventional forms, and at the same time environmentally less destructive.

Access to these technological areas is, however, difficult for developing countries, because of the speed of their development and the fierce competition between both countries and research laboratories.

The objectives of this programme are to increase the dissemination of these technologies, particularly among the least-developed countries, to strengthen specialist training, create favourable research conditions, develop information exchange and at the same time to encourage research on their social implications. This involves strengthening international and regional co-operation through research and training programmes and information exchange carried out jointly by industrialized and developing countries in the light of local conditions and needs. The goal is to improve living conditions in these countries, and at the same time to stimulate basic research, whose results in turn will refine technologies.

In informatics, the emphasis is on training of specialists and the introduction of informatics into education, development of software for applications in a local context, and on understanding the effects of informatics in its economic and socio-cultural aspects. International co-operation has been undertaken to prepare an Intergovernmental Informatics Programme for approval by the 23rd General Conference of Unesco in October 1985. In applied microbiology and biotechnology, emphasis is on development of regional networks of microbiological resources centres (MIRCENs), which specialize in fermented food production, improvement of soil fertility, biofertilizer production, and recycling and conversion of biodegradable waste materials into usable compounds. The renewable energy programme is directed towards diversification of energy sources, and promotes the use of small-scale, inexpensive energy sources among scattered populations and rural areas. It also aims at establishing information networks on renewable energy sources in various regions of the world.

Science, technology and society

This major programme is devoted to the question of the relationship between the advancement of science, technological progress and the satisfaction of human needs and aspirations. Its purpose is to help ensure that the applications of science accord with such needs.

Study and improvement of the relationship between science, technology and society

This programme seeks to shed light on the phenomenon of scientific creation, and the relationship between science, technology and society in various social, economic and cultural contexts. It therefore involves research into these areas, not only to explain them but to allow better-informed decisions to be made in science and technology policies and to facilitate the smooth integration of scientific discoveries and technological innovations into society. It also is aimed at promoting creativity in science and technology and at assessing and preventing risks resulting from them.

Part of the programme aims to encourage both scientists and the public to help participate in formulating science and technology policies, and in assessing the consequences of scientific and technological activities. Another part is devoted to making the public aware of the nature of science and technology and of what they have to offer, both through the mass media and through museums, publications and public information campaigns. Only a well-informed public can make wise decisions on problems involving science and technology, and the public's information comes mainly from the media, museums and similar institutions. This part of the programme therefore is directed at training science journalists, the organizers of technical education centres and those in charge of museums or science and technology exhibitions. The journal *Impact of science on society* is published under this programme.

Science and technology policies

The science and technology policy process involves translating a country's general development objectives into plans and programmes for scientific and technological research and services likely to help in attaining them, and also in translating research results into practical applications. For developing countries, a further need is to revive old knowledge and traditional techniques and make them competitive, so that their people may safeguard their cultural identity and avoid becoming dependent on the advanced technologies that are now the prerogative of the highly industrialized countries. Such revived and improved traditional techniques are often called appropriate technology. At the same time, developing countries must be able to hold their own in international markets with goods and services that incorporate the most advanced technologies, so as not to be relegated to second-class status internationally.

This programme aims to help Member States achieve such goals. This means identifying and supporting the contribution that science and technology can make towards satisfying the needs and aspirations of peoples in terms of socio-economic development. It involves promoting international and regional co-operation in science and technology policy through conferences of ministers and government experts, facilitating contacts among specialists in science and technology policy in developing countries, and encouraging international exchange of science policy information.

The programme is designed to help Member States and intergovernmental and regional organizations to formulate, implement and evaluate their science and technology policies, and to facilitate co-ordination between planners in developing countries.

Finally, it helps refine methods and techniques required to manage national scientific and technological development and to train the skilled personnel for these tasks.

The human environment and terrestrial and marine resources

A new awareness of environmental problems and the importance and finite nature of natural resources has marked recent decades. The establishment in 1972 of the United Nations Environment Programme (UNEP) at Nairobi, Kenya, was one expression of this awareness. Another is the fact that there are now at least 100 countries with ministries of the environment or government departments responsible for such matters.

During this period, it became more than ever apparent that mankind's activities were exerting profound effects on the environment and on natural resource supplies. Furthermore, man's influence during this time increased greatly because of the growth of human populations, expansion of urban areas, and the spread of industry and technology. Society now readily accepts the idea that its activities cannot continue unchecked without causing serious damage to the environment and shortages of certain essential resources, some of them non-renewable. All available data on the scale of deforestation, soil erosion, desertification, reductions in the variety of the genetic heritage of living organisms and the precariousness of food production reveal the growing seriousness of the situation.

Unesco's concern about such matters pre-dates the public's awareness of them by many years: as early as 1951, it set up an advisory committee on arid zone research, which constituted the first international effort to restore fertility to the world's desert regions. These early efforts laid the foundation for the present MAB programme. Today

Unesco's environmental and natural resources concerns find expression in this major programme. The programme reflects the continuation of Unesco's activities in fields in which governmental co-operation has fully proved its worth. These include, besides MAB, the activities of the IGCP, the IHP and the IOC. The programme devotes specific programmes to the earth's crust and to mineral and energy resources; to water resources; to the ocean and its resources; to coastal and island regions; and to the resources of terrestrial environments. It also includes innovations to deal with increasingly important problems such as those involved with urbanization and protection against natural hazards such as floods and earthquakes.

The earth's crust and its mineral and energy resources

The growing consumption of raw materials from the earth's crust makes necessary greater exploration efforts and fuller inventories of mineral and energy resources. Since most readily accessible deposits have already been brought into production, priority must be given in future to prospecting for resources more difficult to locate and exploit, or those that lie in regions still incompletely explored. Deep-level deposits, for example, which can be identified only by means of increasingly complex techniques, must be found; sedimentary basins located on continental margins (which may prove to be valuable sources of fossil fuels) and ocean beds (which may contain extensive metal deposits) must be explored.

Such exploration requires a much greater research effort in the earth sciences, because a better understanding of the processes that have resulted in formation of these ore bodies may be crucial to success in prospecting. The research may, in addition, lead to development of new resources. Research of this kind must be conducted with observations made at many points on the earth's surface: international co-operation among earth sciences specialists of all countries is thus a necessity.

Africa is one of the developing regions with considerable potential for further discoveries of mineral resources, which should contribute to the economic development of countries there. Thus a major regional project has been set up for research on the African Pre-Cambrian and its evolution, which is expected to yield vital clues to the mineral potential of most of the countries of the continent.

Such research cannot be confined with national boundaries, because the main geological formations overlap these. Inter-African and international co-operation therefore has to be promoted so as to conduct a general assessment of geological data on the region and the potential practical problems, before any mineral prospecting is undertaken. This is the task of the project entitled 'Geology for Economic Development'. In this and in other areas of the programme, the most modern and promising techniques—such as remote sensing from earth satellites—are being employed.

In addition to its prospecting functions, earth sciences research contributes to our knowledge of geophysical phenomena, such as the movements that occur at the earth's surface and the thermal processes that take place in the deep crust and mantle. This knowledge may lead to prevention or mitigation of the consequences of natural catastrophes such as earthquakes or volcanic eruptions.

Finally, the earth sciences contribute to our knowledge of the geological and geochemical constraints that must be taken into account in land-use planning, for example in connection with civil engineering and mining projects, groundwater movement and storage of industrial wastes.

This programme therefore has as its objective to open the way to better knowledge of the earth's crust, to promote the training of specialized personnel, to strengthen the research institutions and laboratories needed for such work, and to disseminate information through the organization of training courses and seminars. Its six subprogrammes include the IGCP, which aims at achieving a better knowledge of the geological history of the planet through correlation of world-wide scientific data.

Natural hazards

Natural disasters of geophysical origin such as earthquakes, volcanic eruptions, tsunamis (tidal waves) and landslides take a heavy toll in human lives and material damage. Disasters of climatic origin, such as droughts and floods, deprive large numbers of people of food and shelter, sometimes for long periods.

Relief operations, necessary though they may be, are not the whole answer. Scientific and technical knowledge is needed to avoid or mitigate risks from these sources. And while warning systems have been improved, we are still a long way from being able to predict earthquakes, for example. More research is needed in both causes and effects of such disasters, and the means for reducing the risks caused by them.

This programme fosters such steps through international co-operation in scientific and technical fields, and through direct co-operation with countries affected by natural disasters.

Water resources

The world's water problems are caused not so much by a shortage of water as by an uneven distribution of it. World water resources are more than adequate for the foreseeable future, yet some areas are dangerously short of water and their situation is likely to get worse. This situation is aggravated by the poor quality of much of the water available, partly as a result of pollution caused by factory effluents and the heavy use of pesticides and fertilizers.

The solution to the world's water problems lies in better management of both supply and demand. This should aim to promote water use in such a way that society's needs are met while at the same time water sources are protected for the future.

The water resources programme aims to improve scientific and technical knowledge, train the necessary personnel, build up research and training institutions and stimulate conservation and proper utilization of water resources by decision-makers and the public. The IHP continues to be the main instrument of action of this programme, operating in close co-operation with relevant programmes of the United Nations.

Three major regional projects on the rational use and conservation of water resources in rural areas were begun in 1981 in Africa, Latin America and the Caribbean, and the Arab States: these are designed to contribute to the growth of the scientific potential of countries in these areas, to the progress of research and development of information networks, and to a rational use of water resources based on choice of the most appropriate technologies, including somewhat modified traditional ones.

The ocean and its resources

These studies have particular importance in view of the recent outcome of the long-term deliberations of the United Nations Conference on the Law of the Sea. The conference culminated in a 'new regime' of the sea which sanctions national jurisdiction over 'extensive economic zones'. This has two major implications: it gives many developing countries rights over sea areas that often are more extensive and richer than those they have on land, although they do not always have the technical and financial means and qualified manpower to exploit them; and it vests the international community with added responsibilities in exploration, conservation and management of ocean resources.

If the developing countries with these new resources do not acquire the means of studying and managing them, they may lose a historic opportunity and the substantial benefits they could otherwise have reaped. Manpower training and the strengthening of marine science facilities are therefore indispensable. Co-operative action between countries bordering on regional seas is also increasingly necessary for studies of common interest, such as those of major oceanographic phenomena, and for protection and management of marine resources. And apart from such practically-oriented studies, those of a more fundamental, long-term nature are necessary to aid in the understanding of such phenomena as weather and climate changes.

All such actions require close co-operation between nations. Through its marine science programme and through the IOC, Unesco is ideally suited for such activities. The IOC, with headquarters at Unesco, has been operating for twenty-five years, and it acts as a co-ordinating mechanism for scientific aspects of the whole of the United Nations system's programme. Through it and through its Marine Sciences Division, Unesco helps Member States develop their own resources for marine science research and services.

The programme comprises five subprogrammes: 1. Scientific investigations of the oceans and their resources (the relationship of ocean dynamics to climatic change, living resources, mineral and energy resources, and the chemical properties and quality of ocean waters). 2. Management of marine systems. 3. Ocean services (provision of oceanographic data, information, charts and warnings). 4. Strengthening of international and regional capacities for marine research, ocean services and training. 5. Strengthening of oceanographic co-operation and formulation of intergovernmental policies (through the IOC).

Management of coastal and island regions

The coastal environment is highly conducive to the establishment of human settlements: at present, two persons out of three live there. These regions are also among the most popular for tourism: one-third of world tourism is concentrated on the coasts of the Mediterranean. Yet coastal regions today hang in a delicate balance. Often they have been the sites of ancient civilizations whose prosperity was based on shipping and maritime trade, and on the relatively high productivity of the coastal environment. This environment itself is the product of the complementary effects of land and sea environments and constitutes a complex system marked by the distinctive chemical properties of the waters and by a set of vulnerable entities such as mangroves and coral reefs. Today the whole system is being exposed to the effects of modern development, which is causing extensive damage through degradation and pollution.

The islands of the world—especially small ones—are subject to the same pressures as are continental coasts, together with some other pressures of their own. Island environments are exceedingly vulnerable, and efforts made to increase production to meet development needs or respond to population increases are hampered by severe space restraints. In a large number of islands resources are no longer adequate to satisfy the needs of a growing population, so that exploitation of coastal and marine resources becomes an economic imperative.

An interdisciplinary approach is necessary to understand such problems. Physical, chemical and biological studies of the environments, together with social science studies for rational management, are essential. Precise data are needed about the nature and extent of changes wrought by human activities.

This programme promotes integrated management of coastal zones and islands, fosters international collaboration in understanding the nature and functioning of such systems and facilitates the integration of scientific, socio-cultural and economic information for decision-making purposes. It is also aimed at developing the necessary skills and increasing the number of specialists for the rational use and management of coastal and island regions. The programme benefits from contributions from Unesco's major international programmes such as MAB, IHP, IGCP and IOC.

Land-use planning and terrestrial resources

Competing activities give rise to conflicts of interest in various forms of land-use. Land-use planning therefore should be directed at all the different ways in which land is used and occupied by man, both in natural and urban areas. Although considerable information is available today in this field, little of it can be usefully applied to rational management: it is too specific and the interactions between environments and society have rarely been studied in their totality. Whatever is available is usually published in a form not readily useable either by decision-makers or the public.

The aim of this programme is to develop knowledge of the physical and biological processes and social and cultural conditions that need to be taken into account in rational land-use planning, to train the necessary personnel and to improve structures for research, training and information exchange. It is carried out within the framework of the Man and the Biosphere Programme. MAB is distinctive in that it provides conceptual unity and unity of management for activities relating to the conservation of protected natural areas and the management of rural and urban areas. In mid-1985, 100 Member States were participating in MAB and about 1,000 field projects were underway. (Components of MAB are found also in other programmes, including the previous one and the three that follow.)

Co-operation in this programme between countries with similar scientific concerns is encouraged through regional networks with links between national projects. These make for a better use of available human and financial resources. National pilot projects in research, training and demonstration in land-use planning and resource development constitute key elements in the regional networks. Some 15-20 of these exist in each network and will total about 100 by the end of the plan. Each year some 300 specialists are trained—two-thirds of them on project sites and the rest at centres of excellence in industrialized countries.

This programme covers such subjects as problems of migration and colonization in the humid and subhumid tropics, possibilities of using biomass as a renewable source of energy and studies of the biological resources of inland waters and of traditional land-use methods and their importance for conservation. In arid and semi-arid zones, it deals with problems of the mobility and settlement of pastoral populations, efforts to combat desertification and impacts of irrigation projects. In temperate and cold zones studies are carried out of deciduous and coniferous forests, tundra, mountains and Mediterranean climate areas, impacts of pollution and other man-made changes, particularly in agriculture; specialist training is also undertaken to reduce the serious shortage of land-use planners.

Urban systems and urbanization

By the year 2000, more than half the 6,000 million inhabitants of the earth are expected to live in urban areas. Sixty cities will have more than 5 million inhabitants, of which forty-seven will be located in developing countries. Twelve of the fifteen largest cities in the world will be found in these countries.

This prospect poses serious social and economic problems for the majority of countries, but particularly for developing ones. Problems of urbanization on this scale include inadequate public health and sanitation services, profilerating rapid transit systems, pollution, unhealthy psycho-social conditions and the disappearance of historic centres.

Until now, planning usually has taken little account of the complexity of the relationship between cities and surrounding rural areas. As they develop, cities and towns come to depend more and more on distant regions for their supplies of water, energy, food and building materials. This often leads to a deterioration of surrounding land through over-exploitation.

This programme is aimed at achieving a better understanding of such problems in order to make possible more rational planning and in addition integrated rural development. The programme is based on the idea that planning and management of urban systems requires close collaboration between specialists in the natural and social sciences, and a dialogue between planners, decision-makers, the local population and scientists and engineers. Local populations should be able to participate in both studies and decision-making concerning their environment—and such participation has to be organized.

The programme—which is part of MAB—takes the form of pilot projects centred on small- or medium-sized towns and great cities and investigates such factors as: flows of energy and materials, recycling mechanisms, the psycho-social condition of urban populations in relation to various levels of energy consumption, the perception of the townscape by various strata of the population, creation of open spaces and biological indicators of environmental changes. Particular attention is paid to the interaction of towns and cities with their rural surroundings, urban migrations and the adjustment of migrants, particularly women, to their new environment.

Training and planning and management of urban systems are part of the programme, as is promotion of public awareness of the problems of urbanization.

The natural heritage

Cultural property, such as historic monuments and groups of buildings, and national parks and outstanding sites, despite their obvious differences, have some common problems and can be incorporated into a single concept called 'world heritage'. Both, for example, call for international co-operation for their preservation and enhancement.

In one sense, however, the natural heritage is more important than the cultural one, for it contains the living resources on which the survival of the human race depends: the plants and animals on which man relies for food and countless other products are descended from wild species. Genetic selection, through which the maintenance and expansion of agriculture depends, requires the preservation of as many wild species as possible. In addition, as yet unknown plants, animals and micro-organisms could provide mankind with many new products and services, as recent discoveries have shown, for example in pharmaceuticals. Finally, the preservation of the diversity and beauty of the natural heritage is important for the psychological well-being of man.

It is now acknowledged that deterioration of the natural heritage is occurring almost everywhere as a result of the effects of industry and transport, population growth and urban development, atmospheric and water pollution and major civil engineering works. The World Conservation Strategy revealed that some 25,000 plant species and more than 1,000 species or subspecies of vertebrates are threatened with extinction by the end of the century, mainly because of destruction of their habitats. Yet in many countries, development policies still do not take sufficient account of requirements necessary to preserve the heritage, and some that possess a particularly rich natural heritage have the least means to preserve and enhance it.

This programme is designed to encourage the preservation of natural sites and the maintenance of the greatest possible variety of genetic, animal and plan species. Efforts are directed not only at the protection of notable landscapes and living creatures, but of entire environmental systems and some man-made landscapes, largely through a worldwide network of biosphere reserves. Natural sites needing preservation are identified and listed, framing of national protection policies is encouraged, as is the drawing up of international legal instruments; and national planning, training of specialists and development of public awareness are promoted. Under the MAB programme, 243 biosphere reserves had already been established by mid-1985, covering about two-thirds of the world's biogeographical regions.

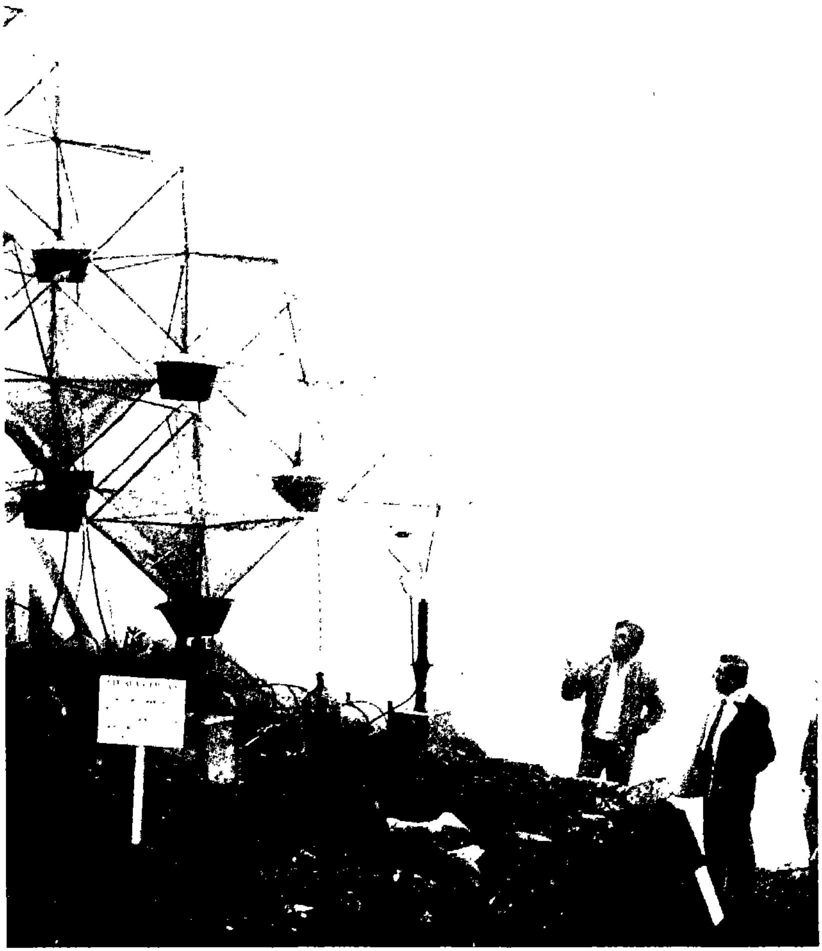
Environmental education and information

Environmental education deserves to be given a place in curricula at all levels and in all types of education, with the dual aims of fostering a more precise understanding of environmental problems and arousing a desire to participate in measures to solve them.

This programme, in co-operation with UNEP, aims to promote widespread awareness of the causes of environmental problems and their impacts and to foster the adoption of attitudes and behaviour likely to contribute to environmental protection and improvement. It does this through production and dissemination of written and audio-visual materials aimed at teachers and the media. It is also aimed at ensuring that national education policies give sufficient importance to environmental issues, and that planners and administrators receive some training in environmental protection.

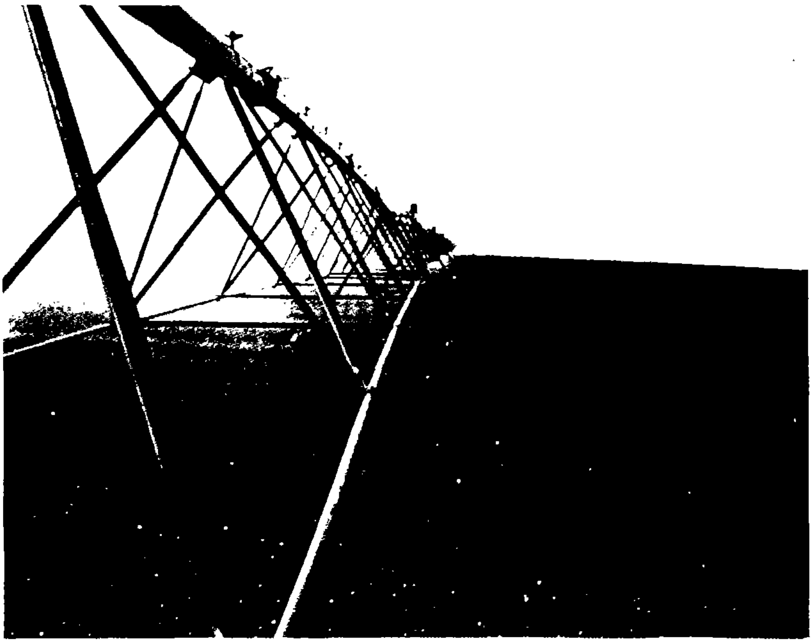
Specialized personnel—for example town planners, engineers, economists and administrators—also have need of accurate, well-balanced and regular information on environmental matters. This kind of education is part of the MAB programme.

These, then, are in broad-brush form the areas covered by Unesco's science programmes. The following chapter describes individual projects or groups of projects in more detail, in order to provide a more comprehensive picture of the way these programmes are executed, and of the effects they produce. One example has been chosen from each of the major areas described above, plus an additional example of a project funded from outside Unesco's own budget.

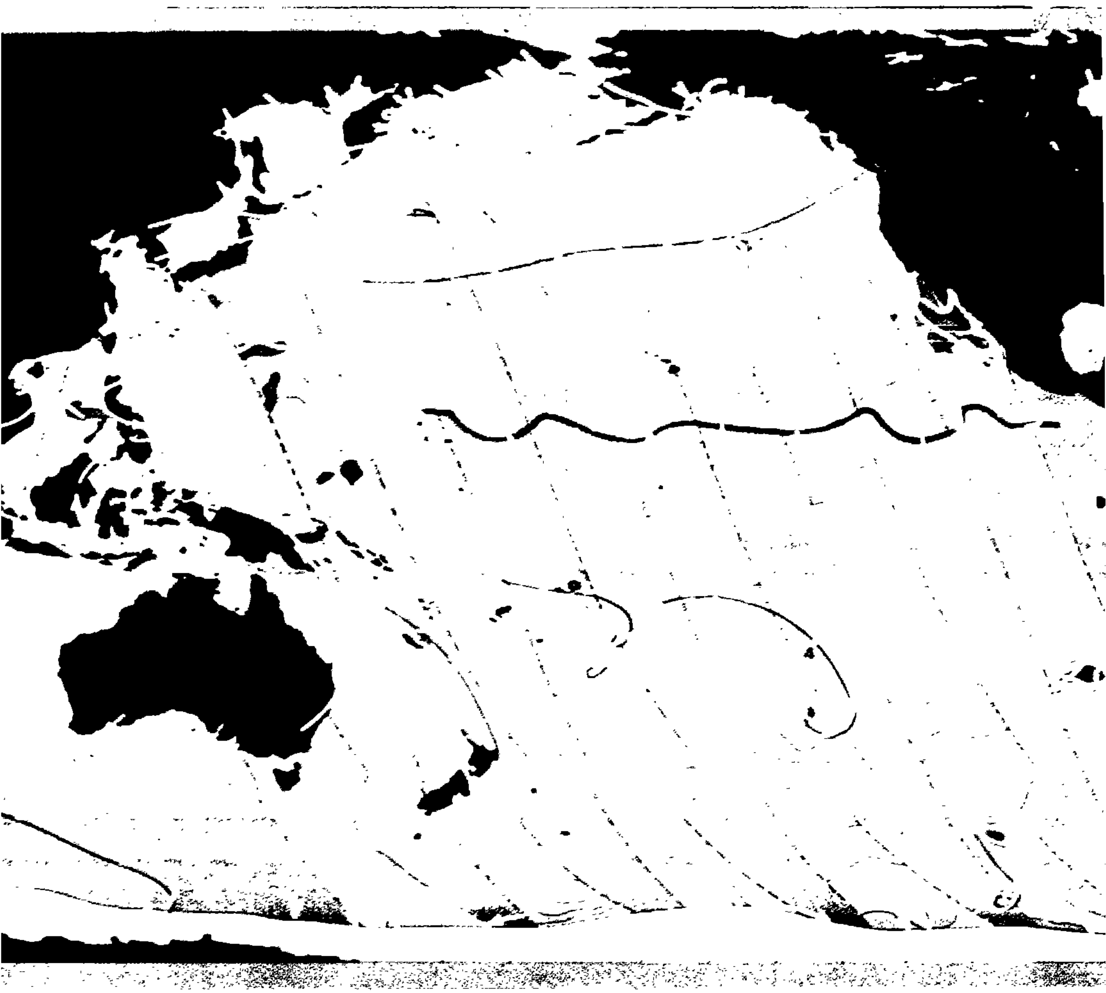


A fog-trap set in an arid area of the Andes Mountains in South America condenses water won, as it were, from the clouds. Unesco-supported research provides a new and unconventional water source that may prove useful in other countries.

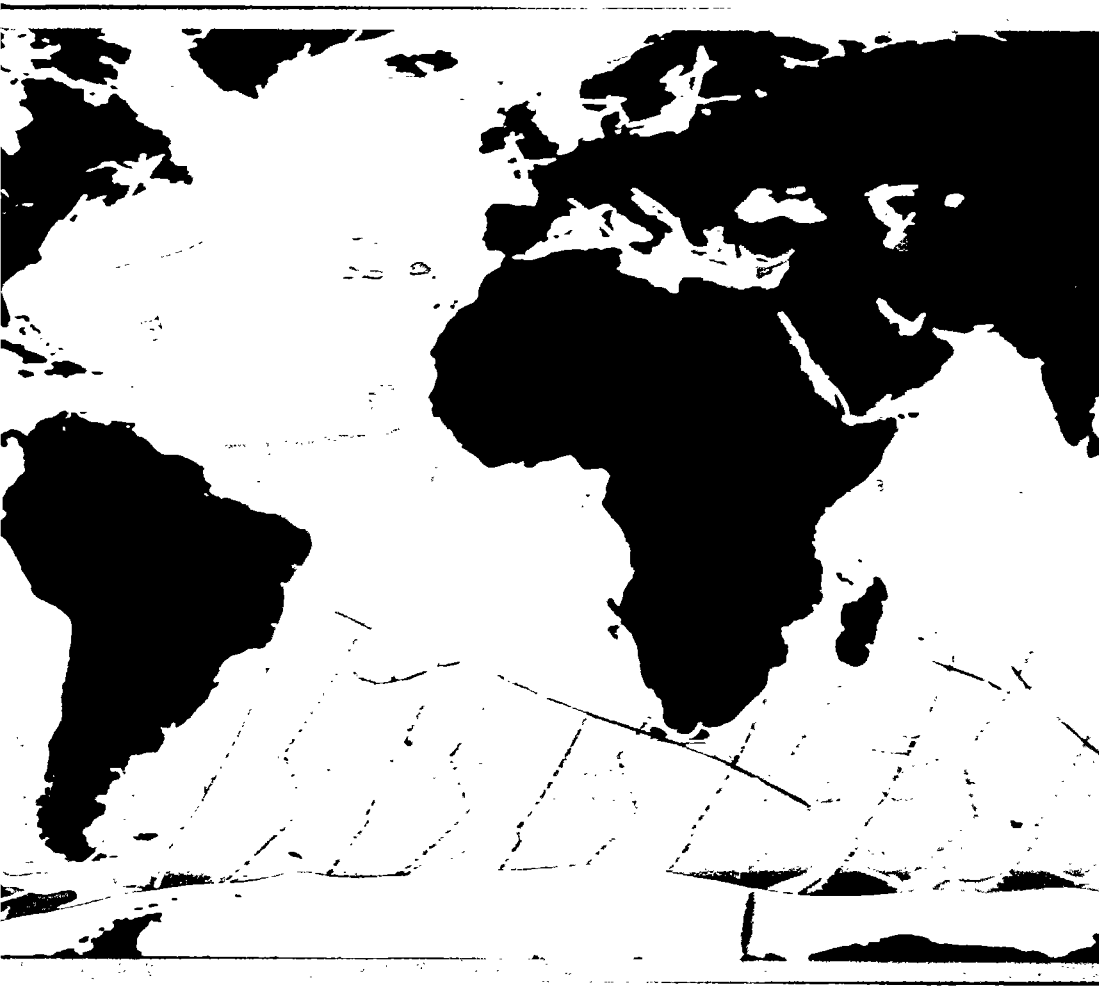
Tourist views Waitaki area of New Zealand, site of a study designed to clarify relationships of man and the biosphere, and of mountain grazing lands. The study falls under Unesco's Man and the Biosphere programme, one of four intergovernmental programmes within the science sector. Cultural disturbance of the landscape that characterized European colonization of the lowlands is now being re-enacted in the uplands by the colonists' descendants. Such studies help regional planners in many parts of the world to resolve conflicts between community, local and national interests.



Some of Unesco's hydrology projects, which fall under the International Hydrological Programme, are concentrated in the world's arid zones. This photograph shows an irrigation project that allows a North African desert to produce food crops.



The image shown here is the first comprehensive view of the winds over the world's oceans. It was constructed by the United States' National Aeronautics and Space Administration from data collected by its Seasat satellite. Wind speeds were calculated from radar reflections from the small wind-driven waves that roughen the sea surface. Seven orbits are represented by the coloured bands during a 12-hour period on 14 and 15 September 1978. The lowest wind speeds are shown in green and yellow, highest in pink and red. White streamlines that parallel the wind flow have been interpolated across areas not covered by the satellite path (depicted in blue). Thick blue lines show where the trade winds converge



form the Intertropical Convergence Zone. Numbers 1 and 2, south of Japan, are phoons (Irma and Judy). Number 3 indicates position of monsoons over the Indian 'cean, while number 4 in the South Pacific is frontal zone of huge low-pressure storm. rojects conducted by Members States of the Intergovernmental Oceanographic Commis- on make use of such data in studies of heat exchanges between the seas and the mosphere, which are crucial to our understanding of climate. The IOC is one of four tergovernmental programmes within Unesco's science sector.

Warrior treating a young camel against scabies in Unesco's IPAL programme.

The traditional Mexican 'Chinampa' agricultural system takes advantage of local environment and can be sustained without large-scale inputs of fertilizers, capital and equipment. Small land plots are used to grow crops from plant materials and mud dredged from the bottom of swamps and lakes, the plots being separated by water channels in which fish can be raised. Sometimes it is combined with small-scale forest industries to produce multiple products from farm and forest. The Institute for the Study of Biological Resources at Jalapa has conducted a MAB-UNEP study of the Chinampa system to see how it could be adapted to different locations. Other countries might benefit from such studies.

Field assistants sample vegetation in the Integrated Project in Arid Lands (IPAL) in Kenya. Goal of the project was to propose solutions that would improve the well-being of pastoral peoples in the whole of the Sahelian zone of Africa and comparable regions worldwide. IPAL led to establishment by the Government of Kenya of a Kenyan Arid Lands Research Station in Marsabit.

SOME PROBLEMS —AND SOME SOLUTIONS

The projects in Unesco's science and technology programmes can be numbered literally in thousands. Obviously it is impractical to describe them all. The approach taken here is to select typical activities from each division within the science sector that will illustrate the chief characteristics of the major programmes. In addition, one illustration is given of the work of the operational programmes, which are funded from sources outside Unesco's regular programme budget but managed by Unesco. The examples chosen are centred in every major geographical region in which Unesco operates except Europe.

Promoting ingenuity in the basic sciences

In some Asian countries between 1979 and 1981, the price of glassware for chemistry laboratories rose by nearly 60 per cent and many chemicals doubled in price. Yet during the same period, laboratory funding remained static. Basic chemistry instruments become so expensive that many universities were forced to stop using them in their teaching programmes. If the trend continued, students might cease to acquire experience with modern laboratory techniques—an outcome that would have serious implications for the future development of these countries.

Dismayed by such a prospect, a group of chemistry and physics teachers at the University of New Delhi decided in 1980 to build their own chemistry instruments. Major advances in micro-electronics in recent years had made this possible by simplifying the design of instruments through the use of silicon chips containing complex integrated circuits. Although these chips could contain hundreds or even thousands of individual electronic components, an instrument designer needed to know nothing of their intricate circuitry: he could buy chips to perform designated functions and then simply wire them into the instruments the way enthusiasts hook up audio equipment. In addition, the chips were extremely cheap, often costing no more than a few dollars each.

The University of Delhi professors were encouraged in their project by Unesco's Division of Scientific Research and Higher Education and by the teaching committee of the International Union of Pure and Applied Chemistry. They focused their efforts on developing meters that would measure the electrical conductance and acidity of solutions, because these instruments could be applied in a wide range of analysis experiments and could illustrate important chemical concepts. By the end of their first year's work, the instructors found that they could make such instruments for as little as US $20, a fraction of the cost of commercial instruments.

For certain experiments, commercial instruments used platinum-coated electrodes, which were much too expensive for the group to purchase. After considering alternatives, the professors decided to try using graphite rods from discarded dry-cell batteries as substitutes. They were delighted to find that the graphite electrodes made an excellent replacement for the platinum-coated ones—and that they were, in addition, sufficiently versatile for undergraduate chemistry experiments.

Refinements to their home-made instruments brought the cost to about US $35—but the results they provided were comparable with those obtainable from commercial instruments costing ten to thirty times as much. In addition, the home-made equipment could be produced to meet fully commercial-level standards of finish and performance as tested in international standards laboratories.

A similar project is being promoted by Unesco's Division of Scientific and Higher Education through the Asian Physics Education Network (ASPEN): a Laser Optics Kit based on a neon-helium laser built from locally-available materials. The kit is to be patterned on one already built in prototype by the Asian Institute of Physics in co-operation with ASPEN, and is expected to cost around US $800.

The monetary savings are expected to be of the same order as those obtained with chemistry equipment. But monetary savings are not the only advantages to such schemes. The learning process involved in building equipment from local materials is quite as important, and helps developing countries become less dependent on industrialized countries when meeting their development requirements.

There is also, of course, a significant advantage in the fact that such solutions do not require the expenditure of scarce hard currency. But the learning experience in the case of laboratory instruments can have additional value. Most developing country physics laboratories in universities are not well-equipped with demonstration equipment. One reason is cost. Another is maintenance difficulties.

If a particular piece of equipment—say a Van de Graaf high voltage generator—is subject to frequent breakdowns, it may rarely be used, and students may thus never see certain types of demonstration. This will leave them at a distinct disadvantage compared with their rich-country counterparts, whose universities may typically spend as much as US $3,000 per student on laboratory equipment during their undergraduate programme.

Although scientific principles can often be taught as easily with quite simple equipment as with the most modern, if a student never sees a certain piece of modern equipment he will be completely unfamiliar with it when he has to use it later.

The Laser Optics Kit not only calls upon the ingenuity of developing country scientists to develop sophisticated equipment with their own resources and opens their eyes to new possibilities within their reach; it also proves that it is not just second-rate science that can be carried out under their financial limitations. The Laser Optics Kit involves precision equipment and the most up-to-date technology: the laser itself (a source of extremely pure light of just one wavelength); a 'light bench' for positioning the laser in association with other equipment such as lenses and diffraction gratings; and light-measuring apparatus.

The chemistry and physics projects are part of a continuing Unesco programme aimed at supporting in developing country universities natural sciences courses relevant to these countries in the light of recent developments in international science. Other aspects of this programme include:

- Training courses in Africa and Asia to familiarize university teachers with development of practical chemistry and physics teaching programmes.
- Seminars in Arab States on improvement of curricula for biology.
- Seminars in Africa for university lecturers on curricula improvement in mathematics.
- Travelling demonstration workshops in Asia for training laboratory technicians in science faculties.
- A course in Asia on the relationship between university teaching and industrial activities.

These projects illustrate several characteristics of Unesco's activities in the basic sciences:

– They work by developing existing indigenous resources.
– They are aimed at solving specific problems or filling demonstrable needs.
– They have both training and research aspects.
– They function by means of international co-operation between governments, non-governmental agencies and professional associations.

Renewable energy and information networks

The development of low-cost, alternative energy supplies is an urgent requirement of many developing countries. Solar energy is a fruitful field for new applications, and one that offers much promise in the kinds of situation often found there.

Rural health centres, for example, require refrigerated storage for vaccines, yet often electrical power is unavailable in remote areas in which these are situated. Villages and small communities, equally isolated, frequently require artificial cooling for storing agricultural produce.

Although solar-powered cooling research was begun as early as the mid-1930s, up-to-date information about such systems was not readily available in a single comprehensive publication. Assessments of the economic promise and technological details on how to proceed to solve specific problems, particularly in developing countries, were very difficult to obtain.

A consultant, working with Unesco's staff, completed a worldwide study of solar-powered cooling and refrigeration technology in 1984. He compiled information obtained through a literature search and a questionnaire sent to some 150 institutions and individuals and evaluated it in terms of his own knowledge and experience in a report that will be made available by Unesco to those interested.

The report describes some current programmes in active solar space cooling systems and selected major projects of particular interest, including a solar-driven cold store for developing countries. And it presents individual case studies in space cooling and refrigeration in Thailand, France, Papua New Guinea, Romania, Belgium and Kuwait. Economic assessments of some projects are included. In addition, the report includes both the questions featured in the questionnaire and the names and addresses of those who responded to it.

The report shows that a wealth of experience exists in this field that can be shared throughout the world, but it cautions that comparatively few examples can be shown at present to be economic compared with the costs of conventional cooling and refrigeration systems. It also points realistically to the fact that commercially installed systems in the United States have shown poor performance compared with identical systems installed in research organizations. On the other hand, the report points to the advantages of passive systems of solar cooling, principles of which have been employed in some countries for hundreds of years. Suggestions are made by the report for educational programmes in the field.

The solar cooling and refrigeration study is but one example of Unesco's diversified energy programmes designed to promote the availability of alternative forms of energy to developing countries through a more realistic mix of conventional and new sources of energy. Another is its development of information systems and networks that can collect, process, store and disseminate facts and figures on all the new and renewable energy sources such as wind, biomass, geothermal, and ocean. Such information is fundamental for anyone dealing with energy problems, but—especially for users in developing countries—it is difficult to obtain and expensive. By stimulating and co-ordinating the establishment of national, regional and global information systems designed by their users and employing both conventional and modern information-handling and communication techniques, Unesco is trying to put the right information into the right hands at the right time. The objectives are to create international networks of institutions and centres of excellence transferring and sharing energy information through a variety of channels, to avoid unnecessary duplication and to provide specialized services to all users—research and development personnel, planners, policy makers, administrators, manufacturers and the public.

The approach was formulated as the result of a study conducted by Unesco in 1980. The data needed for the study were collected by 37 individuals who undertook fact-finding missions to 256 organizations in 55 countries over 5 continents, in the course of which 655 interviews were carried out. In addition, 23 organizations of the United Nations system and 21 governmental and intergovernmental organizations were consulted or visited.

Unesco's contribution to the identification and use of new and renewable energy sources draws on information from physical, environmental and life sciences, engineering and technology, economics, planning, manufacturing and extension training. In integrating these diverse elements of energy information, taking into account local social and cultural conditions, Unesco is able to help countries deal with their energy needs and speed their development.

Matching science and technology to national needs

In 1979, a group of Caribbean countries approached Unesco and UNDP for help in planning their scientific and technological developments. As a result of their request, a Unesco consultant spent six months visiting twelve countries in the region to discuss possibilities for co-operation and to gather information on national and regional priorities in science and technology.

The consultant found much common ground in the different countries' perceptions of needs and priorities—and also considerable overlap and often duplication among regional initiatives. He reported, in fact, that 'the number of similar projects supported by different aid donor agencies is quite striking. It means that Caribbean countries are not getting the most out of available financial resources. And since generally it is the same people that are involved, unnecessary strain is imposed on limited human resources'.

A Caribbean council for science and technology—if eventually set up—would have an important role to play, the consultant reported. But clearly it was the willingness of territories to exchange and share technological knowledge freely that would determine the fate of regional co-operation.

The consultant concluded that the commonality of problems in science and technology in the area offered considerable scope for mutually advantageous regional co-operation. Such co-operation could be described under three headings: science and technology planning, scientific and technological services, and research and development.

But he found that, with hardly an exception, the territories visited lacked effective mechanisms for establishing scientific and technological priorities, and for integrating these activities within the broader framework of national socio-economic development objectives. All recognized the need to strengthen their science and technology policy and planning infrastructures, and many were in favour of setting up national science councils for this purpose, but they did not have a clear idea of how to integrate these bodies in the overall national planning system. In addition, there was a general lack of trained personnel in the field.

The consultant recommended a number of steps: regional training seminars, publication of a newsletter and an information network, compilation of an inventory of skills and natural resources, strengthening of science curricula in schools, and establishment of research and development programmes in priority areas, among others. Furthermore, the Unesco Secretariat proposed draft statutes for the Caribbean Council for Science and Technology (CCST), an independent intergovernmental organization.

The CCST statutes were eventually adopted at an intergovernmental meeting in Kingston, Jamaica, in 1980, and subsequently ratified. The first plenary session of the CCST was held in Bridgetown, Barbados, in 1981. Subsequent sessions were held in Jamaica in 1982 and in Curaçao, Netherlands Antilles, in 1983. Countries currently members of the CCST are Belize, Cuba, Dominica, Grenada, Guyana, Haiti, Jamaica, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago.

The diversity of the organization's membership, in terms of size, language, culture and political organization, is exceptional: the largest country, Cuba, contains 115,000 square kilometres of territory and a population of roughly 10 million, while the smallest, Saint Vincent and the Grenadines, has only 390 square kilometres and a population of about 100,000. There are one Spanish-speaking, one Dutch, one French and eight English-speaking countries in the CCST. Despite these differences, and because of the commonality of the scientific and technological problems facing the various countries, the organization manages to function smoothly.

The establishment of the CCST was a direct response to a perceived need of Caribbean countries for a mechanism to make the best and most effective use of the region's scientific personnel and institutions in applying science and technology to the region's development. Its major function is to enhance regional co-operation and mutual assistance in science and technology and to strengthen self-reliance while maintaining the independence of the member countries.

A good deal has been accomplished during the organization's short existence. Work has begun on the following eight projects:

1. An assessment of national science and technology capabilities, notably human resources.

2. The establishment of a science and technology journal for the region.
3. Preparation and exchange of audio-visual material for education in science and technology, including two films.
4. A study of the consequences of energy crop development on food supplies in the area.
5. Conservation and exchange of the germplasm of crop plants.
6. The development of agro-industries and employment opportunities, particularly in rural areas.
7. Study of the potential and limitations of newly-emerging technologies for developing countries.
8. Development of a science and technology policy for the Caribbean region.

Given the diverse characteristics of the countries that comprise CCST, its establishment alone must be considered a major achievement. The progress achieved so far on the above projects adds further evidence of the usefulness of this development. It also provides a good example of one way in which Unesco is able to help developing countries to formulate their science and technology policies at the subregional intergovernmental level.

Building defences against natural hazards

In October 1980, one of the most catastrophic earthquakes that had ever occurred in North Africa struck El Asnam, Algeria. Almost 80 per cent of the city was destroyed, 2,500 people were killed, thousands more were injured and 300,000 were made homeless. Damage to property was estimated at about $4,000 million.

The disaster prompted the Arab Fund for Economic and Social Development and the Islamic Development Bank, as major donors of development assistance in Arab and Islamic countries, to take action. In 1981, they decided to try to reduce earthquake damage throughout the Arab region, in which the El Asnam earthquake was only the latest in a long series of similar disasters, through a well-planned, long-term programme rather than temporary relief. They asked Unesco to prepare a scientific proposal for a feasibility study.

Unesco's proposal was prepared by its Earth Sciences Division and undertaken by a team of nine scientists between 1981 and 1982. The study concentrated on Algeria, Egypt, Iraq, Jordan, Libya, Morocco, Saudi Arabia, Sudan, Syria and Tunisia. These countries were chosen because they suffer a particular risk or have already shown interest in seismology. The hope was that eventually all Arab States would participate in the proposed programme because of the long history of earthquake risk in the entire area.

The team of scientists found 'a general lack of experience in earthquake engineering and engineering seismology in Arab countries', despite the fact that hundreds of earthquakes are recorded in the area annually and about twenty felt by inhabitants each year. No specific criteria existed in the countries for repair and strengthening of structures damaged by past earthquakes or for strengthening of existing structures, except for an elaboration of a regional building code in Algeria after the El Asnam disaster. Only two countries had developed their own seismic building codes (Algeria and Morocco), and these were mainly based on one drawn up by France for that country's conditions, which obviously differ from those in Arab countries. Egypt and Jordan were preparing to develop codes of their own, while most of the other countries used either the French or American code. Syria used the Soviet code.

Engineering structures such as dams, irrigation systems, major transportation systems, industrial and power plants had no specific requirements and were designed in accordance with the codes used by foreign designers or consulting companies. These codes were based on empirical experience without appropriate consideration of the nature of expected ground motions at the sites, or of the dynamic properties of the structures. Furthermore, seismic zoning or seismic hazard maps were usually non-existent in these countries.

There was practically no organized research throughout the region and little training of personnel or public information regarding earthquake hazards.

As a result of the study, Unesco published a report proposing a five-year, $105 million Programme for Assessment and Mitigation of Earthquake Risk in the Arab Region (PAMERAR). It pointed out that, although the cost is high, 'the probable losses arising from a major earthquake are tens of thousands of lives and tens of billions of dollars'. It proposed the establishment of an Institute for Earthquake Engineering and Engineering Seismology to serve the region, training of specialists to build warning networks and shock-resistant buildings and become familiar with earthquake hazards, and programmes of emergency preparedness to minimize injury and economic losses.

Unesco's involvement in earthquake hazards goes back many years. In 1960, the Economic and Social Council of the United Nations requested the Secretary-General to obtain the co-operation of Unesco and other specialized agencies in undertaking a study to reduce damage from earthquakes and related problems. This move led to the establishment, in 1962-1963, of an International Institute of Seismology and Earthquake Engineering (IISEE) in Japan, with Unesco's participation and support. Unesco's assistance continued until 1972, when the IISEE was taken over entirely by the Japanese Government.

Earthquakes are just one form of natural hazard whose consequences Unesco works to mitigate. Another is the tsunami, also known as a seismic sea wave or, popularly, as a tidal wave. Strictly speaking, the popular term is incorrect, because a tsunami is not caused by a tide, but by gravity waves in water bodies resulting from earthquakes or events connected with them, such as landslides. (They may also sometimes be caused by volcanic island explosions or man-made nuclear explosions.)

Tsunami waves are extremely long: from crest to crest they can reach several hundred kilometres. They travel at great speeds—1,000 km/hr or more. When they approach a coast and enter shallow water their length and speed decrease but their height increases, sometimes producing crests more than 35 metres high. Tsunamis cannot be seen easily from aircraft or ships because in deep water their height is only about one metre.

On 22 May 1960, the most destructive tsunami of recent history struck the coast of Chile. All coastal towns between the 36th and 44th parallels were either destroyed or heavily damaged by the combined action of waves and quake. The toll included 2,000 killed, 3,000 injured, 2 million homeless and $350 million damage. Off Corral, waves were estimated to be 20.4 metres high. The tsunami went on to cause 61 deaths in Hawaii, 20 in the Philippines and 100 or more in Japan. Estimated damage in Japan was $50 million, in Hawaii $24 million, and along the west coast of the United States and Canada several million.

Many regions of the Pacific have suffered tsunami damage or are prone to it: Japan, the Asian coast of the Soviet Union, the Aleutian Islands, Alaska, Hawaii, the entire west coast of South America, the west coasts of the U.S.A. and Canada, New Zealand, Australia, French Polynesia, and the Philippines. In addition, some coastal areas bordering other seas are liable to damage. At least seven near-shore seismic events causing tsunamis have occurred in the last ten years, resulting in loss of lives and property.

Early warning is of great importance for the protection of coastal populations from tsunamis. But because of the difficulty in detecting them visually, seismological and tidal stations are necessary, using sophisticated systems and fast communications. The first Pacific tsunami warning system was set up by the United States in 1948, with headquarters in Honolulu, Hawaii. With the aid of its equipment, it was able to provide acurate arrival times once the location was known of the triggering event and the direction of travel of the tsunami, because the propagation of the waves follows known physical laws.

In 1962, ten countries co-operated with the United States system, so that it was already international. However, more countries were needed to establish additional observation posts. Therefore the IOC in that year recommended that Member States integrate their seismic, tidal and communications systems with that of the United States. In 1965, the IOC recognized the existing United States centre at Hawaii as the International Tsunami Information Centre and established an International Co-ordination Group for liaison among member countries. As of today, there are twenty-two member countries. Two regional Tsunami Warning Centres are established in the Pacific, one in Alaska and the other in Hawaii. These centres deal with tsunami warnings in the northern part of the Pacific. Another centre is planned for coverage of the southern Pacific.

Tsunami Warning Centres have so far been unable to provide tsunami warnings to many areas in time to be useful. Losses can only be reduced if a denser network of these centres and better communications exist, and if better programmes of preparedness and public education are in effect. This is the goal of the IOC-Unesco programme.

Unesco's natural hazards programme is aimed not only at the mitigation of damage from these events, but also at attaining a better understanding of their causes. As a result, it may become possible in future to predict the circumstances under which the events occur.

Harvesting water from the clouds

High in the Andes Mountains of northern Chile in a tiny community known as El Tofo, a strange-looking contraption made of mosquito-type netting and metal tubing juts into the sky. Ninety square metres in area, it is a 'fog trap' which condenses fog and produces from it 1,000 litres of water a day. Except for the fog, there is no other water resource in the area.

The trap was built by Prof. Carlos Espinosa at nearby Antofagasta, a town of 200,000 inhabitants whose only local freshwater resource also is fog, or cloud cover. The city's present drinking water supply comes from a source 400 kilometres away, contains arsenic and is in danger of being disrupted at any time by earthquakes.

Prof. Espinosa has worked on the problem of providing a more reliable water supply for the area for more than twenty years. Recently, he has had the support of Unesco through its Major Regional Project on the Use and Conservation of Water Resources in Rural Areas of Latin America and the Caribbean. Two of his fog traps have been sent to Peru where climatic and hydrological conditions are similar. Another is near Antofagasta at the University of La Serena. The La Serena device collects 200 litres per day and provides drinking water for the workers in a local mine. Visitors there can spend the night at a house where they can drink tea and take a bath in fogwater. The excess is used to irrigate plantations.

Much development is needed of these fog traps, because there are many designs and some are 50 per cent more efficient than others, for reasons not understood. The fog constitutes a reliable source of water for a number of months of the year in these areas of Peru and Chile as a result of a thermal inversion caused by the difference in temperature between the earth and the air.

The coastal fog is known locally as Camanchaca, and the symbol of its exploitation is a little cedar at La Serena that, although only a few feet high, is 25 years old: it received the water with which it was planted and first grown from a fog trap, but it soon became so big that it could catch and condense its own water.

Archaeological remains suggest that these now sparsely-populated regions long ago were covered with trees and supported many more people, but tree-cutting began to change the area into a desert. The remains of the old forest can still be seen today. Human habitation ceased when the wells, once filled with water condensed from the trees, dried up.

Prof. Espinosa and other Chilean scientists decided the natural fog traps should be replaced with artificial ones, and that is when their work began. Today, 30 kilometres south of Antofagasta, where the rainfall is practically non-existent (5 mm a year), a group of ecologists have begun to live from the fog water, even mixing the cement for their cisterns with it. They keep in touch with the Universidad del Norte in Antofagasta by means of radio transmissions powered by solar energy. The project is financed with the help of a small grant from the Unesco regional project.

The results of these experiments could be applied to other semi-arid and arid regions elsewhere in the world. But the fog catchers are only one aspect of the Latin American-Caribbean regional water programme. Terracing of land sometimes as steep as 50-60 degrees is also being carried out experimentally. These lands are considered by the local people to be more valuable to them for reclamation than the rich coastal areas because there expensive mechanical methods are required, the land has drainage problems, and the reclaimed land is used largely for export crops.

Besides the Latin American-Caribbean regional hydrological projects, others are being carried out in Africa and the Arab States. These stress the adaptation of traditional and low-cost water storage and conservation techniques. They are all part of Unesco's water sciences programme, whose aim is to improve the assessment, planning and management of the world's water resources.

Combining modern and traditional knowledge

In recent years, modern man's conception of the value of mangrove systems has been undergoing change. Regarded in some parts of the world as wastelands of little or no value unless they were converted (for example for tourist or recreation facilities, oil refinery and tin mining sites or shipping installations), they are now recognized as highly productive and resilient systems that provide a wide range of free goods and services in their natural state.

Traditional societies have known this for centuries: they have made their living from mangrove systems, obtaining from them medicines, firewood and charcoal, fodder, wood for construction and furniture, and crustaceans, molluscs and finfish among other commodities. They have learned over the years that mangroves are self-maintaining and renewable resources, and that they can provide a self-repairing coastal protection barrier for their communities without cost.

As the world's population has soared, however, coastal communities as a whole—including mangrove systems—have become more and more threatened. Their conversion to other activities can result in severe consequences for coastal people and their regional economies. Many plant and animal species in mangrove areas are threatened with extinction. Demand for mangrove products is multiplying. These problems, furthermore, increase as human population pressures grow. And such growth is believed certain: while today the population of coastal regions is believed to be about 3,000 million, by the year 2000 that number is expected to grow to between 3,800 and 4,400 million.

Unesco has therefore undertaken a major programme of coastal region research and management. Included in it are projects designed to recover the centuries-old traditional knowledge of mangrove systems that peoples in these areas have developed. In 1983, for example, Unesco organized a seminar for the Asian and Pacific regions to collect such traditional knowledge and management methods; other similar projects are being planned for the future. The task has an urgency borne of the rapid loss of this knowledge through industrialization, urbanization, and the alienation of the young from the traditions of past generations. The aim is not only to gather but to evaluate traditional lore in the light of scientific knowledge, in order to make better use of the mangrove resource.

One project, for example, with the Forest Products Research and Development Institute in Los Baños in the Philippines will document the traditional uses of mangroves in that country and in Thailand, Malaysia and Indonesia, in collaboration with researchers in those countries. Information on traditional uses of the various mangrove species will be collected and compiled in a document giving the local and scientific names, and the species' occurrence and distribution. It will be published in the form of a handbook designed for the non-specialist.

The need for such a document is illustrated by the confusion surrounding the Philippine name 'bakawan'. Wood from mangrove trees is often sold in the Philippines under this name, but bakawan also means a mangrove forest, with the result that many Filipinos mistakenly believe a mangrove forest consists only of bakawans, whereas a bakawan is really one species of mangrove tree.

Because populations in other ASEAN countries have many different ethnic groups with their own languages or dialects, such a situation is believed to exist elsewhere as well. Thus many people in industry may be unfamiliar with the variety of exploitable species available in mangrove forests. The proposed guide will be illustrated and designed to appeal to the non-scientist as well as to silviculturists, foresters and forest industry field workers.

Contrasting with this rather simple, straightforward and non-technical approach to assessment of mangrove resources is another Philippines project designed to make use of the most advanced technology: remote sensing techniques from earth satellites. The Philippines' Natural Resources Management Center conducted for that country the first comprehensive inventory in Asia of mangrove forest cover using this technology. A training workshop on the subject for participants from other parts of the region was held in 1983.

The Philippines experience with remote sensing has shown that synoptic data on the distribution and gross conditions of mangrove areas, such as can be produced by remote sensing techniques, can make a significant contribution to the proper management of these areas. But this kind of data is difficult and costly to obtain using traditional survey methods because many mangrove areas are inaccessible. The rapid development of remote sensing makes it possible to obtain such data rapidly and at less cost.

These two projects illustrate some of the objectives of Unesco's programme on Research and Training Leading to Integrated Management of Coastal Systems (COMAR): fostering international co-operation in gaining a better understanding of coastal and island systems; promoting collaboration between specialists of various kinds; and integrating scientific, socio-cultural and economic information for decision-making.

Helping man and nature adapt to each other

Pastoral peoples have learned throughout the ages how to adapt to the rigours of life in the world's arid areas. When rainfall grows scarcer in one location, they move to another, searching for enough water and forage to sustain themselves and their animals. From an ecological point of view, pastoralism is the best-adapted form of pasture land-use in the world's drylands.

In recent decades, however, nomads have lost vast expanses of their former rangelands as a result of the encroachment of agriculture, political boundary changes and other factors. At the same time, the number of both nomads and animals has increased, while animal productivity has remained the same. To increase this productivity in order to better the nomads' lot, development agencies at one time sank deep boreholes to make water more widely available. But attracted by these—and by the shops, missions and dispensaries that sprang up around them—large numbers of nomads began to give up their wandering and to adopt a sedentary way of life.

The results were therefore the reverse of what the development agencies had hoped for: destruction of pasture around the boreholes through the large congregation of animals there, deterioration of pastures further afield through overgrazing, and depletion of wood supplies by the increasing human populations. These became the most serious causes of desertification in arid and semi-arid grazing lands.

To study these problems, Unesco and UNEP agreed in 1976 with the approval of the Government of Kenya to set up a research, training and demonstration project in the Marsabit District of northern Kenya. The project, organized as part of the MAB programme, was called the Integrated Project on Arid Lands (IPAL). By means of this project it was hoped to understand the problems better and to propose solutions that would improve the well-being of pastoral peoples not just in Kenya but in the Sahelian zone of Africa generally—and to some extent in comparable regions worldwide. As from 1980, funding for this project was provided by the Federal Republic of Germany.

IPAL's underlying assumption was that, through research and training, improved land-use systems could be devised to reverse the trend of land degradation and to sustain land production sufficiently to meet the needs of the growing, partially sedentary, pastoral population of northern Kenya.

IPAL's fertility analysis of soils in the area showed that no major minerals were lacking, and although nitrogen levels were low, lack of water was the limiting factor in vegetation production, average rainfall being only 225 mm a year. Livestock were found to be the most important factor in environmental degradation, through their destruction of soils and vegetation and also because of the enormous amount of wood used by the pastoralists to enclose their animals at night for safety. IPAL's efforts therefore were directed towards development of methods of controlling the impact of livestock on the environment through grazing and production strategies.

Results of initial analysis showed that 16 to 21 per cent of the study area was overstocked. This is understandable since livestock are the pastoralists' main form of food—principally milk and meat—and are regarded as their major source of wealth. At the same time, studies showed that the overall area had the potential to support twice the present livestock densities. The solution was therefore seen to lie in better livestock distribution. (Other studies showed that water resources were sufficient.)

Socio-economic studies were also undertaken by IPAL. These showed that there was a growing awareness on the part of the pastoral people that total reliance on pastoral nomadism would not provide sufficient insurance against drought nor the economic base necessary for improvement of living standards. The new services provided by government and missionaries (schools, clinics, water) are appreciated and many nomads are reluctant to return to their former way of life. Overall the trend is towards a sedentary existence.

As a result of these studies, IPAL prepared an Integrated Resource Management Plan for the area, containing comprehensive and interrelated management proposals concerning water, range, woodlands and livestock, human health, marketing, roads and communications, and education, training and extension work.

Recommendations included dispersion of livestock to reduce the impact of grazing and woodcutting; introduction of planned watering points, with control of water availability to reduce damage done by present concentrations; improvement of security measures to reduce banditry and livestock raiding; designation of areas of strict control of grazing and woodcutting to promote rehabilitation of vegetation; and provision of artificial fencing materials wherever livestock concentrations occur, to take the place of wood materials. Other recommendations dealt with water catchment areas, a co-operative livestock management system, and improved marketing facilities.

The project concluded that the prime emphasis at first should be to support the subsistence base of pastoral herding rather than to stress commercial activities. Once the pastoral economy had been placed on a firmer footing, there was no reason why it could not produce a surplus of livestock and meat for markets beyond the pastoral community, which would enrich the pastoralists. Eventually, other means of storing wealth might be sought than 'on the hoof', thus reducing the stress on the environment.

IPAL came to an end in December 1983. In order to ensure the long-term continuity and expertise necessary to implement the IPAL Resources Management Plan, the Government of Kenya announced its intention of setting up a Kenyan Arid Lands Research Station in Marsabit. This facility is to monitor results and continue to operate the network of research and training facilities already established by IPAL, and is expected to continue to employ a large number of the technical staff trained by IPAL. The new institution commenced operation in the autumn of 1984.

IPAL thus has contributed both to the fulfillment of MAB's overall goal, which is the rational use and conservation of the earth's resources, and to Unesco's scientific objectives of promoting research, training and demonstration activities in the tropics. The project has, in addition, much wider implications: it has already organized four international orientation seminars, which have brought together sixty-eight specialists in pastoral land-use from thirty-three countries in addition to the more than 1,000 scientists, administrators and other professionals from fifty-six countries who have visited the project. These activities, with the help of IPAL's publications programme, will continue to act as a stimulus for new approaches to combatting desertification in areas inhabited by nomadic societies in other parts of the world.

Developing local engineering resources

In the mid-1970s, engineers in many Arab countries had to go abroad if they wished to pursue postgraduate education, and there was little contact between Arab industries and engineering schools. Anxious to improve this situation, the Egyptian Government entered into a contract in 1975 with the UNDP and Unesco. The purpose was to assure a supply of well-qualified professors and adequate engineering research and to improve industry-university co-operation through establishment of a Centre for Engineering Research and Training at Cairo University. Funds for the project came from UNDP and Unesco implemented and managed the programme with the aid of high-level consultants engaged on contract.

During the course of the programme, five industrial problems were identified in and around Cairo and contracts were signed between the Centre and the industries involved to solve these problems. One of these concerned the inefficient use of fuel in industry.

The Centre's research revealed for the first time that, because combustion monitoring instruments had not previously been used by Cairo industries, boilers and furnaces were operated with unnecessarily high fuel-to-air ratios, thus wasting fuel. In the opinion of the consultants who visited some of the industries involved, the fuel wasted every year in the country as a whole represented some 50 million Egyptian pounds (about 40 million US dollars).

As a result of these observations, Centre consultants studied power stations in Cairo and surrounding districts and suggested methods of improving boiler efficiency and output by properly adjusting the fuel-air ratio.

The final project report, published shortly after the project ended in 1983, said this resulted in both improved output and efficiency of one of the four Cairo power stations. 'The immediate outcome was that the Ministry of Electricity and Energy decided not to buy gas turbine generating units costing 30 million (Egyptian) pounds, because they were no longer needed to meet the power demand.'

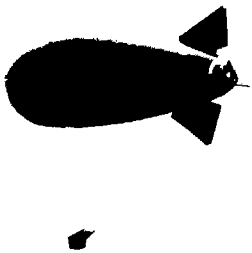
Other problems dealt with by Centre research led to improvements in the quality and design of diesel engines and helped increase their useful life and their ability to compete on the market with imported engines.

Still other research was expected to improve the design and thus the cost-effectiveness of locally-produced railway coaches, and to lead to quieter Egyptian-produced air conditioners.

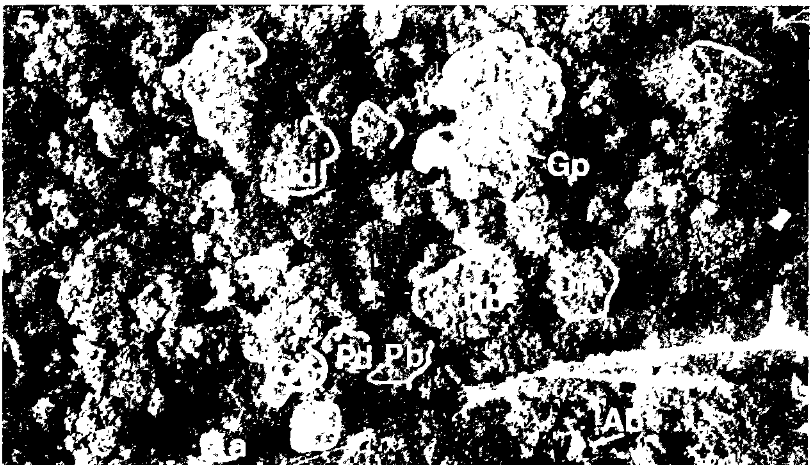
The report noted that the establishment of the new Centre had contributed to the improvement of engineering education and applied research in Egypt, and reduced the need for students to go abroad for postgraduate studies. It said the postgraduate students had become better suited, after the completion of their work, to faculty positions and to industrial work. In the course of the project, the Centre was equipped with modern laboratory apparatus and a library for postgraduate students. Both long- and short-term courses were taught by consultants from Egypt and abroad, resulting in the training of about 750 engineers over the nine years involved. In addition, faculty members participated in forty-two study tours in Europe and the United States.

The Cairo programme is an example of the type of project Unesco manages through its Operational Programmes Division. Funding for these projects comes from outside Unesco's regular budget and is supplied usually by United Nations or other funds.

The foregoing examples give some idea of the range and substance of Unesco's science and technology programmes. The next chapter describes the organizational ways in which these programmes are carried out.



Research on tropical forests in Côte d'Ivoire. Photographs taken from a blimp under control from the ground provide an inexpensive means of aerial photography that permits identification of tree species and distribution (see below). The method, much less expensive than aerial photography by airplane, is a form of appropriate technology.



HOW UNESCO FUNCTIONS IN SCIENCE

Although Unesco's mission in its science programmes is to enhance the development of science, Unesco itself does no scientific research. Nor does it function primarily by making research grants to scientists outside the organization, as do some development agencies (although it does give research grants).

Unesco's role in science is best described as a promoter of science, or as a 'mover' of scientific activity. *Webster's New International Dictionary* defines a mover as 'one that sets something in motion', or as 'one that incites or instigates to action or promotes an action that has been begun'. That is precisely what Unesco does in science and technology.

Unesco does this through the medium of other scientific and technological organizations—the professional bodies of the appropriate disciplines themselves. If no professional body exists for the purpose, and if the scientific community thinks one would be desirable, Unesco may help to create it. This was the case, for example, with the International Computation Centre in Rome, mentioned earlier. Unesco may help with networks of scientific institutions, as it did by contributing to the creation of the African Network of Scientific and Technological Institutions (ANSTI), with the aid of UNDP and the Federal Republic of Germany in 1980. The ANSTI project aims at bringing about close collaboration between African engineering, scientific and technological institutions involved in postgraduate training and in research and development significant to the region.

The major scientific body with which Unesco collaborates in its science programmes is the International Council of Scientific Unions (ICSU), which is international science's interdisciplinary professional organization. Founded before Unesco—in 1931—ICSU has sixty-six national members (usually academies or research councils), twenty international scientific union members, and twenty-three national and scientific associate members. This close association involves an annual subvention from Unesco of about $500,000 a year for ICSU's activities. ICSU helps Unesco both to plan and to carry out its scientific programmes and, because of its wide membership, can draw on the world's scientific talent in doing so.

Unesco works with non-governmental scientific organizations other than ICSU, as well. For example, the water sciences programme makes use of several international associations: the International Association of Hydrological Sciences, the International Association of Hydrogeologists, the International Commission on Irrigation and Drainage, the International Association of Hydraulic Research and the International Water Resource Association. Its Major Regional Projects operate mainly through the National Commissions of the IHP to reach the research bodies.

Unesco also works through its five Regional Offices for Science and Technology: these can call on the assistance of scientists and institutions within the region in which they are situated. The Regional Offices for Science and Technology are situated in Nairobi, Kenya (for Africa); Montevideo, Uruguay (for Latin America and the Caribbean); New Delhi, India (for South and Central Asia); Jakarta, Indonesia (for South-East Asia); and, temporarily Paris (for the Arab States). There is also a Unesco representative for science and technology in Beijing, People's Republic of China.

As noted earlier, Unesco has also set up three regional centres to deal with different aspects of the natural sciences, and a number of international networks. The activities of the Latin American Regional Biosciences Network serve as an example of how this has been done in just one area of science. Since its formation in 1975 with the signing of an agreement between the governments of Bolivia, Chile, Colombia, Ecuador and Peru, the network has carried out forty training courses in nine different countries with 640 students, 320 of whom came from neighbouring countries and received fellowships. These courses dealt with such fundamental biological problems as the biochemistry of plant flowering, the physiology of the adaptation of humans and animals to high altitudes, phytoplankton of the tropical Pacific and basic aspects of mammalian reproduction. Other courses deal with important applications of biotechnology such as studies dealing with the causative agent of trypanosomiasis, the immunology of malaria, and the tissue culture of plant cells. The network has granted sixty one-year postgraduate fellowships for training biologists from countries less developed in these sciences. These fellows were trained in the best universities and institutes in the region and 95 per cent returned to their own countries for research and teaching. In addition, 150 research projects dealing with problems of special relevance to the area and aimed at training young biologists have been supported.

Other networks have been set up in South-East Asia and the Caribbean for research on the chemistry of natural products, and in Central and Southern Asia for research on the chemistry of medicinal and aromatic plants. In South-East Asia, the chemistry and microbiology networks have completed fifty short-term courses involving approximately 1,000 trainees, together with 150 lecturers from all over the world. The only costs involved in these courses were air fares for trainees and lecturers. In co-operation with the International Organization for Chemical Sciences in Development (IOCD), a new regional network is to be established in Latin America for research on sources of chemical energy. Networks already exist in a number of countries in cell and molecular biophysics, molecular biology and genetics, electrochemistry and applied mathematics and systems analysis. In the Arab States, networks will be set up in informatics, physics, chemistry and biosciences, and one already exists in South-East Asia in the microbiology of natural products. In addition, a large number of microbiological resource centres (MIRCENs) have been established throughout the developing world, their object being to preserve microbial gene pools and make them accessible to developing countries.

In the training of scientific and technological personnel, Unesco places heavy emphasis on learning through doing research, mainly, as noted earlier, by means of workshops, courses, seminars and symposia. Some 10,000 individuals from developing countries have received training in this way. In the earth sciences alone in a single year (1983), there were about 400 participants, while from 1976-1983 they totalled over 1,500.

Consultancy services, grants for research and travel, and fellowships are other means by which Unesco carries out its science programmes. In addition, Unesco participates in the activities of Member States at their request through consultants, study grants, equipment or financial contributions for specific purposes. Such activities are usually conducted through UNDP, the United Nations Financing System for Science and Technology for Development and Funds-in-Trust.

Unesco also co-operates with the International Foundation for Science in awarding research grants in chemistry and biology, and with the Committee on Science and Technology in Developing Countries (COSTED) in awarding travel grants to allow developing country researchers to participate in international conferences. Other organizations with which Unesco co-operates in furthering research and training include IBRO, ICRO, IOCD, ICTP and the International Federation of Institutes for Advanced Study (IFIAS). At Unesco's initiative, a Unesco-COSTED-IFIAS Scholarship Programme on Multidisciplinary Studies of Development Problems was started in 1979. Fellows work at an IFIAS member institute or on an IFIAS project.

Another kind of network through which Unesco operates is illustrated by IOCD, mentioned earlier. Created in 1981 under Unesco's auspices, IOCD is a non-governmental body whose small secretariat has been supplied by Unesco. Dedicated to addressing urgent problems of developing countries, it promotes collaboration among chemists from different countries to achieve this goal. An example of IOCD's activities is its programme of chemical synthesis of new drugs in developing country laboratories for treatment of tropical diseases. More than 800 million people suffer from such diseases, yet few pharmaceutical companies do any research in the area because the victims are poor and there is little profit to be made.

IOCD organized a meeting of internationally known medical chemists in Rio de Janeiro in March 1982, to define the chemical nature of the compounds to be synthesized and the strategy to be followed. The scientists proposed a list of more than sixty new compounds to synthesize with potential activity against the six major tropical diseases (malaria, filariasis, schistosomiasis, trypanosomiasis, leishmaniasis and leprosy), and selected laboratories in which to investigate them, most of them in developing countries. Eleven of these laboratories today are involved in such synthesis under the leadership of IOCD advisers.

Other IOCD services include an analytical service programme that offers spectroscopic measurements of samples provided by developing country scientists, a biological screening programme to evaluate compounds isolated from natural sources and synthesized by developing country scientists, a world-wide maintenance and repair programme for chemical and laboratory equipment in developing countries, and chemical education and training courses.

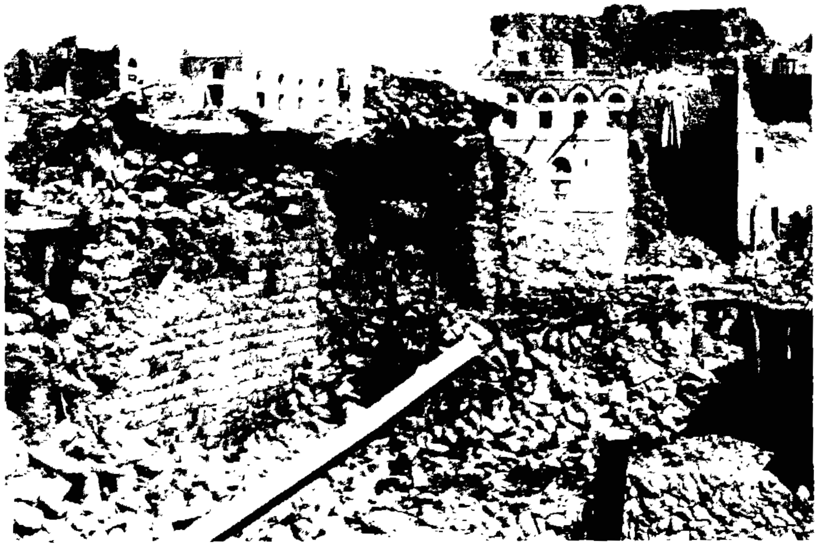
The above examples of the ways in which Unesco works in science are just that—examples. It is difficult to generalize about the organization's methodology because, while certain themes are commonly played in all activities in Unesco science, each programme produces its own variations. Certain words, however, recur repeatedly in descriptions of the aims of Unesco's science programmes in official documents: 'promote', 'encourage', 'facilitate', 'contribute to', 'strengthen'. These suggest the approaches all programmes have in common.

'Unesco', a former Assistant Director-General of the Organization has said, 'is a great market for the traffic of knowledge'. In the meeting rooms of the Paris headquarters, 'week after week and year after year, the experts of the world bend their attention to the latest problems before their disciplines'.[1]

His words describe yet another way in which Unesco's work is done. At such meetings, the programmes of, for example, the International Hydrological Programme or the International Geological Correlation Programme are hammered out. Meanwhile, throughout the offices of the Secretariat staff, the ideas that arise there and elsewhere are fitted into the necessary administrative mould.

In these and other ways, the scientific programmes of Unesco go forward. How they are paid for is the subject of the next chapter.

1. Richard Hoggart, *An Idea and its Servants, Unesco from within*, Chatto and Windus, London, 1978.



Earthquake damage in El Asnam, Algeria. Unesco was asked by the Arab Fund for Economic and Social Development and the Islamic Development Bank to prepare a scientific feasability study to reduce such damage in Arab countries. Its report was issued in 1984.

WHERE THE MONEY COMES FROM

Unesco's science programmes are paid for from two principal sources: its regular budget and extra-budgetary funds. The latter include a number of United Nations sources (e.g. UNDP, UNEP, UNFPA), together with funds from the World Bank, regional development banks, Funds-in-Trust from Member States, and others.

In recent years, the Science Sector's share of Unesco's regular budget has been increasing. For example, the general budget for 1981-1983 was $557,644,000, and the Science Sector's share was $66 million, or 11.8 per cent. Between that budget and the next, the budgeting period changed from three years to two, so that for the period 1984-1985, the total budget was $374,400,000. Of this, $56.6 million went to the Science Sector—or 15.1 per cent. (The above budgetary figures exclude what are known as 'general costs', shared equally between the different sectors.)

The funds from extra-budgetary sources consistently amount to a much larger total than Unesco's regular budget: usually about 50 per cent more. These projects are executed by Unesco in co-operation with the concerned Member State. Individual extra-budgetary project funding, as well as the total, also tends to be larger than in the regular budget. This is because the former projects often have to do with large undertakings such as research centres or educational institutions. A recent project involved the strengthening of the Marine Science Research Centre in Tripoli, Libya. The budget was $2,200,000, provided by the Government of Libyan Arab Jamahiriya through a Funds-in-Trust arrangement. Another involved the strengthening of the Ocean Research and Development Institute of the Republic of Korea, at a cost of $1,300,000, with funds from UNDP. The previously-mentioned project, whereby the University of Qatar acquired an oceanographic vessel, cost $3 million, the sum being supplied by the Government of Qatar through Funds-in-Trust.

In some projects funding comes both from Unesco and from other United Nations sources. For example, for 1984-1985, a programme to assist in development of land-use planning techniques, taking into account the geological constraints of the environment, was budgeted at

$49,700 from Unesco's regular programme and $400,000 from the United Nations Environment Programme. Unesco's total annual commitment to the international scientific programmes such as the IHP, IGCP, MAB and those of the IOC is around $30 million.

But alongside these large amounts are found some small ones for individual projects in the regular budget. For example, in 1984-1985, research grants to individuals in applied physics in developing countries averaged only $1,000 each, a training course in Nigeria in cell and molecular biology was budgeted at $2,000, while a grant to help the International Mathematical Union support a liaison bulletin for the main mathematical institutes of developing countries amounted to only $2,000. The costs of science projects implemented through contractual arrangements in Unesco's regular budget for 1984-1985 range from $500 to $20,000.

In its background document prepared for the 1979 United Nations Conference on Science and Technology for Development (UNCSTD), *New perspectives in international scientific and technological co-operation*, Unesco said that if science and technology are to be effective development tools on the scale required to meet present-day needs, 'the essential financial resources must be raised to a level that is in keeping with the needs'.

In the words of this report: 'Both the regular budgets of the organizations of the United Nations system and the extra-budgetary funds placed at this disposal for their technical co-operation programme will have to be increased very substantially if there is to be an effective qualitative transformation of the global effort. If there is a real political will among Member States to put science and technology to effective use for development, this political will must be reflected above all in the field of finance.'

So far, the needs far outstrip the funds available.

A FINAL WORD

Earlier in this booklet, Unesco's role in science and technology was characterized as that of a promoter or mover of scientific activities. The effects of the actions Unesco undertakes, which may be relatively small in themselves and may be set in motion or managed by at most a small number of scientists, are greatly amplified by the actions of others.

That this is true is illustrated by the fact that Unesco's science and technology activities translate into participation by a total of more than 20,000 scientists each year, and an annual expenditure for national or sub-regional projects of about $500 million. These figures should be compared with Unesco's scientific staff, which includes 362 posts, and its regular budget for science and technology, which amounted to $55,669,000 for the two years, 1984-1985. In addition, more than 4,000 researchers benefit each year from educational programmes organized under the guidance of Unesco.

In the face of such figures, it is easy to see that the few examples of Unesco's science projects given in earlier chapters tell only a small part of the story of what Unesco does in science and technology. In a lecture that he gave at the University of Nairobi early in 1984, the Nobel prizewinner in Physics, Professor Abdus Salam, described another aspect. Prof. Salam, who is Professor at the Imperial College, London, and Director of the ICTP in Trieste, noted that one of the major reasons for the scientific brain-drain from developing to developed countries was the scientific isolation of scientists in developing countries. One of the main reasons for establishing the ICTP was to reduce this isolation by allowing developing country physicists to work in an international centre for a few weeks or months before they return to teaching and research in their own countries. Unesco is one of the two sponsors of the ICTP, and every year about 2,400 physicists—half of them from developing countries—spend an average of two months there.

'There is no question', said Prof. Salam, 'that the Trieste Centre still is the model for future international assays in scientific collaboration, particularly for developing countries.' This is because of two characteristics of science in developing countries, Prof. Salam said: first, its subcritical size, and second, that it is not part of international science. And 'without internationalization, science cannot flourish..'.

What the developing world needs, Prof. Salam maintains, is a scientific community that has shared in the pride of having created some parts of science. 'Our youth are craving to meet this challenge; it is this challenge which makes them migrate to western universities and institutions. We must ask ourselves: do we provide like opportunities for our best young men, nurturing their talents for our civilization, or do we leave them to wither away, or if they are strongly committed to science, to migrate and enrich the countries of Europe and America with their talents and their contributions?'

This is a challenge that Unesco is meeting, not only through institutions like ICTP but in its science programmes generally. Through the educational programmes it initiates or supports, through the funds it provides for developing country scientists to attend international scientific meetings, and through the opportunities it gives these scientists to play a role in international programmes such as MAB, the IOC, the IGCP and the IHP, Unesco helps give developing countries the chance to participate at the forefront of science and technology—or at least to be aware of what is going on there.

Only by so doing will the developing countries be able to become equal partners in the world of tomorrow. The urgency of this task is greater now than it has ever been because of the challenge offered by such sciences as informatics, biotechnology and micro-electronics. The advances in these fields are presenting the world with a scientific and technological revolution equal in importance to the industrial revolution. Just as those countries that were not able to profit from the industrial revolution suffered subsequently, so too will those that do not make use of this new revolution.

Hence the need to continue Unesco's programmes in science and technology for the benefit of developing countries, and to seek new and even more effective ones. For the developed world the need for Unesco's international programmes is at least as great as it was in the beginning, for reasons we have already seen. Though in some respects the requirements of the developing and the industrialized countries may differ, they share a common need for the continuation of the kinds of programmes Unesco supports. And because of Unesco's unique role as the United Nations body charged with both human or social and technical aspects of science and technology, it is the only existing organization that seems suited to these responsibilities.

In its submission to UNCSTD, Unesco encapsulated the situation as follows:

> Science and technology, if they are to be successfully developed so that they become an integral part of continuous and harmonious development and contribute to the progress of man, must therefore be rooted in social realities, in the fullest sense of the term. The problems posed by the planning and conduct of scientific and technological development thus occupy a place apart among all the problems of socio-economic development: they possess their own intrinsic complexities and difficulties. At the same time they cannot be properly analysed or resolved unless they are viewed in the overall context of the development of each given society and treated within the search for appropriate global solutions.

Thus to answer the question posed by the title of this booklet: 'Why the "S" in Unesco?', the answer might be said to be: to foster the development of science and technology throughout the world in order to increase both the material and spiritual welfare of mankind—but to do so only within the cultural context of every national group, in a way that responds to their own needs, wishes and aspirations.