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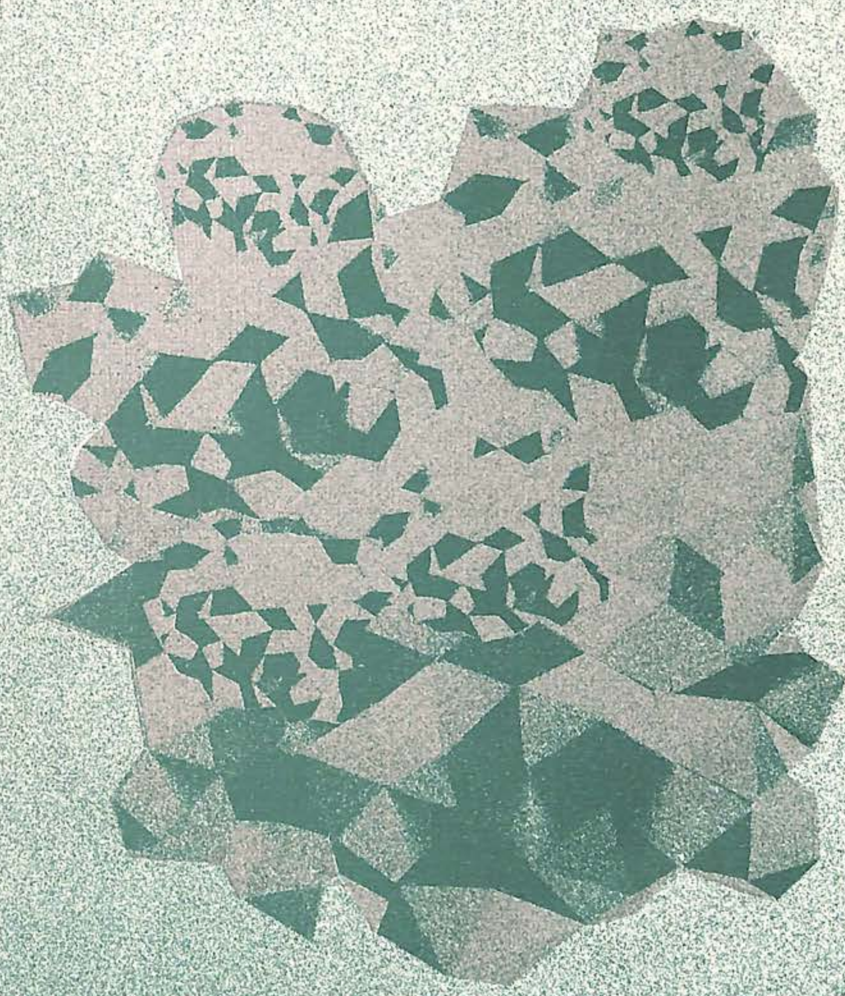
CSIRO Annual Report 1980/81



Commonwealth Scientific and Industrial Research Organization, Australia

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CSIRO Annual Report 1980/81

CSIRO
P.O. Box 225
Dickson, A.C.T. 2602
Telephone: (062) 48 4211

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COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

The Honourable David Thomson, M.C., M.P.,
Minister for Science and Technology,
Parliament House,
CANBERRA, A.C.T. 2600.

The Executive of CSIRO has pleasure in submitting to you, for presentation to Parliament, its thirty-third annual report, which covers the period 1 July 1980 to 30 June 1981. The report is submitted in accordance with section 57 of the Science and Industry Research Act 1949.

J.P. Wild (Chairman)
N.K. Boardman
D.P. Craig
W.L. Hughes
H.M. Morgan
R.K.R. Morris
W.J. McG. Tegart
P.D.A. Wright

Role and Functions of CSIRO

CSIRO was established by the Science and Industry Research Act 1949. Under the Act, CSIRO succeeded the former Council for Scientific and Industrial Research established in 1926. The Act was last amended in 1978.

The main role of the Organization is to plan and execute a comprehensive program of general scientific research on behalf of the Commonwealth.

The functions of CSIRO are laid down in the Science and Industry Research Act 1949. In summary, these functions are:

- to carry out scientific research relevant to Australian industry, the community, national objectives, national or international responsibilities, or for any other purpose determined by the Minister;
- to encourage and facilitate the application and utilization of research results;
- to liaise with other countries in matters of scientific research;
- to train research workers;
- to make grants and award fellowships and studentships relevant to the Organization's research;
- to recognize, cooperate with and make grants to industrial research associations;
- to establish, develop, maintain, and promote the use of, standards of measurement of physical quantities;
- to collect, interpret and disseminate scientific and technical information; and
- to publish scientific and technical reports, periodicals and papers.

Contents

Introduction

At the back of this volume the reader will find a chart that shows how CSIR and CSIRO evolved through the years. For the most part the evolution has been gradual and, until the 1970s, took place within an expanding organization. The year of this annual report, 1980/81, saw the start of a new phase in our evolution: a deliberate policy to stop certain activities and switch the resources to new activities.

The Executive's current policy may be summarized as follows:

1. Whatever we do we must do well. If resources are reduced then we must reduce the number of our activities, not the quality.
2. We must be selective in our fields of research and concentrate on nationally important and scientifically rewarding areas.
3. We must maintain our tradition of scientific excellence and remember that the maintenance of excellence depends on the performance of and the encouragement given to the individual. The needs for controlled objectives on the one hand and the scientist's freedom to follow his nose on the other must be carefully balanced.

How do we choose the problems we work on? Our first boundaries are set by our Act which makes scientific research on behalf of industry and the community our main role. At all levels of the Organization we maintain close links with representatives of industry and Government agencies, State and Federal, and our objectives are largely determined by interaction between our scientists and these representatives. In addition, we have the CSIRO Advisory Council and State Committees comprising eminent persons from all walks of life. We interact constructively with the Australian Science and Technology Council which advises the Prime Minister. We have our own Planning and Evaluation Advisory Unit which analyses the total scene and seeks out long-term trends. Finally, it is our own Executive, comprising four scientists and leading figures drawn from primary, secondary and tertiary industry that makes the final decisions on broad objectives.

Our current areas of research include many that have formed our traditional base and continue to be as important now as in past decades; the whole fields of agriculture and earth resources are examples. These continue at roughly constant levels. In addition, we have a short-list of research areas that we have singled out for potential expansion as resources become available. These (in no special order) are:

- **energy**—with emphasis on the development of alternative liquid fuels and the conservation of existing stocks;

- **water and soils**—the Australian continent's greatest need and most critical factor limiting its growth is water;
- **oceanography**—vital to Australia, yet neglected in the past;
- **manufacturing technology**—for an important branch of industry that urgently needs to become more innovative and self reliant;
- **biotechnology**—an expanding field with boundless possibilities; and
- **plant pathology**—with the aim of reducing diseases that are a scourge to agriculture.

In 1979/80 we set in motion major new initiatives on behalf of oceanography and manufacturing technology, as described in the annual report for that year. This year we have tackled energy and biotechnology. Next year we intend to focus particularly on the problems of water and soils.

The reorganization and intensification of energy research has resulted in the formation of an Institute of Energy and Earth Resources to replace the former, differently structured, Institute of Earth Resources. An important part of the reorganization was made possible by the decision of the Government to redeploy approximately one-third of the staff of the Australian Atomic Energy Commission Research Establishment to CSIRO to work on non-nuclear energy research. Most of the scientific staff to be transferred will form a new Division of Energy Chemistry based at Lucas Heights (Sydney). At the same time, the Division of Mechanical Engineering is to be closed down and the majority of its staff redeployed into a new Division of Energy Technology based at Highett (Melbourne).

Other structural changes include the decision to close the Division of Chemical Technology and redeploy its staff to a new Division of Cellulose Research and a new Industrial Microbiology Unit. The latter will form part of our intensification of effort in biotechnology. The latest initiative in the agriculture sector is to form a new Queensland-based Division of Tropical Animal Science from resources taken mainly from existing Divisions. This new Division will provide a focus for livestock research in the tropics and subtropics and provide a more direct liaison with the existing Division of Tropical Crops and Pastures while maintaining close scientific links with animal Divisions in the south.

I hope, through these examples, to convey the vigour with which the Executive of our Organization, restructured following the Independent Inquiry in 1978, is responding to ever-changing national needs.

The efficiency with which we can adapt and respond to the needs of the time depend critically on consistent and dependable funding for the Organization. A 2% cut in staff resources largely depletes each Division of its redeployable vacancies for a year and so prevents the recruitment of new specialist staff to tackle new problems as well as depriving the Organization of an injection of young scientists. As a result of a decision arising from the Review of Commonwealth Functions (RCF) in 1980/81, CSIRO will be subjected to a cut of 2.16% in 1981/82.

Across-the-board cuts mean that each time the Government makes a staff ceiling cut in the Public Service, CSIRO receives a cut of a similar magnitude to that imposed on Government departments. We believe a distinction should be made between an organization such as ours, on which the future growth and prospects of the nation vitally depend, and the administrative arms of government. It is the Executive's belief that the national interest requires a larger government commitment to science and technology rather than a reduction.

Another RCF decision, taken without consultation, was to close our Scientific Liaison Offices in London and Washington, ending a long history of dedicated service to Australia. These Offices provided a valuable means of keeping Australia abreast of developments in science and technology policies in these countries and facilitated the operation of science agreements. They also undertook a variety of important tasks such as recruiting senior scientific staff.

Our principal function is to undertake strategic research on behalf of industry and the community. Research programs span many years, even decades, as one thing leads to another. To describe a single research result in isolation from the work and ideas that have led up to it can often be rather meaningless. Beginning with this annual report, we are therefore introducing accounts (Chapters 12-16) of some main themes of our research work, their past evolution, the present work and future prospects. Some years of annual reports will be needed before all such themes can be comprehensively covered.

Meanwhile, the year 1980/81 has had its crop of notable achievements that have come to fruition during the year. On the side of the biological sciences, these include:

- the discovery of a naturally occurring protein (Epidermal Growth Factor) that, by modulating the thickness of the wool fibre, shows promise of yielding a practicable biological method of defleecing sheep;
- a vaccine for increasing the ovulation rate of ewes by some 40%;
- a killed vaccine to immunize cattle against Tick Fever; work is under way to isolate the specific protective protein that, with the aid of genetic engineering techniques, will enable the vaccine to become a commercial reality;
- the development and marketing of highly specific substances (monoclonal antibodies) for the diagnosis of human and animal diseases (in collaboration with the Garvan Medical Research Centre and Bioclone (Australia) Pty Ltd);
- the eradication of the water weed *Salvinia* (which causes serious blockages in Australian waterways) at a test site at Mt Isa by the

introduction of a specific variety of weevil from South America; and

- the implementation of a computer-controlled management technique (SIRATAC) for the application of insecticide and irrigation water on the cotton crops in the Namoi valley; the system, operated by a non-profit company, is being widely adopted by cotton farmers and may be extended to other crops in due course (in collaboration with the NSW Department of Agriculture).

On the side of the physical sciences, highlights of our research include:

- the development of esters which act as highly effective insecticides but are non-toxic to other wildlife;
- the world-wide commercial launching of SIROSPUN, a new system of spinning worsted weaving yarns involving a single-stage production in place of the conventional two stages (in collaboration with Repco Ltd and the International Wool Secretariat);
- construction by Austep of the first full-scale SIROFLOC water purification plant, now supplying about 5% of Perth's water supply from bore water and recently recognized by the 1981 'Plant of the Year' award of the Society of Chemical Industry of Victoria;
- installation of the first commercial gas drainage system in Australia which prevented the probable closure of a highly efficient and valuable coal mine on the NSW south coast;
- the development and commercial realization of a microfiche reader that brings reading within the scope of handicapped or disabled people; and
- the development of a device that detects wear and faults in steel reinforced conveyor belts used by the mining industry.

These are but a few of a much longer list that could be given, but they serve to illustrate the diversity of our research activities. Most of our research is of the kind that leads to foreseeable application. A small part of it contributes to basic knowledge with no application in sight. One of the most significant fundamental discoveries of our time was the discovery at the University of Cambridge in 1968 of pulsars, which proved that stars can finish their lives by collapsing to small spheres (neutron stars) of fantastically high density—thus revealing a new state of matter. Up till recently, all known pulsars were located in our own galaxy (the Milky Way) but astronomers eagerly speculated that they might be discovered in other galaxies, which would open new paths of investigation. This discovery was made during 1980/81 with the CSIRO radio telescope at Parkes, thanks to one of our scientists in collaboration with two colleagues of the University of Tasmania. Using innovative data processing techniques, they succeeded in detecting a number of pulsars in our nearest galaxy, the Magellan Clouds. This is a notable achievement of importance to basic science.

CSIRO continues to enjoy the highest respect and confidence of the Government and the Australian people. Yet it is clear that the decade we have now entered is proving to be more difficult for CSIRO than former, more expansive, times. Nevertheless, the Organization will continue to adapt to changing circumstances; and through its policies of selectivity and concentration it will continue to strive to improve its response to as many of the strategic research needs of industry and the community as resources allow.

J.P.Wild
Chairman

Summary

Throughout its 55-year history the Organization has adapted its structure and the emphasis of its research to meet the changing needs of the nation. The year 1980/81 has seen major structural changes as well as development and refinement of existing policies and practices within CSIRO. The chart included at the back of this report shows the structural development of CSIRO since its inception as CSIR in 1926.

In response to the financial stringencies being applied generally to the public sector, CSIRO has accelerated its move towards selective concentration of objectives and resources in its research programs. This has involved a critical reappraisal of research priorities throughout the Organization. The resource allocation strategy being developed by the Organization was described in its 1979/80 annual report, and progress in its development and implementation is discussed in Chapters 1 and 2 of this report, 'Strategic Research Planning' and 'Distribution of Research Effort'. This strategy will enable CSIRO to respond more effectively to problems of national concern and to changes in the research requirements of the nation. Areas of research designated as having high priority for expansion in CSIRO in the 1980s are: biotechnology, energy, land and water, manufacturing technology, oceanography and plant pathology. These are discussed further in Chapters 2, 3 and 4.

Consultation is an integral part of the Organization's resource allocation strategy and, in order to determine its research priorities on the basis of the best advice available, the Organization needs to consult extensively with Federal and State governments, sections of the community and other research workers. The channels for consultation and the approach being developed for determining research priorities at the broadest level are described in Chapter 1 of this report, 'Strategic Research Planning', and Chapter 11, 'Advisory Council and State Committees'.

The most significant changes in the reporting year related to CSIRO's energy research. Following consideration of a report on the research activities of the Australian Atomic Energy Commission (AAEC), the Government decided to transfer to CSIRO a substantial number of staff for work on non-nuclear energy research (see Chapter 3). The move confirmed CSIRO's role as the Commonwealth's principal scientific research organization and was accompanied by revised arrangements for consultation with the Department of National Development and Energy.

Following consideration of a number of reports making recommendations on industrial research and development, the Government decided to provide more support for research associations and to re-examine associated administrative arrangements. Grants for these associations had traditionally been provided through CSIRO's budget appropriation. With the establishment of a Department of Science and Technology, it is considered more appropriate for the Department to take responsibility for the funding of research associations (see Chapter 4).

Reviews of the Divisions of Entomology, Soils, Land Use Research, Land Resources Management, Wildlife Research, Mechanical Engineering, the Dairy Research Laboratory, the Centre for Animal Research and Development, and Wood Science and the Division of Chemical Technology were completed in 1980/81. The results of these reviews are reported in Chapter 5. Reviews of Computing Policy and Facilities and the Divisions of Animal Production, Cloud Physics and Mathematics and Statistics are in progress.

Major changes to CSIRO's Institute and Divisional structure were decided upon in 1980/81. These included the reallocation of Divisions to the various Institutes, the establishment of several new Divisions and the closure of others. The Institute of Earth Resources will become the Institute of Energy and Earth Resources with the transfer of staff and resources from the AAEC mentioned above. Details are set out in Chapter 6.

The work of the Consultative Council and personnel policies relating to recruitment, promotion and studentships are described in Chapter 7.

A calendar of events and senior appointments and retirements are shown in Chapter 8. One of the significant events during the year was the official opening of the Tropical Cattle Research Centre at Rockhampton, Queensland.

Allocation of resources in 1980/81 for the construction of works and buildings, repairs and maintenance and the acquisition of land and buildings is described in Chapter 9. CSIRO's largest current construction project, the $118M Australian Animal Health Laboratory at Geelong, Victoria, is now more than 50% complete.

Expenditure from CSIRO's direct Appropriation and revenue in 1980/81 amounted to $184 922 914. Audited financial statements are shown in Chapter 10.

Results of CSIRO's research programs are described in the Organization's many other publications. However, to illustrate something of the wide range of CSIRO's research, recent achievements in the areas of Cattle Production for the Tropics, Integrated Pest Control, Wool Processing, Mineral Exploration and Standards of Measurement are described briefly in the section on research.

Research Policies and Administration

This section is designed to meet CSIRO's statutory reporting obligations, with the exception of the requirement relating to advice given to the Executive by the Advisory Council, which is reported on in the section entitled Advisory Council and State Committees.

Amendments made in 1978 to the Science and Industry Research Act 1949 introduced a requirement to state in each annual report the policies relating to the Organization's research that were current at the beginning of the reporting year, together with a description of any developments in those policies occurring during the year. The response developed by the Organization to meet this requirement has two main components. These are:

- a comprehensive statement each year of the research objectives being pursued by the Organization and the level of resources devoted to each objective; and
- an initial statement of general policies relating to research, followed by statements of policies relating to specific areas of research, as these policies are developed.

The statement of research objectives and resources is presented in Chapter 2. The initial statement of general policies relating to research appeared in the 1978/79 Annual Report. Policies relating to specific areas of research which were developed during 1980/81 appear in Chapters 3-5 of this Report.

1. Strategic research planning

The main role of CSIRO is to plan and execute a comprehensive program of general scientific research on behalf of the Commonwealth of Australia. To fulfil this role, research priorities must be established and sufficient resources allocated to enable the work to be carried out effectively. As the range of subjects suitable for research expands rapidly and the costs involved increase, the complexity of the decisions involved in research management will inevitably increase. As a result, the Organization needs to reappraise a variety of issues, including:

- which research activities it should engage in;
- how its resources should be distributed among these activities; and
- which activities are sufficiently well served by other research agencies in the public or private sector, either in Australia or internationally, to require no input from CSIRO.

It is essential that a considerable proportion of CSIRO's resources be directed to areas with potential for the longer-term future, as distinct from areas that are currently proving successful. Predicting the likelihood of scientific success and economic and community needs some ten years ahead presents a considerable challenge to the Organization's research planning processes.

In order to carry out its functions effectively and respond to national problems as they arise, a national research body such as CSIRO needs a broadly-based research capability and expertise in a range of disciplines. It must have methods of determining which areas the community considers to be important and to require a research input, and it needs to take account of information and advice from the community on factors which may be important in formulating research policy, priorities and resource allocation. It also needs to provide an atmosphere that will promote and maintain the creativity that is essential for good research.

The Organization is developing a formal system for determining the options for its research initiatives. Particular emphasis is being placed on using more efficiently existing or potentially available resources. The process of strategic research planning is a continuing one which must take account of changing perceptions and circumstances. Strategic planning helps to determine the merits of various research alternatives in relation to the overall balance of research effort, and provides information about the timing of new initiatives which would be of benefit to the community.

Classification of Research

To provide information on CSIRO's research activities in a form which is useful to industry and other potential users, and to assist the Organization in its strategic planning, existing research activities have been broken up into four categories—research sectors—which can be successively split into smaller, more specialized groupings until the basic unit of research management—the program—is reached.

The current breakdown of research is into:

- Rural Industries
- Mineral, Energy and Water Resources
- Manufacturing Industries
- Community Interests.

The Community Interests research sector may serve as an example of the successive breakdown of research sectors. This sector is split into three subsectors: Knowledge and Management of the Natural Environment; Tertiary Industry; and Public Health. The subsectors are split into 13 research areas (for example, environmental protection, building and construction), then into 56 specific research programs such as Interaction of Animal Populations with Tropical Grasslands and Stock Industries; Nutrition and Human Ecology; Air Pollution Abatement; and the Development of Computerized Information Services.

Where research is directly relevant to Australian industries, research areas are generally classified according to the Australian Standard Industrial Classification (ASIC) prepared by the Australian Bureau of Statistics. However, this form of classification can be unhelpful when the solution to a problem in one industry grouping is found by research related to another. This is understandable since many disciplinary studies, and even multidisciplinary ones, are applicable to the problems of a number of industries. The allocation of a research program to a simple industry sector is, therefore, not always logical. Further refinements to the classification will be needed to meet CSIRO's planning and information requirements.

Collecting Information

Information required for strategic planning needs to encompass:

- the social and economic factors relating to a specific industry or community interest, and indications of areas for which research is likely to be economically or socially desirable;
- particular industry or community interest needs which might benefit from Australian research; or
- the scientific opportunities available. These are areas of research which have potential for increasing the productivity or competitiveness of existing industries, creating new industries, or increasing the well-being of the community, with a reasonable expectation of success in the short-, medium- or long-term.

Emphasis is given to new opportunities which arise as a result of advances in scientific theory and techniques or in technology. Often these are found to cross industry boundaries.

The mechanisms used by CSIRO to collect these kinds of information from within the Organization as well as externally vary in their formality and the particular research sector with which they are concerned. The more formal mechanisms are covered below.

Setting Research Priorities

The CSIRO Advisory Council is an integral part of CSIRO's research planning system and is the primary vehicle for providing the Organization with independent external advice. The Council comprises members of the community, permanent heads of Commonwealth Government departments and others, broadly representing the potential beneficiaries of CSIRO research and providing advice from that perspective. Details of the work of the Advisory Council and its State Committees are included in Chapter 11. Briefly, the Council's functions are to provide advice to the Executive of CSIRO on:

- CSIRO's objectives and the priorities needed to achieve them;
- industrial or economic matters which may be important in setting those objectives; and
- the interests of the Australian community which CSIRO could further.

At present, the Council is concentrating on the broader planning questions in the four research sectors and has established standing committees associated with each of them.

Strategic Planning Studies

The reports of the Planning and Evaluation Advisory Unit (PEAU) are an important source of information used by the Executive in determining research policy and priorities. In compiling these reports, PEAU consults widely both inside and outside CSIRO to ascertain relevant social and economic factors and the views of industry and community representatives on their research needs.

The views of scientists concerning opportunities for research to meet perceived needs and having a reasonable expectation of success in the near-, mid- or long-term, and appropriate to CSIRO's research role, are then sought. Reports placing current CSIRO research in a national perspective, and providing summaries of resources allocated to research areas and the timescales of ongoing programs, are then prepared.

From all of this information, gaps and imbalances in the Organization's current research effort can be ascertained. After further external and internal consultation, these provide a basis for Executive decisions on future research policy and priorities.

Agricultural Research Planning

A strategic planning study of the agricultural subsector is being undertaken at present and will illustrate the procedure described above.

A document containing preliminary planning information has been compiled and sent to the CSIRO Advisory Council, ASTEC, State and Commonwealth Departments concerned with agriculture, and to major industry organizations for advice prior to finalization of a report.

The document includes information on:

- CSIRO's role in agricultural research in relation to the other organizations involved, such as State Departments of Agriculture, universities and industry;
- the likely future direction of Australian agriculture. This summarizes conclusions of a joint CSIRO/BAE socio-economic review which also identified areas where future research might be economically desirable;
- a description of CSIRO's current agricultural research and related programs;
- information on the current allocation of resources and the timescale of ongoing programs, including an indication of the extent to which this research is directed to the needs of the various agricultural industries; and
- a suggested list of themes for future research emphasis by CSIRO where there are good research opportunities with potential for economic benefit.

Advice received as a result of these further consultations will be incorporated into the report and a list of priority options will be prepared for consideration by the Executive. The Executive will then re-determine CSIRO's agricultural research policy.

Other Planning Studies

The Planning and Evaluation Advisory Unit is also assembling and analysing material relevant to the Manufacturing Industries and Community Interests sectors and the Forestry and Fishing and Energy subsectors. As appropriate, this material is provided to review committees to assist them in their work.

Reviews

Strategic research planning leads to the establishment of research policies and broad research priorities by the Executive. Within this framework, research is assessed and recommendations made for improving its effectiveness by means of reviews. Divisional reviews are a longstanding feature of CSIRO management and their use and scope have been expanded over the past ten years. More recently, the place of reviews in the Organization's management system has been the subject of detailed examination. As this examination is still continuing, the description of the review process set out in this report is subject to change.

An essential feature of reviews will be their emphasis on the accountability structure of the Organization. A Chief of Division is responsible and accountable to the Institute Director for the Division's research and management. The Director, in turn, is responsible and accountable to the Executive for the research and management of his Institute.

Divisional reviews usually take place near the end of a Chief's term of appointment, that is, at five- to seven-year intervals. In the intervening period, the Director monitors the performance of the Division, while giving the Chief wide discretionary powers. The Director is responsible for ensuring that each Division in his Institute conducts research in accordance with the broad research policies and priorities established by the Executive, that appropriate resources are allocated to each task and that the research is effective in terms of the resources available. Towards the end of a Director's term, the Executive may commission a review of the Institute.

In 1981, new draft terms of reference for the conduct of reviews of Divisions were released covering:

- the national need for research in the Divisions' areas of interest;
- the quality of the research;
- progress towards research objectives and the success in transferring results to users;
- the appropriateness of internal management arrangements and the effectiveness with which resources are utilized; and
- the future direction and appropriate institutional arrangements for which a continuing need is identified.

Reviews of particular subjects or disciplines, or reviews of industry-related subsectors, may also be commissioned by the Executive. These reviews are expected to cover the present state of knowledge in a particular field, for example atmospheric science, and assess its importance; define an appropriate research role in that field for CSIRO; propose an order of research priorities; and review existing arrangements for collaboration and technology transfer. These reviews also lead to the development by the Executive of broad research objectives, and Directors and Chiefs are required to refine these progressively into programs of research. Directors are responsible for implementing the decisions made by the Executive on the basis of review reports and for submitting progress reports after six months and two years.

The reviews that have taken place during 1980/81, the Executive's response to them, and the resulting policy statements are set out in Chapter 5.

2. Distribution of research effort

This chapter sets out the current distribution of CSIRO's research effort and briefly describes areas of research designated for expansion. It forms part of the Organization's response to a requirement in the Science and Industry Research Act 1949 that each annual report should describe the research policies current at the beginning of the reporting year and any developments in those policies during that year. The selection of particular research objectives from among all those possible within CSIRO's statutory charter, and the relative levels of financial and manpower resources devoted to the pursuit of selected objectives, are the principal expressions of CSIRO's research policies. This chapter presents tables summarizing the distribution of CSIRO's research effort to selected objectives. Each table also provides a baseline from which changes in emphasis in the following year can be measured, in order to report on the Organization's policy directions. Policies for specific areas of research which have been developed during the reporting year appear in Chapters 3 to 6.

Table 1 shows the distribution of resources to research areas according to the classification being used by CSIRO for strategic planning. Assigning research programs to particular categories is often by a process of best fit. The nature of research means that a program may benefit a number of diverse industries and provide other community benefits as well. However, in Table 1 each research program has been allocated to the one research category to which it is primarily relevant.

Table 2 shows the distribution of financial and manpower resources according to the research objectives of the Organization's Institutes, Divisions and Units. The definition of the research objectives for the various research components of CSIRO is given in Chapter 6, 'Organization'. A still more detailed account can be found in the publication 'CSIRO Research Programs 1980-81'.

Changed Emphases

Categories of research nominated by the Executive in 1979/80 as having high priority for expansion were:

- biotechnology
- energy
- water and soils
- manufacturing technology
- oceanography.

During 1981, plant pathology has been added to this list.

TABLE 1	% of Total Research Expenditure		% of Total Direct Professional Staff	
Rural industries				
Agriculture				
Plant improvement	2.5		1.9	
Plant physiology and biochemistry	1.9		2.0	
Soil fertility and plant nutrition	2.8		2.5	
Agricultural systems	3.3		2.6	
Management of crop and pasture pests and diseases	3.2		2.5	
Livestock production	6.5		5.2	
Livestock health	5.7		4.0	
Agricultural engineering	0.3		0.3	
		26.2		21.0
Forestry				
Production	2.0		1.8	
Management	1.5		1.6	
Harvesting	0.3		0.3	
		3.8		3.7
Fishing				
Resource assessment	3.6		2.4	
		3.6		2.4
Total – Rural industries		33.6		27.1
Mineral, energy and water resources				
Mineral resources				
Exploration	2.7		3.1	
Mining and beneficiation	2.9		3.5	
Environment	0.5		0.6	
		6.1		7.2
Energy resources				
Coal	2.4		2.6	
Petroleum and oil shale	0.4		0.6	
Substitute liquid fuels	2.7		3.0	
Renewable energy	1.4		1.7	
Energy storage and conservation	0.9		1.1	
		7.8		9.0
Water resources				
Water management	1.8		2.0	
Water technology	0.5		0.5	
		2.3		2.5
Total – Mineral, energy and water resources		16.2		18.7

TABLE 1 continued	% of Total Research Expenditure		% of Total Direct Professional Staff	
Manufacturing industries				
Resource-based manufacturing industries				
Food processing	5.1		6.5	
Textiles	5.5		4.1	
Hides and leather	0.4		0.4	
Forest products	1.3		1.4	
Basic metal products	1.2		1.6	
		13.5		14.0
Technology-intensive industries				
Electrical and electronic equipment and instruments	1.6		1.9	
Advanced materials	1.3		1.3	
Specialty polymers	0.4		0.4	
Chemical, pharmaceutical and veterinary products	2.2		2.2	
		5.5		5.8
Industrial machinery and equipment				
Materials processing technology	1.3		1.3	
		1.3		1.3
Standards				
Physical and mechanical quantities	1.2		1.0	
Electrical quantities	1.6		1.5	
Thermal and optical quantities	1.3		1.4	
Properties of solids, liquids and gases	1.0		1.0	
		5.1		4.9
Total – Manufacturing industries		25.4		26.0
Community interests				
Knowledge and management of the natural environment				
Fauna	3.1		3.0	
Flora	0.8		0.7	
Land	5.2		5.7	
Oceans	1.3		0.9	
Atmosphere	2.4		2.3	
Environmental protection	1.2		1.3	
Astronomy	2.9		2.6	
		16.9		16.5
Tertiary industry				
Building and construction	2.9		3.6	
Mathematics and statistics	1.8		3.3	
Computing	1.5		2.8	
Information services	0.1		0.1	
		6.3		9.8
Public health				
Human nutrition	1.3		1.6	
Industrial hygiene	0.3		0.3	
		1.6		1.9
Total – Community interests		24.8		28.2
CSIRO – Research total		100.0		100.0

TABLE 2	% of Total Research Expenditure		% of Total Direct Professional Staff	
Institute of Animal and Food Sciences				
Division of Animal Health	4.4		3.2	
Division of Animal Production	5.6		4.6	
Division of Food Research	4.8		6.1	
Division of Human Nutrition	1.3		1.6	
Centre for Animal Research and Development	1.4		0.5	
Molecular and Cellular Biology Unit	0.9		1.1	
Wheat Research Unit	0.2		0.4	
		18.6		17.5
Institute of Biological Resources				
Division of Entomology	5.2		4.2	
Division of Fisheries and Oceanography	4.8		3.3	
Division of Forest Research	3.0		2.8	
Division of Horticultural Research	1.1		1.2	
Division of Irrigation Research	1.0		1.2	
Division of Plant Industry	5.6		5.1	
Division of Tropical Crops and Pastures	4.0		2.5	
Division of Wildlife Research	2.0		1.8	
		26.7		22.1
Institute of Earth Resources				
Division of Applied Geomechanics	1.8		1.7	
Division of Land Resources Management	2.6		2.4	
Division of Land Use Research	2.1		2.5	
Minerals Research Laboratories	10.2		12.5	
Division of Soils	2.9		3.5	
		19.6		22.6
Institute of Industrial Technology				
Division of Applied Organic Chemistry	1.9		1.9	
Division of Building Research	3.4		4.1	
Division of Chemical Technology	1.9		2.1	
Division of Manufacturing Technology	1.2		1.3	
Division of Mechanical Engineering	1.7		1.8	
Division of Protein Chemistry	2.1		1.9	
Division of Textile Industry	2.9		1.9	
Division of Textile Physics	1.7		1.5	
		16.8		16.5
Institute of Physical Sciences				
Division of Applied Physics	5.6		5.5	
Division of Atmospheric Physics	1.5		1.4	
Division of Chemical Physics	1.8		2.1	
Division of Cloud Physics	1.1		0.9	
Division of Computing Research	1.5		2.8	
Division of Environmental Mechanics	0.4		0.5	
Division of Materials Science	1.3		1.6	
Division of Mathematics and Statistics	1.8		3.3	
Division of Radiophysics	3.0		2.7	
Australian Numerical Meteorology Research Centre	0.3		0.5	
		18.3		21.3
TOTAL		100.0		100.0

The most significant changes in the allocation of professional research staff occurred in the categories of **energy research** and **manufacturing technology**, both designated by the Executive as having high priority for expansion. In energy research, some forty professional staff were added to the energy resources subsector, increasing the level of effort by twenty per cent. In manufacturing technology, ten professional staff were added to the basic metal products and materials processing technology areas, increasing the level of effort by some eighteen per cent.

In **biotechnology**, the Executive initiated an extensive subject review with the aim of identifying major new initiatives for CSIRO research (see Chapter 5). It also decided that an Industrial Microbiology Unit should be established as a consequence of its examination of the Review Committee Report on the Division of Chemical Technology (see Chapters 5 and 6). Ten professional staff have been added to biotechnology programs in two research areas (plant improvement, and agricultural chemicals, pharmaceuticals and veterinary products), and further expansions are expected to be made in the light of the outcome of the subject review.

Expansion in the field of **marine science** was largely taken up with moves to establish the new Marine Science Laboratory in Hobart and to acquire an oceanographic research vessel. Recruitment of professional staff in these areas will proceed in parallel with these major capital expansions, but a modest increase was achieved with an increase of some six professionals (about 7.5%) in the combined areas of oceanography and fisheries research.

In the category **water and soils**, the Executive decided to undertake a major review before deciding on significant expansions. As reported in Chapter 5, a review of the major land Divisions (Land Resources Management, Land Use Research and Soils) was completed in 1980/81, and in June 1980 an internal examination of objectives and priorities for water research was commenced following an Executive seminar on this topic. A major new initiative in this area is envisaged when the examination currently under way has been completed.

In **plant pathology**, the fields currently receiving attention include plant viruses (particularly in pastures and annual crops), soil-borne diseases, diseases of forest and woodland trees, and diseases in new crops (including crops in tropical areas). However, the Executive realizes that an increased effort is needed in plant pathology since the present effort is by no means adequate and new approaches to many of the problems are now possible. Research approaches include novel identification methods, the introduction of novel sources of disease resistance into breeding programs, disease management strategies and the study of disease organisms as components of complex ecological systems. The nature of the reorganized program will depend on the examination that is currently being conducted of the area.

Some of the variations from figures in the corresponding Tables for 1979/80 arise from refinement of the system of classification and more accurate identification of the levels of staff and financial resources allocated to the various categories of research included within the classification. Others arise from redeployment of staff and re-orientation of some research programs. Because of the nature of CSIRO's research and the need to employ the best scientists available, recruitment often takes a considerable time. As a result, CSIRO usually has a pool of positions which are in the process of being filled. Variations from year to year, therefore, also reflect changes due to loss of staff from ongoing programs who are replaced during the following year.

A significant proportion of the resources to support high-priority programs were derived from general reductions in other programs.

3. Energy research

Australian Energy Situation

Australia is regarded as an energy-rich country, although the full extent of its energy reserves remains uncertain. There are, however, wide variations in the supplies and reserves of different fuel sources, with large reserves of coal and uranium, less of natural gas condensates for liquid fuel requirements and only limited supplies of oil. Natural gas is being found in increasing quantities and is being utilized increasingly, and there may be potential for exploitation of extensive oil shale deposits. Consequently, Australia is likely to remain one of the few OECD countries that is a net exporter of energy; however, substantial imports of petroleum are required to meet present and projected domestic requirements.

Opportunities exist for Australia to capitalize on its overall substantial supplies of energy fuels, both as an exporter of the fuels that it has in abundance and in the development of indigenous energy-intensive industries, for example aluminium production. Projected growth in electricity demand to the end of the century both for these industries and as a result of substitution of electricity for other commercial and industrial applications will be met mainly by coal-based generating systems that already supply about 80% of Australia's electricity.

Government Energy Policy

The main energy problems facing Australia are its reliance on oil for transport and the present and projected increasing demand for imports of oil to compensate for deficiencies in indigenous supplies. It is against the perspective of these particular problems that the Government's recent policy statements on energy have been made. The most recent statement, made by the Prime Minister in August 1980, confirmed the following measures as central to the Government's energy policy:

- encouragement of conservation of scarce sources of energy, particularly liquid fuels;
- promotion of substitution for oil by available alternative energy sources—mainly natural gas, LPG and coal-based electricity;
- increased oil exploration activity and maximization of the development of existing fields;
- development of alternative sources of energy such as shale oil, coal liquefaction, ethanol and methanol; and
- increased support for energy research, development and demonstration.

Oil parity pricing was seen as a key policy measure in the attainment of energy policy objectives.

Development of CSIRO's Energy Research Policies and Priorities

The statement of Government energy policy referred to above was preceded by similar statements in November 1977 and June 1979. The frequency of these statements is indicative of the need to keep abreast of changes in the national and international energy scene and, similarly, CSIRO has found it necessary to review regularly its policies and priorities for energy research.

A statement of CSIRO policy and priorities for energy research was first presented in the Organization's annual report for 1978/79. This was based on a number of reviews of areas of national need and of research opportunities appropriate to the Organization in these areas. Since that time a number of events have taken place both within CSIRO and externally that necessitated a re-examination of the Organization's energy research policies and priorities, and facilitated the development of a more broadly based and definitive statement of these policies and priorities.

Within CSIRO, the formation and subsequent activities of the CSIRO Advisory Council and of the Planning and Evaluation Advisory Unit facilitated the generation of quantitative data and the formulation of broadly based advice on these data and their implications for CSIRO research. The Executive also decided in June 1981 to transfer the bulk of the resources of the Division of Mechanical Engineering to a new Institute of Energy and Earth Resources to facilitate coordination of the Organization's research activities.

External events included Australia joining the International Energy Agency (IEA) early in 1979; that Agency subsequently reviewed Australia's energy policies and priorities. Also, the Government commissioned a review of the Australian Atomic Energy Commission's Research Establishment (AAECRE) which culminated in the Prime Minister's announcement in April 1981 that CSIRO's energy research capacity would be expanded by the transfer of some 100 professional staff, or about a third of the professional resources of the AAECRE, to CSIRO. This transfer will enable expansion of the CSIRO research effort in such areas as the mining of energy resources, fossil fuels, alternative fuels, renewable energy and energy conservation. The decision presents opportunities for further major expansion of CSIRO's energy research effort beyond the significant expansion already achieved in 1980/81 (see also Chapter 2). Details of programs to be undertaken and of organizational arrangements will be presented in the 1981/82 annual report.

In its 1979/80 annual report the Organization announced its intention to develop in more detail its policies and priorities for energy research and the formation of a working party for this purpose under the chairmanship of Dr W.J.McG. Tegart, the member of the Executive with particular responsibility for energy research matters. The working party drew on detailed studies conducted by the Planning and Evaluation Advisory Unit and interacted closely with the CSIRO Advisory Council in formulating the policies and priorities described below. The formal advice received from the Advisory Council and the Executive's response to that advice are presented in Chapter 11. The outcome of this examination and interaction with external bodies was the publication of a report entitled 'CSIRO Energy Research, Planning and Policy'.

The working party's study led to the identification of six areas of energy research appropriate to an expanded CSIRO effort in accord with the high priority afforded by the Executive to this aspect of its activities. These six areas are: coal; petroleum, gas and oil shale; substitute liquid and gaseous fuels; renewable energy; energy storage; and energy conservation. (See Table 3 for further details.) It can be seen that these areas accord with the Government's policies referred to above.

The study also led to the identification of those areas in which CSIRO should not be involved or should only carry on a reduced program. Identification of such areas is as important as identification of areas for expanded effort because of the need for both Australia and CSIRO to concentrate their research activities. The Executive has endorsed a policy of concentration of research effort that applies to all research areas. Areas identified as inappropriate for CSIRO are nuclear energy generation; large-scale energy generation and transmission systems; magnetohydrodynamic energy conversion; wave and tidal energy systems; and geothermal energy.

The identification of both appropriate and inappropriate research areas reflects Australia's particular problems and opportunities on the one hand, and the charter and special capabilities of CSIRO on the other.

The Organization's energy research effort must also take into account the following factors:

- the importance of international collaboration; and
- the need to consider research directed towards energy policy objectives in conjunction with research directed towards different, but related, objectives.

CSIRO recognizes the importance of international collaboration and has participated actively in international conferences, workshops and cooperative programs such as the Australia/US Information Exchange on Solar Energy, the Australia/West Germany Workshop on Solar Energy Heating Systems, and the Australia/West Germany Joint Feasibility Study on Coal Conversion. Negotiations are in progress for a joint Australia/ Japan program on solar collector testing, fluidized bed combustion and energy use in buildings. CSIRO, with the aid of National Energy Research, Development and Demonstration Council (NERDDC) funds, has also recently set up and is managing the Commonwealth Regional Renewable Energy

Resources Information System (CRRERIS), which covers 19 Commonwealth countries in the Asian and Pacific areas.

Of recent particular significance has been the opportunity afforded by Australia's membership of the IEA to participate in R&D projects conducted under the Agency's auspices. These projects are carried out under the overall IEA Group Strategy for Energy Research, Development and Demonstration which guides the objectives of the joint research projects and provides a framework that assists in the formulation of national energy R&D programs. In developing its own plans for future directions in energy research, CSIRO has been able to take into account this internationally based Group Strategy.

The Organization also recognizes the need to balance its energy-directed research activities with activities having related objectives. Many activities with related objectives are becomingly increasingly important due to the changing national and international energy scene. Of particular significance in this regard are research programs aimed at meeting environmental and public health objectives, for instance research associated on the one hand with the localized environmental effects of coal usage and on the other hand with the broad implications of potential carbon dioxide build-up in the atmosphere associated with the increasing use of fossil fuels, particularly coal. Similarly, major energy development projects and energy-intensive processing industries make competing demands on land and particularly water resources, warranting an increased research effort so that political and management decisions can be made on a sound basis.

Appropriate Research Areas

The Organization has developed broad goals for CSIRO research in each of the six research areas referred to above, as well as in the major related research area of environmental implications. These goals and the current Divisional research programs aimed at achieving these goals are shown in Table 3. More comprehensive information on these programs can be obtained from the publication 'Directory of CSIRO Research Programs'.

Research activities that show particular promise in meeting these goals and that will be given increased emphasis include:

- basic coal science studies and research on mining and transportation techniques (e.g. pipelining) to facilitate the economic use of Australian coal supplies;
- studies on the genesis of Australian oil deposits and basic oil shale science studies directed towards facilitating petroleum exploration and the economic use of oil shale as a source of both energy and chemical feedstocks;
- catalysis as potentially the most significant research area for facilitating liquefaction and gasification of coal; and
- ion implantation techniques for second-generation photovoltaic devices.

An important factor that has emerged from CSIRO's energy planning studies is the desirability of balancing the Organization's research effort devoted to the more immediately perceived problem areas against the needs of longer-term, and perhaps consequently more speculative, research opportunities. The Organization recognizes that, just as there can be no single solution or technology option that will overcome the predicted shortfall in the supply of indigenous liquid fuel, so a combination of known and new techniques will be needed in the future to utilize the various forms of energy supply.

Thus diversity in research activity is important, both in terms of a number of areas for concentrated attack and in terms of time-scale of potential application. The Organization has therefore examined the time-scale in which its current research activities are expected to make a significant impact on the exploitation and use of energy supplies. Accordingly, projects have been classified into the following categories:

- near-term (results available within 10 years)
- medium-term (results available in 10 to 20 years)
- long-term (results available in more than 20 years).

A summary statement of the areas of energy research within CSIRO in these categories is given in Table 4. About two-thirds of the present CSIRO energy research effort is directed towards applications in the near-term. The programs are mainly in the areas of coal, energy conservation, and application of existing technologies for utilization of renewable energy resources. Substitute liquid and gaseous fuels by conversion of fossil fuels fall mainly into the medium-term category, while new techniques such as *in situ* processing of deep coal and shale oil deposits have long-term potential.

The Organization believes that its present balance of research effort is appropriate in terms of the time-scale of its activities, but it will continue to keep this aspect under review as existing projects reach fruition and new projects are initiated.

Financial Arrangements for Energy Research

CSIRO has 220 professional staff engaged in energy research and development, and expenditure in 1980/81 was $14.3M, or 7.8% of CSIRO's total research expenditure.

CSIRO receives considerable financial support from industry, particularly the coal industry through the research levy on production collected by the Commonwealth, and other sources. In 1980/81, CSIRO projects were supported by $2.8M provided by the National Energy Research, Development and Demonstration Program (NERDDP).

TABLE 3

Appropriate areas and goals for CSIRO Energy Research

Research areas appropriate for CSIRO	Broad goals for CSIRO	Current Divisional research
1. Coal	Improve the science and methodology underlying the exploration and assessment of Australian coal resources. Improve the technology of extracting, beneficiating, transporting and utilizing Australian coals.	Coal exploration and characterization Coal mining Coal preparation and transportation Coal utilization
2. Petroleum, gas and oil shale	Contribute to the cost-effectiveness of petroleum exploration by an improved understanding of Australian oil geology, exploration methods and characterization. Research new means for enhancing the recovery of oil and gas. Contribute to oil shale geology, characterization and assessment.	Oil exploration and characterization Oil shale exploration and characterization Petroleum recovery
3. Substitute liquid fuels	**From fossil fuel**: Contribute to the assessment and development of processes for production of liquid fuels, and to a lesser extent, petrochemical feedstocks, from Australian coal, natural gas and shale resources. **From biomass**: Develop technologies for the production, from agriculture and forest products and wastes, of ethanol, vegetable oils and liquids derived from volatile fatty acids as substitute liquid fuels and chemical intermediates.	Coal conversion Organic chemistry of fuels and metals Catalysts and catalytic processes for fuel-conversion technology Agro-industrial systems Biotechnology
4. Renewable energy	**Solar energy**: Develop cost-effective solar systems for domestic and industrial heating and cooling. Research means for storage of solar energy; develop efficient photovoltaic cells for small-scale ion implantation electricity generation. **Wind energy**: Assess the potential of wind energy resources in Australia.	Renewable energy resources engineering Solar conversion Solar energy research Solar engineering unit Solar energy storage Solar photolysis of water Protected cropping Assessment of renewable energy resources Wind energy Mathematical models, wind power

TABLE 3 continued

Research areas appropriate for CSIRO	Broad goals for CSIRO	Current Divisional research
5. Energy storage	Develop systems and equipment that will permit economic energy storage, including high energy density batteries with improved performance; test improved batteries for use in electric vehicles.	Energy storage
6. Energy conservation	Increase efficiency in the use of energy through scientific and engineering support to the National Energy Conservation Program. Improve analysis and design procedures for energy conservation in buildings and industrial processes. Improve techniques for assessing and reducing fuel consumption in road vehicles.	Energy conservation engineering Energy management Thermal investigations
Major research of direct relevance*		
1. Environment	Investigate the nature and causes of atmospheric and water pollution; develop systems and equipment for reducing environmental hazards and improving public health and safety aspects associated with the production and use of energy resources in Australia. Provide data on the efficient use of water, land and other resources critical to national energy needs.	Atmospheric constituents Atmospheric pollutants Air pollution abatement Urban areas Environmental impact (of coal combustion)

* Other research of less direct relevance is not included

TABLE 4

Projected application periods for CSIRO energy research

Time periods	On-going CSIRO research
Near-term goals (In use within 10 years) Find new sources of, and use existing, fuels more effectively with due regard to the environmental, social and economic factors involved. Apply existing technologies for utilizing renewable energy resources.	Improve methods for the characterization of primary energy resources. Improve recovery and extraction technologies for coal and gas. Develop techniques for substitution (by gas, coal, electricity), conservation and improved utilization of petroleum fuels for transport and other uses. Develop and demonstrate advanced thermal conversion applications of solar energy and production of liquid fuels from biomass, e.g. automotive distillate from oilseed crops. Investigate environmental problems and technical aspects of safety relating to existing technologies.
Mid-term goals (In use between 10 and 20 years) Develop alternative energy resources, processes and storage systems with due regard to the environmental, social and economic factors.	Identify and develop new and improved processes for the production of alternative fuels. Identify and develop processes for improved utilization of renewable energy resources. Identify and develop improved energy storage and conversion systems.
Long-term goals (In use beyond 20 years) Develop advanced renewable energy resources, processes and storage systems. Develop *in situ* processing of coal and shale.	Identify and develop new and more efficient processes for utilizing renewable energy resources. Identify and develop technologies for *in situ* processing of deep coal and shale oil deposits. Identify and develop new and more efficient energy storage and conversion systems.

Research areas presently inappropriate to CSIRO

Nuclear energy generation, large-scale energy generation and transmission, magnetohydrodynamic energy conversion, wave and tidal energy systems, geothermal energy.

4. Manufacturing industry

Introduction

Over one-quarter of CSIRO's total research effort is directed to support for manufacturing industries, particularly the resource-based industries such as food processing, textiles, basic metal industries, forest products and leather.

In the past, CSIRO has directed less effort to the high-technology or science-intensive industries. In these industries, new technology is often a major source of competition between firms and many firms are overseas-owned, which often limits the conduct of local in-house R&D or the right to develop and market new products. Thus it is more difficult for CSIRO to define research activities that satisfy the dual criteria of:

- having high priority in the national interest; and
- being more appropriately carried out by CSIRO than by firms themselves.

Efforts are now being made by both CSIRO and industry groups to define better those research areas to which CSIRO can properly contribute. Initiatives have already been taken by the Organization in the fields of biotechnology and microelectronics, and discussions are continuing with other industry groups, for example chemical industry groups.

The features which most readily lead to development of a CSIRO program supportive of a particular sector of manufacturing are an industry understanding of the longer-term research that is CSIRO's main role, the definition of industry trends and prospects that deal with a comparable time horizon, and the subsequent identification of topics in which a number of firms have a mutual interest. Both CSIRO and industry groups with which successful interaction is developing recognize the need for careful selection of research topics; there are many areas where derivative technology will continue to offer the best prospects for commercial success in the private sector.

Industry trends and characteristics are not the only factors that affect CSIRO's selection of research topics. As an Organization with a predominantly strategic role, CSIRO has a particular responsibility to be alert to the implications for industry of trends in science. For example, developments in materials science have recently taken on new and significant dimensions for industry. These developments are related to fundamental principles of physics and chemistry and CSIRO is in the forefront of research in this field with investigations into catalysis, surface and film effects, and composite materials.

Policy

CSIRO recognizes the diversity of manufacturing industry and, in developing a general policy towards the manufacturing sector, has concentrated on the aspects that are common to most of the industry.

The Organization has undertaken a general examination of recent Government policies applying to the manufacturing sector, with particular emphasis on those of potential importance to CSIRO. The Executive agrees with the Government's view that innovative performance in manufacturing is important, a view that the Government expressed in its responses to the reports of the Committee on Policies for Manufacturing Industry (Jackson Committee), the Study Group on Structural Adjustment (Crawford Committee), the Committee of Inquiry into Technological Change in Australia (Myers Committee), and the Independent Inquiry into CSIRO (Birch Committee).

Two aspects of CSIRO's general policies that apply to all industry sectors but which have special relevance to the development of policies relating to manufacturing have emerged as being of central importance.

Firstly, resources will be concentrated on research of a more strategic and longer-term nature than is normally conducted by individual firms. In this way, CSIRO can generally complement rather than supplement industry's research activities. In some instances there may be a need to concentrate initially on shorter-term tactical work in order to heighten industry's research awareness and its subsequent receptivity and capability to develop and utilize the results of longer-term strategic research.

Secondly, the Organization is aware of the Government's policy, reiterated in announcing the extension of the Industrial Research and Development (IR&D) Incentives Scheme, that individual firms should maintain a meaningful stake in research from which they stand to be the main beneficiaries. In recognition of this policy and of the existence of Government IR&D support measures directed specifically at individual firms, the Executive has confirmed its commitment to undertaking research that is potentially of value to a large number of firms. However, CSIRO will continue to make available its unique skills and capabilities on an equitable basis to individual firms, provided this does not inhibit the Organization's performance of its main role of strategic research in support of industry and community interests. Additionally, CSIRO will continue to pursue arrangements with individual firms where these provide the best means of implementing CSIRO's research results in the national interest.

Specific measures endorsed by the Executive that have particular relevance to research related to the manufacturing sector are:

- greater selectivity and concentration of research projects;
- encouragement of industry in its definition of research objectives;

- strengthening of CSIRO's techno-commercial skills as an aid to the selection of projects;
- direct participation by CSIRO in the further development of its research results, particularly by ensuring that know-how and expertise are made fully available to companies, especially small companies, when developing CSIRO's research results;
- granting of preferential treatment to individual firms where this is the best way of securing benefits that are in the national interest;
- utilization of patents and licences in such a way as to ensure maximum use of, and benefit from, CSIRO's research results;
- facilitation of mobility of CSIRO staff both internally and externally;
- the development of promotion criteria that will incorporate acknowledgement of the importance of practical achievement; and
- further promotion and support of research associations.

During 1980/81, the CSIRO Advisory Council provided formal advice to the Organization on a number of ways of facilitating CSIRO's contribution to the technological capabilities of the manufacturing sector. The Advisory Council's recommendations touched on many of the policy considerations mentioned above. Council's recommendations, together with the Executive's formal responses, are reported in Chapter 11.

As part of the continuing process of developing more detailed policies and priorities for its manufacturing industry research, the Organization's Planning and Evaluation Advisory Unit is currently undertaking an analysis of this sector of industry. The analysis is expected to be completed in late 1981 and the results will be combined with an evaluation of possible research opportunities appropriate to the sector as an aid to directing future CSIRO activities in support of Australian manufacturing.

Interaction with Manufacturing Industry

Interaction with industry is necessary in order to obtain a mutual perception of problems and opportunities, to make industry's needs known to CSIRO, and to provide the opportunity for CSIRO's research results to be transferred to, or taken up by, industry. The scope of, and the large number of companies operating in, Australian manufacturing make effective interaction a constant challenge. CSIRO and sections of manufacturing industry have cooperated in establishing a wide range of mechanisms for interaction; these were described in the 1979/80 annual report.

Interactions at Divisional, Institute and Executive levels have continued and been strengthened during 1980/81. An example of this was the agreement reached with the Research Committee of the Australian Chemical Industry Council in April 1981 on the basis for developing industry objectives compatible with CSIRO's charter, namely:

- research should be of general applicability to the chemical industry and of a longer-term nature, typically looking some 10 years or more ahead; and
- research should be based on unique Australian circumstances and opportunities, for example the development of chemical feedstocks derived from Australian coal.

A program of consultation between the Council and individual CSIRO Divisions has been initiated and will be followed up with a more detailed assessment of industry characteristics and perceived requirements on the one hand and CSIRO capabilities and perceived research opportunities on the other.

Research Associations

Research associations provide an important medium of interaction with manufacturing firms, particularly for those parts of manufacturing that are characterized by a large number of small firms. CSIRO has been chartered since 1926 to provide support for research associations and is represented on the governing body of each association that receives Government support.

The conduct by research associations of tactical research and technology transfer within industry is regarded by CSIRO as a valuable complement to its conduct of longer-term strategic research. Equally valuable from CSIRO's point of view is the two-way flow of information afforded by the participation by CSIRO officers in the management of research associations. Research associations can be made aware of CSIRO's research results pertinent to their activities and also provide a means for alerting the Organization to the research requirements of particular industry groups. Some of these requirements are of a long-term nature and consequently influence the conduct by CSIRO of its strategic research.

The Independent Inquiry into CSIRO saw an expanded role for research associations in assisting manufacturing industry to raise its research awareness, and defining and working on problems of common interest. Subsequently a number of other bodies also recommended to Government an expanded role for research associations. These include the Australian Science and Technology Council (ASTEC), the Study Group on Structural Adjustment, and the Committee of Inquiry into Technological Change in Australia. In responding to the report of the last-mentioned of these inquiries in September 1980, the Government announced an expanded promotional role and increased financial support for both new and existing associations.

The Minister for Science and Technology, on the advice of both his Department and CSIRO, decided that the best way of giving effect to the Government's policy of increased support for research associations and of maintaining the beneficial relationship of the associations with CSIRO was to:

- maintain CSIRO membership on the governing bodies of research associations;
- transfer responsibility for funding research associations to the Department of Science and Technology; and
- establish a Research Association Executive Group, comprising representatives from CSIRO and the Department of Science and Technology, having the following terms of reference:
  - to determine the need for changes to the number and type of research associations;
  - to recommend to the Minister, on this basis, any changes in structure; and
  - to make budgetary recommendations to the Minister.

The Executive Group was subsequently established in June 1981. Among its first tasks are the revision of the conditions and guidelines for recognition of research associations consistent with the Government's decision to maintain the block grant form of support, and the development and instigation of a promotional campaign.

CSIRO has welcomed the Government's decision to expand its support for research associations and believes that the formation of new associations, combined with continued participation by CSIRO in their management, will contribute significantly to the Organization's interaction with the manufacturing sector.

Organization of Research

In 1980/81, certain organizational initiatives or rearrangements were undertaken with a view to strengthening CSIRO's support for manufacturing industry. The Division of Chemical Technology is to be replaced by a Division of Cellulose Research and an Industrial Microbiology Unit. The Division of Cellulose Research will provide a sharper focus for research on all aspects of the science and technology of wood and other ligno-cellulose resources. Its research will encompass materials presently derived from these resources as well as new products such as chemicals, fuels and new types of composite constructional materials. The Industrial Microbiology Unit will examine the opportunities for application to industrial processes of the important new area of biotechnology.

The Division of Mechanical Engineering is to be replaced by a Division of Energy Technology and most of this Division's resources are to be directed to work relating to energy. The future of agricultural engineering activities in CSIRO is under review.

The Division of Manufacturing Technology, with laboratories in Melbourne and Adelaide, has strengthened its research programs in active collaboration with industry. Research at the Adelaide laboratory includes work in foundry technology, welding, materials engineering, metal forming, energy management in heat treatment, and product and process innovation and control. Research at the Melbourne laboratory includes studies in die-casting technology, arc technics, machining, and integrated engineering manufacture encompassing manufacturing control systems and robots.

The establishment of a very-large-scale integration (VLSI) program in the Division of Computing Research was reported in the 1979/80 annual report. The Group responsible will conduct research into the design of very-large-scale integrated circuits with up to 100 000 devices per chip. Funding for the program is $1.5 million spread over three years.

Recent developments in structured chip design in the United States have provided the technical basis for the work of the Group which, at full strength, will have 15 members. Technical expertise will be split equally between hardware and software, and links with overseas laboratories and universities will be maintained. The Group will offer a Multi-Project Chip implementation system for Australian experimental design.

A specific goal of the Group is to establish within three years an internationally competitive capability in VLSI design and in applied microsystem architecture. Another goal is to establish an Australian capability for the design of VLSI chips, which can then be fabricated in overseas plants if necessary.

In addition to these developments, research of particular relevance to the manufacturing sector has continued in a number of areas, including:

- specialized polymer materials and new pesticides in the Division of Applied Organic Chemistry;
- methods for processing primary products rich in protein, such as wool, hides and skins, in the Division of Protein Chemistry; and
- products and processes for the manufacture of yarns, fabrics and garments in the Division of Textile Industry.

More comprehensive coverage of CSIRO research in support of manufacturing industry can be obtained from the publication 'CSIRO Research Programs 1980-81' and the annual reports for 1980/81 of the Institutes of Industrial Technology and Physical Sciences. Attention is drawn in particular to the chapter 'Manufacturing in Australia' in the former Institute's annual report.

5. Reviews

Reviews of CSIRO's research effort are conducted on a regular basis in order to confirm the broad objectives of the research and to determine its effectiveness. Some reviews concern a subject area or discipline and often span the research activities of a number of Divisions. Divisional reviews, on the other hand, involve an examination of the effectiveness and relevance of the research programs of an individual Division.

Revised arrangements for reviews are being introduced, partly to extend and strengthen the highly decentralized style of management which is suited to CSIRO, and partly to take account of the experience gained since late 1978 in conducting reviews within an Institute structure. Further details are provided in Chapter 1, 'Strategic Research Planning'. Reviews which the Executive has considered or initiated during the year are discussed below.

Completed Research Reviews

Division of Entomology

The Division of Entomology was reviewed prior to the anticipated retirement of the Chief in August 1981. Following the review, the Executive decided to continue the main activities of the Division. These activities are: methods of controlling arthropod pests by biological, physical and chemical means, and by varying the conditions of crop culture; the integration of these methods into management systems; control of weeds by biological agents; the modification of control practices that have undesirable characteristics; and understanding the role of insects in the environmental balance.

Moreover, the balance between basic science and the applications of the results of basic science to problems of economic and social significance will remain substantially unchanged. However, the staff of the Division will be encouraged to develop research strategies that will cover the range of the Division's responsibilities from basic through to applied research.

A number of specific recommendations made by the review committee will be adopted. These include:

- the various techniques for studying insect migration and movement will be concentrated on one or two specific projects;
- work on insect pathogens will be examined with a view to strengthening the programs, and specialist reviews of the work on orchard pests and pasture scarabs will be undertaken;
- the project on the genetic control of sheep blowfly will be reviewed to assess its scientific innovation, its immediate practical application and its potential as a model for similar

studies; and

- the use of radar as a research tool in insect migration will be critically reviewed in about three years' time.

The Division is responsible for the care and maintenance of the Australian National Insect Collection. Discussions are to be held with the Department of Home Affairs and the Environment to rationalize the roles of the Division of Entomology and the Bureau of Fauna and Flora in the maintenance of the collection as part of the national heritage.

Centre for Animal Research and Development (P3T)

In early 1980, the Australian Development Assistance Bureau (ADAB) conducted a review of the Centre for Animal Research and Development (P3T), Bogor, Indonesia. The Centre, which began operating in 1974, is partly funded by ADAB and staffed jointly by CSIRO and Indonesia. The intention is to develop a viable research institute for which Indonesia will progressively assume control. CSIRO's role is to establish research facilities, provide senior scientific and technical staff initially, and train Indonesian staff to undertake independent scientific research. It is planned that Indonesia will have full responsibility for the planning, administration and performance of the Centre's research programs by December 1984.

The major recommendations and conclusions of the review report were accepted by Indonesia and Australia. CSIRO, however, recorded some reservations, particularly about the timetable for the run-down of expatriate staff.

Some of the report's recommendations and conclusions were:

- CSIRO is satisfactorily fulfilling the mandate given to it as executing agent. In the five years of its existence, P3T has made impressive progress under difficult conditions.
- The buildings and equipment at P3T are appropriate to the objectives expressed in the Memorandum of Understanding. The capital cost exceeded the original estimate but is not out of line with that of similar facilities built between 1975 and 1979 under the auspices of the Consultative Group on International Agricultural Research. Nevertheless, the facility is costly to maintain. Further expenditure on buildings and plant should be scrutinised with a view to containing the cost of operation and maintenance.
- There should not be two separate Indonesian Institutes for animal husbandry research, and P3T should be incorporated into the Central Research Institute for Animal Husbandry (CRIAH) of the Agency for Agricultural Research and Development as a project.
- The Memorandum of Understanding between the Governments of Indonesia and Australia should be revised to take account of the proposed change in status of P3T. The new Memorandum of Understanding should contain objectives for P3T which conform to those of CRIAH.

- Steps should be taken to rationalize the programs of P3T and LPP, the existing Indonesian institute for animal husbandry research within CRIAH. Various options are feasible. The allocation of future responsibilities will be a task for the persons designated to direct CRIAH and its component units.
- There should be a major reduction in Australian scientific, technical, administrative and servicing staff by 1984. However, a limited presence of experienced Australian personnel is recommended until 1989 in order to provide the research guidance and technical servicing that are likely to be required. There is scope for the specialised technical staff at P3T to provide some supervision and training for technicians throughout CRIAH.
- The training program of P3T has made considerable progress although it has had to work almost entirely with new graduates rather than more experienced personnel. Future training programs for P3T should be coordinated with those for other groups within CRIAH, in order to provide an appropriate interdisciplinary balance. The limited career prospects for technicians constrain the development of training programs for this category of personnel.

Division of Soils

It was noted in last year's annual report that the Division of Soils would be reviewed in 1980/81. The primary outcome of the review, which was considered at the same time as the review of the Divisions of Land Use Research and Land Resources Management, is that CSIRO will continue to undertake a major program in soil science research and in the application of this research to the Australian environment. The Division will conduct research into the physics, chemistry and biology of soils and in the interrelated disciplines of pedology and geomorphology and will extend this knowledge to applications in dryland and irrigated agriculture, forestry, hydrology, engineering and conservation. The work of the Division will be reorganized to give stronger emphasis to a disciplinary approach, and will continue to be conducted in a number of regional centres.

Recommendations for new or expanded research activities that have been accepted are:

- the resources devoted to studies of soil-water management will be strengthened so that the Division can serve as a centre of expertise in the scientific management of saline soils;
- a Soil Engineering Section will be established to cover tillage, erosion, drainage and water conservation on farms;
- the Soil Mechanics Section will be greatly strengthened and work will begin on relating soil mechanics techniques more closely to the physical processes of soils;
- a program of research on soil fertility will be established in collaboration with appropriate CSIRO Divisions.

The Division will continue its work on pedology and micromorphology.

Further opportunities will be explored for collaborative research with universities and appropriate State departments.

Together with the Divisions of Land Use Research and Land Resources Management, the Division of Soils will be relocated from the Institute of Earth Resources to the Institute of Biological Resources on 1 July 1981.

Divisions of Land Use Research and Land Resources Management

As foreshadowed in the 1979/80 annual report, a review of the Divisions of Land Use Research and Land Resources Management was conducted in 1981. The work of the two Divisions is broadly complementary but they are geographically separated, one being located in the east and the other in the west of Australia. A particular purpose of the review was to indicate specific areas in which complementary programs and objectives could be developed for the two Divisions. The Executive decided that a thorough investigation should be made of objectives and priorities for water research and of arrangements for the organization of land and water research in CSIRO before finalizing its consideration of the review committee's report. This investigation will also include an examination of the possibility of building up CSIRO's research effort in Western Australia, particularly research into crops and pastures, soils, forests, and animal production.

Together with the Division of Soils, the Divisions of Land Use Research and Land Resources Management will be transferred in the interim from the Institute of Earth Resources to the Institute of Biological Resources. Since these Divisions conduct research on the better use, management and productivity of land and water ecosystems, they will benefit from direct association with biologically-oriented Divisions. The needs of the proposed Institute of Energy and Earth Resources in relation to environmental research will be considered in the context of the further investigation referred to above.

Dairy Research Laboratory

The Dairy Research Laboratory was reviewed prior to filling the position of Officer-in-Charge. It was determined that the present organizational arrangements for research should be retained, and that the Laboratory should continue to concentrate on longer-term problems of relevance to the dairy manufacturing industry as a whole. Where tactical research is an extension of the usual more basic work, it will be taken to the development stage in collaboration with State research establishments, the Australian Dairy Corporation or industry. However, the Laboratory will reduce its direct involvement in engineering advisory services.

The Dairy Research Laboratory will continue to be a national centre for research on milk used for manufacturing purposes and on milk products, including cheese starters, flavour studies, the physical chemistry of dairy manufacturing processes, and minimizing the impact of factory wastes.

The Laboratory will enhance its relations with other institutions with a view to the joint planning of research and extension programs for the dairy products industry, and will develop further its technology transfer programs.

Division of Wildlife Research

A review was conducted of the Division of Wildlife Research preparatory to recruiting a new Chief. The Executive has determined that the main objective of the Division is to understand the biology of both native and introduced vertebrates in relation to wildlife management and pest control. This entails research on the status and basic biology of species and their interactions with their environments in order to gain information about fundamental principles of animal ecology, behaviour and physiology.

Mechanisms are to be established for planning multidisciplinary research with other Divisions and organizations, including coordination of related research activities in other Divisions.

A report on the balance, emphasis and consequent location of the Division's activities is to be prepared. The report will take account of the role and level of involvement of State and other Commonwealth agencies involved in wildlife research, and those aspects of wildlife research which are of particular national significance, together with the deployment of staff and the need to ensure that certain skills are readily available to the Division.

The Division is responsible for maintaining and fostering the Australian National Wildlife Collection as part of the national heritage. Unless ideal repository conditions become available elsewhere, the Collection will continue to be housed in the Division and suitable facilities will be provided for its maintenance and expansion.

Division of Mechanical Engineering

With the seven-year term appointment of the Chief of this Division due to end in April 1982, a review was commenced in the latter part of 1980. The review included a critical examination of the objectives and programs of the Division, their relevance to national needs and priorities, an assessment of the quality and scientific content of the research, whether optimum use was made of available resources, and scrutiny of the management and internal organization of the Division. Against this background and related activities outside the Division, the review committee provided advice and recommendations to the Executive on CSIRO's work in mechanical and related engineering.

In view of the engineering and technology orientation of many of the programs in the Divisions of Mechanical Engineering, Manufacturing Technology and Building Research, the committee remarked on the problems of reviewing one Division in isolation, and felt that resource allocation on a Divisional basis was no longer the most effective means of utilizing limited resources. There was a need to restructure and redistribute the resources available to the three Divisions in a more efficient and rational way.

The committee concluded that the Division of Mechanical Engineering should concentrate on fewer problems of higher priority, the scientific content of some programs should be enhanced and greater emphasis should be given to collaborative work with other CSIRO Divisions, tertiary education institutions and particularly industry. It noted that the Division's skills were concentrated in the fields of heat, mass and momentum transfer applied to various energy, agricultural engineering and human environmental programs.

At the time the report of the review committee was being assessed, the Executive was also considering a review of its Institute structure, necessitated by a number of internal and external requirements, including the agreement reached on the future of the Australian Atomic Energy Commission Research Establishment, as a result of which CSIRO is to create a new Institute of Energy and Earth Resources as a focus for its energy research activities following transfer of resources from the Commission to CSIRO.

The Executive considered that the energy-related work of the Division should be combined with some of the resources acquired from the Australian Atomic Energy Commission to cover the higher priority area of energy conservation research. The bulk of the Division's resources will therefore be transferred to a new Division of Energy Technology which will come into being on 1 September 1981. Other resources will be used to strengthen the Division of Manufacturing Technology and an investigation will be made of research requirements and opportunities in the field of agricultural engineering.

Wood Science and the Division of Chemical Technology

A review of the Division of Chemical Technology was commissioned in 1980, in advance of the retirement of the Chief of the Division. At about the same time, Professor E.L. Ellwood of North Carolina State University, USA, agreed to conduct a review of wood science in CSIRO. The review of the Division included:

- a critical examination of the Division's objectives and programs and their relevance to national needs and priorities;
- an assessment of the quality and content of the research and the use made of resources allocated to meeting objectives;
- the management and internal organization of the Division;
- advice on any aspect of CSIRO's work in chemical technology and biotechnology.

Professor Ellwood's task was to critically review CSIRO research on the provision and utilization of wood and its products; to advise on the adequacy and effectiveness of research on industry problems; to recommend the management and organizational structure best suited to meet the research needs of industry; and to suggest ways of improving national and international collaboration in wood science.

While commenting on a few details relating to questions of balance in the use of resources in the Division of Chemical Technology, the review committee reported favourably on the overall status of the research. Both the subject and the Divisional review committees noted a decline in CSIRO's capabilities in wood science and technology, and the need to strengthen wood science research to support the Division's work on wood conversion.

Each review recommended an amalgamation of all existing CSIRO research groups working on wood science and technology, most of which were in the Divisions of Chemical Technology and

Building Research. As a result of these recommendations, a Division of Cellulose Research will be formed early in 1982, on the retirement of the Chief of the Division of Chemical Technology.

The committee reviewing the Division of Chemical Technology recommended that resources should be provided to supply the Division with microbiological skills. In responding to this recommendation the Executive also took into account the preliminary work of its subject review on biotechnology. A decision to form an Industrial Microbiology Unit, which will draw on the resources of the Division, was announced as part of the restructuring of Institutes in June 1981. This Unit will be established when a leading microbiologist has been recruited as its Officer-in-Charge.

Research Reviews in Progress

The establishment of committees of review for the following Divisions were reported in the 1979/80 CSIRO Annual Report:

- Animal Production
- Cloud Physics
- Mathematics and Statistics
- Computing Policy and Facilities.

Animal Production

The review of the Division of Animal Production began in October 1980 and the review committee's report was submitted to the Executive in June 1981. The Executive's decisions will be reported in the 1981/82 annual report.

CSIRO contributes about a quarter of the total research manpower for Australia's livestock industries. Its effort covers health, nutrition, reproduction, animal breeding and genetics, and pasture utilization and management. The review committee regarded the Division's research as complementary to that of State Departments of Agriculture and universities, but considered that there should be greater collaboration between CSIRO's own plant and animal Divisions.

The committee recommended that the Division of Animal Production continue to concentrate on the extensive grazing industries, and not divert resources to intensive livestock industries such as pig and poultry farming. Additional resources should be directed to research for the tropical beef cattle industry, and the committee recommended the establishment of a new Divison of Tropical Animal Health and Production to undertake research for this industry.

In the committee's view, the Division of Animal Production has high scientific standards and is effectively managed. However, the amalgamation five years ago of the former Divisions of Animal Physiology and Animal Genetics has yet to achieve the desired collaboration between physiologists and geneticists.

The committee agreed with the Chief's policy of redeploying some resources to more applied research associated with the

Division's discoveries. It considered that the extension/liaison role of the Division could be more effectively developed through closer collaboration with State Departments of Agriculture.

The committee's general conclusion about the Division of Animal Production was that it has the mandate and facilities to carry out medium- to long-term interdisciplinary strategic research for the livestock industries, and should continue with this role. Despite significant progress at the level of understanding processes, major problems remain for the livestock industries, inhibiting their efforts to increase productivity and adjust to declining terms of trade. The Division of Animal Production, in conjunction with other CSIRO Divisions, Departments of Agriculture and the industry, should continue to face this challenge.

Computing Policy and Facilities

A Computing Policy and Facilities Advisory Committee was established in 1979, with CSIRO and external membership, to advise the Executive on CSIRO's role in computing research in Australia. In particular, the Committee was asked to consider:

- the requirements for computing facilities for research, information storage and processing;
- the range of customers to be serviced and the computing services to be provided by CSIRONET (CSIRO's integrated network for scientific computing and data processing);
- the appropriate balance between CSIRO and non-CSIRO users of CSIRONET; and
- how the Executive's need for continuing policy advice on the operations of CSIRONET can be met in future.

The committee reported to the Executive in June 1981, and was asked to re-examine a number of recommendations in the light of developments that had occurred since the report was prepared. A review of the research activities of the Division of Computing Research will also be undertaken within the next year. The outcome of both these examinations will be set out in the 1981/82 annual report.

Water Resources Research

Following the review of the Divisions of Land Use Research and Land Resources Management (see 'Completed Reviews'), the Executive instituted a review of research related to Australia's water resources. The review will examine priorities for water research and appropriate institutional arrangements for coordinating and carrying out recommended research programs within CSIRO. The committee will be chaired by Dr N.K. Boardman, a member of the Executive.

Divisions of Mineral Engineering and Applied Geomechanics

A Committee was appointed to review the Divisions of Mineral Engineering and Applied Geomechanics in advance of the retirement of the then Chief of both Divisions early in 1981. The Organization's contribution to the minerals industry, the community and the national and international objectives of mineral science and engineering will be examined, as well as the following matters:

- CSIRO's ability to anticipate the research requirements of the industry;

- the effectiveness of liaison between CSIRO and the industry, with particular reference to the communication of the results; and
- possible research activities for CSIRO in the fields of mining, mineral processing and extractive metallurgy.

The Review Committee is expected to report at the end of September 1981.

Government Review of Commonwealth Functions

The Government's Review of Commonwealth Functions had a number of implications for CSIRO. One of these was the transfer of resources from the Australian Atomic Energy Commission described above. Others were:

- New procedures would be introduced for the acquisition of computing equipment by the Government. CSIRO has become the major technical adviser to the Government in this matter.
- The Australian Scientific Liaison Offices in London and Washington, which have been CSIRO's responsibility for over 30 years, would be closed. The majority of their functions will cease; however, the overseas missions will assist with aspects of certain essential functions such as recruitment of scientific staff. In the light of these developments, CSIRO's policies relating to its statutory function of acting as a means of liaison between Australia and other countries in matters connected with scientific research is being reassessed.
- CSIRO staff numbers would be reduced and the capital works program scaled down. Construction of buildings for the Divisions of Materials Science and Applied Organic Chemistry, scheduled for commencement in 1981/82, has been postponed.
- The Minister for Science and Technology would place high priority on rationalizing the activities of CSIRO and the Bureau of Meteorology relating to weather and climate. It is expected that the rationalization, involving a clear delineation of the research roles and responsibilities of each organization and means of consultation, will be completed by the end of 1981.

Review of Overseas Scientific Liaison

In mid 1980, the Executive commissioned a review of overseas scientific liaison. As this function is carried out on behalf of the Commonwealth rather than for CSIRO alone, the review committee included external as well as internal members. Notwithstanding the announcement in April 1981 of the Government's decision to abolish the London and Washington Scientific Liaison Offices, the review continued. The committee was expected to report in July 1981 and the outcome will be reflected in the 1981/82 annual report.

6. Organization

On 30 June 1981, CSIRO had a total staff of 7489 people located in 109 laboratories and field stations throughout Australia. About one-third of the staff are professional scientists, with the others providing technical, administrative or other support. An organization chart appears overleaf.

Executive

CSIRO is governed by an Executive comprising three full-time Members, one of whom is Chairman, and five part-time Members. The Chairman is the Chief Executive of the Organization and he is assisted in this role by the other two full-time Members of the Executive. The Executive is primarily concerned with the development of policies relating to the scientific and technical direction of the Organization and its internal management; relationships with Government, advisory bodies and other institutions; the definition of broad areas of research; the securing and distribution of resources to each area; and monitoring the effective performance of the Organization.

The Executive is assisted in defining the broad areas of research in which CSIRO should be working, and in allocating resources to those areas, by the Directors of five research Institutes. An Executive Committee, comprising the full-time Members of the Executive and the Directors, supported by the Secretaries of the other main elements of the Organization meets regularly to consider these and related matters.

The Chairman, in his capacity as Chief Executive, is supported by:

- an Office of the Executive, in respect of broad policy formulation and organizational coordination and development;
- a Finance and Administration Branch, in respect of the CSIRO budget system, works, buildings and property management services, administrative systems development and the Regional Administrative Offices; and
- a Personnel Branch, in respect of personnel, industrial relations and pay and conditions policies.

Institutes, Divisions, Units and Bureau

The research work of the Organization is carried out in five Institutes, each headed by a Director. Institutes are groupings of Divisions and Units with related research interests. The latter are

EXECUTIVE

Chairman
Dr J.P. Wild

Full-time Members
Dr N.K. Boardman
Dr W.J.McG. Tegart

Part-time Members
Professor D.P. Craig
Dr W.L. Hughes
Mr H.M. Morgan
Mr R.K.R. Morris
Mr P.D.A. Wright

Chief Executive
Dr J. P. Wild

Executive Member
Dr N. K. Boardman

Executive Member
Dr W. J. McG. Tegart

INSTITUTE OF ANIMAL AND FOOD SCIENCES

Director
Dr K. A. Ferguson

Divisions and Chiefs

Animal Health
Dr A. K. Lascelles

Animal Production
Dr T. W. Scott

Fisheries
Dr B. D. Stacy (*Acting*)

Food Research
Dr J. H. B. Christian

Human Nutrition
Dr B. S. Hetzel

Units and Officers-in-Charge

Project for Animal Research and Development
Dr R. H. Wharton

Molecular and Cellular Biology
Dr G. W. Grigg

Wheat Research
Mr E. E. Bond

Office of the Executive

Executive Secretary – Mr L.G. Wilson

Finance and Administration
Secretary – Mr H.C. Crozier

Personnel
Secretary – Mr K.J. Thrift

Planning and Evaluation Advisory Unit

Director – Dr D.E. Weiss

Bureau of Scientific Services

Director – Mr S. Lattimore

INSTITUTE OF INDUSTRIAL TECHNOLOGY

Director
Professor Emeritus H. W. Worner

Divisions and Chiefs

Applied Organic Chemistry
Dr D. H. Solomon

Building Research
Dr F. A. Blakey

Chemical Technology
Dr H. G. Higgins

Manufacturing Technology
Mr R. H. Brown

Mechanical Engineering
Dr B. Rawlings

Protein Chemistry
Dr W. G. Crewther

Textile Industry
Dr D. S. Taylor

Textile Physics
Dr A. R. Haly

INSTITUTE OF BIOLOGICAL RESOURCES

Director
Mr M. V. Tracey

Divisions and Chiefs

Entomology
Dr M. J. Whitten

Forest Research
Dr J. J. Landsberg

Horticultural Research
Dr J. V. Possingham

Irrigation Research
Dr D. S. Mitchell (*Acting*)

Land Resources Management
Mr R. A. Perry

Land Use Research
Dr R. J. Millington

Plant Industry
Dr W. J. Peacock

Soils
Dr A. E. Martin

Tropical Crops and Pastures
Dr E. F. Henzell

Wildlife Research
Dr C. H. Tyndale-Biscoe (*Acting*)

INSTITUTE OF PHYSICAL SCIENCES

Director
Dr J. R. Philip

Divisions and Chiefs

Applied Physics
Dr J. J. Lowke

Atmospheric Physics
Dr G. B. Tucker

Chemical Physics
Dr L. T. Chadderton

Cloud Physics
Dr M. J. Manton (*Acting*)

Computing Research
Dr P. J. Claringbold

Environmental Mechanics
Dr D. E. Smiles

Materials Science
Dr J. R. Anderson

Mathematics and Statistics
Dr C. C. Heyde (*Acting*)

Oceanography
Dr A. D. McEwan

Radiophysics
Dr R. H. Frater

Unit and Officer-in-Charge

Australian Numerical Meteorology Research Centre
Dr D. J. Gauntlett

INSTITUTE OF ENERGY AND EARTH RESOURCES

Director
Mr I. E. Newnham

Divisions and Chiefs

Applied Geomechanics
Dr K. G. McCracken (*Acting*)

Energy Chemistry
Dr P. G. Alfredson

Energy Technology
Dr D. C. Gibson (*Acting*)

Fossil Fuels
Prof. A. V. Bradshaw

Mineral Chemistry
Dr D. F. A. Koch

Mineral Engineering
Dr D. F. Kelsall

Mineral Physics
Dr K. G. McCracken

Mineralogy
Mr A. J. Gaskin

Unit and Officer-in-Charge

Physical Technology Unit
Dr E. G. Bendit

Organization Chart

The structure of CSIRO shown in this chart includes changes which will come into effect on 1 September 1981. The Division of Mechanical Engineering will cease to exist on that date.

headed by Chiefs and Officers-in-Charge respectively. Divisions and Units are each responsible for a coherent set of research programs, the Units being responsible for narrower fields of research and having fewer staff than Divisions.

Directors are responsible, in consultation with their Chiefs and Officers-in-Charge, for regularly reviewing the research objectives, programs and priorities within their Institutes. Chiefs and Officers-in-Charge provide scientific leadership and managerial direction in the pursuit of broad goals established by the Executive.

The broad objectives and fields of research of Institutes, Divisions and Units and functions of the Bureau of Scientific Services and the Planning and Evaluation Advisory Unit are set out below.

The Bureau of Scientific Services, headed by a Director, is responsible for facilitating and promoting the transfer and utilization of technology and scientific and technical information.

A Planning and Evaluation Advisory Unit, headed by a Director, assists the Executive in the development of strategies for priority setting and resource allocation.

Objectives, Fields of Research and Functions

The broad objectives and fields of research or functions of the various CSIRO Institutes and their component Divisions and Units, the Bureau of Scientific Services and the Planning and Evaluation Advisory Unit are given in the following pages. Where structural changes are scheduled to occur by 1 September 1981, the information is given as at that date except in the case of the Division of Mechanical Engineering which will cease to exist on that date and where the information is given as at 30 June 1981. A more detailed account of the objectives of current CSIRO research may be found in the publication 'CSIRO Research Programs Directory 1981-82'.

Institute of Animal and Food Sciences

The Institute comprises the following Divisions and Units:

- Division of Animal Health
- Division of Animal Production
- Division of Fisheries Research
- Division of Food Research
- Division of Human Nutrition
- Centre for Animal Research and Development
- Molecular and Cellular Biology Unit
- Wheat Research Unit.

The Institute conducts scientific and technological research aimed at improving the efficiency of livestock production, the management and productivity of Australia's fisheries resources, the conservation of its marine ecosystems, and the quality and safety of human foods; and at obtaining a better understanding of the relationships between human diet and health.

The Institute's activities include research on:

. control of animal diseases;
. nutrition, reproduction, genetics and management of livestock;
. marine ecosystems and the ecology and population dynamics of the ocean's harvestable resources;
. methods of processing, handling and storing meat, fish, dairy foods, fruit, vegetables and grain;
. identification of nutritive imbalances and deficiencies in the diets of Australians and investigation of their effects on human health;
. molecular and cellular biology and its application in the livestock and pharmaceutical industries.

Division of Animal Health

The Division's research, on health aspects of animal production, is directed mainly to problems of the grazing sheep and cattle industries, although some deals with problems of the poultry and pig industries. Most of the work aims at resolving aspects of bacterial, viral, and parasitic diseases of sheep and cattle. More basic studies are directed to assessing the potential of genetic selection for disease control, especially control of internal parasites of sheep and cattle. The Division is also involved in immunological studies aimed at improving vaccines and vaccination procedures.

Division of Animal Production

The Division aims to assist the animal industries by providing new and improved technologies offering significant gains in efficiency of livestock production. Its research is mainly in the fields of nutrition, reproduction, genetics, and livestock management.

Division of Fisheries Research

The Division investigates the ecology of marine populations and applies the knowledge gained to the development of management strategies for harvestable resources such as lobsters, prawns, and fish.

Division of Food Research	The Division's research relates to maintenance of the quality of meat, fish, dairy, fruit and vegetable foods throughout the chain of events from production to consumption. Microbiological safety, nutritional value, flavour and appearance are among the aspects of quality involved. Processing and storage methods are examined with a view not only to improving final quality, but also to avoiding or utilizing wastes and reducing the energy and labour costs of processing and handling.
Division of Human Nutrition	The Division studies nutritional processes with a view to identifying the existence and health consequences of nutritive imbalances and deficiencies in Australian diets. Its research includes experimental studies in developmental biology and in metabolism and digestion, and epidemiological and behavioural studies with emphasis on the relations between nutrition, lifestyle and human health.
Centre for Animal Research and Development	The joint Indonesian-Australian project is conducted by CSIRO on behalf of the Australian Development Assistance Bureau (ADAB). Its general aim is to undertake animal research and development activities designed to find ways to improve the efficiency with which meat and eggs are produced, while taking into account the need to optimize the role of livestock in mixed farming systems.
Molecular and Cellular Biology Unit	The Unit is conducting research in areas of modern biology dealing with the nature, properties and functions of the animal cell and chemical manipulation to modify these properties.
Wheat Research Unit	The Unit's research aims at elucidating the chemical, biochemical and physical factors governing the quality, processing properties and marketability of wheat and wheaten products. Where it is considered relevant, studies, usually in collaboration with other workers, are extended to other cereals, including triticale, barley, rice and oats. Particular emphasis is placed on studies of wheat proteins, quantitative methods for estimating important quality factors, and the chemical structure of wheat gluten. Work is also being conducted on the use of cereal crops as renewable sources of liquid fuel and by-product protein.

Institute of Biological Resources

The Institute comprises the following Divisions:

Division of Entomology
Division of Forest Research
Division of Horticultural Research
Division of Irrigation Research
Division of Land Resources Management
Division of Land Use Research
Division of Plant Industry
Division of Soils
Division of Tropical Crops and Pastures
Division of Wildlife Research

The Institute conducts scientific and technological research aimed at improving the management and productivity of Australia's land, soil, water, agricultural, pastoral and forestry resources, and the management and conservation of Australian ecosystems.

The Institute's activities include research on:

. application of the plant sciences to the management and utilization of crops, pastures, forests and native ecosystems;
. introduction, selection and breeding of plant material as a basis for developing new and improved varieties of crop and pasture plants and forest trees;
. control of insect pests of plants and animals, and of weeds and plant diseases, with particular emphasis on research aimed at reducing dependence on chemical control;
. biology of native and introduced animals in the context of conservation and pest control;
. assessment and management of land, soil and water resources in agricultural, pastoral, forested and near-urban areas.

Division of Entomology

The main aim of the Division is to undertake biological research on insects and related arthropods by acquiring knowledge relevant to the solution of problems of economic and social significance. The research involves the study of the identity, abundance and distribution of insects; and of their behaviour, pathology and genetics. The main activities of the Division are the development of methods of control of arthropod pests by biological, physical and chemical means and by variation of conditions of crop culture, with the aim of integration of these methods into management systems; control of weeds by biological agents; the modification of existing control practices where these have undesirable attributes; and the understanding of the role of insects in the environmental balance. A current specific responsibility of the Division is to maintain and foster the Australian National Insect Collection as part of the national heritage.

Division of Forest Research

The Division's research programs on forest resource characterization, forest management, forest ecology, tree breeding and genetics, and harvesting are designed to supply a scientific basis for the balanced management of Australia's forests in relation to wood production, water supply and ecosystem preservation.

Division of Horticultural Research

The aim of the Division's research is the improvement of woody perennial horticultural crops in Australia. These include a range of grapevines and subtropical and tropical fruit and nut species. Emphasis is placed upon the development of new techniques for the selection and breeding of improved plant types and on understanding the complex interaction between plant performance and the environment.

Division of Irrigation Research

The Division is concerned with improving the productivity of irrigated crops and improving the efficiency of water resource management. Current research is concentrated on soil and root-zone factors which adversely affect crop yields in irrigated, fine-textured soils; efficient use of nitrogenous fertilizers; efficient scheduling of irrigation water; breeding of oilseed crops; development of biologically based methods for treatment of waste-waters; management of aquatic plants; the physics, chemistry and biology of turbid waters; and the development of energy-saving methods for the production of crops in greenhouses for arid or temperate conditions.

Division of Land Resources Management

The overall aim of the Division is to provide a scientific basis for the better management of land and water resources. Its research includes studies on environmental processes and the social and economic aspects of current and alternative resource management in pastoral, agricultural and forested lands.

Division of Land Use Research

The Division has the broad aim of promoting better use of land and water resources in Australia. It provides the Commonwealth, State and local authorities responsible for national and regional land-use decisions with improved methods of gathering, processing and using information on resources. To this end it is engaged in research concerned with resource surveys, resource evaluation for a range of possible uses, techniques for making decisions about the use of resources, and techniques for natural resources management. The research includes investigations aimed at achieving a better understanding of relevant physical, biological and socio-economic processes.

Division of Plant Industry

The Division is concerned with improving agricultural production through research in the plant sciences, including plant breeding and plant introduction, biochemistry and physiology, nutrition, and microbiology, and with developing new and existing crops, pastures and agricultural practices to meet both current and future requirements in Australia. The Division is also a major centre for research on the Australian flora and vegetation, its taxonomy, ecology and management.

Division of Soils

The Division's objectives are to conduct research into soil science, including the physics, chemistry and biology of soils, together with the integrative disciplines of pedology and geomorphology, and to develop the principles for its application in both dryland and irrigated agriculture, forestry, hydrology, engineering and conservation.

Division of Tropical Crops and Pastures

The Division conducts research on field crops and pastures in tropical and subtropical Australia, excluding the arid zone. In pasture research, the emphasis is on beef production. The main aims are to develop new legume-based pastures, and to define the effects of environment and management on their growth and productivity. Some studies are done on the ecology of native grasslands. The Division's irrigated and dryland crop research is mainly concerned with developing grain-legume, fibre and fuel crops that are new to Australian agriculture, and improving the performance of grain sorghum and soybeans at lower latitudes.

Division of Wildlife Research

The main objective of the Division is to understand the biology of vertebrates, both native and introduced, in relation to wildlife management and pest control. The general objects of the research are to study the status and basic biology of species and their interactions with their environments, to provide information about fundamental principles of animal ecology, behaviour and physiology, and to show how this knowledge may be applied to the management of wildlife populations.

Institute of Energy and Earth Resources

The Institute comprises the following Divisions and Units:

- Division of Applied Geomechanics
- Division of Energy Chemistry
- Division of Energy Technology
- Division of Fossil Fuels
- Division of Mineral Chemistry
- Division of Mineral Engineering
- Division of Mineral Physics
- Division of Mineralogy
- Physical Technology Unit.

The Institute conducts scientific and technological research relating to the more effective definition, utilization and management of Australia's energy and earth resources.

The Institute's activities include research on:

- locating, evaluating, defining and characterizing Australia's energy and earth resources; and
- planning their recovery, development and effective use, consistent with the minimization of environmental stresses.

Division of Applied Geomechanics

The aim of the Division's research is the development, from theoretical and practical studies, of methods for the identification and solution of selected mining and related problems.

Division of Energy Chemistry

The Division concentrates on chemical research directed towards the development of energy resources particularly relevant to Australia.

Division of Energy Technology

The Division's engineering research is directed towards the establishment and improvement of the technology required for a balanced utilization of Australia's energy resources.

Division of Fossil Fuels

The Division undertakes research in basic and applied sciences to improve methods of exploring for and characterizing fossil fuels; to achieve a better understanding of the chemical and physical processes that occur during coal conversion and coal combustion; to improve existing processes and develop new ways for treating fossil fuels and certain minerals; and to elucidate and, where possible, ameliorate any adverse environmental consequences resulting from the production, treatment or use of these resources.

Division of Mineral Chemistry

The Division's expertise in physical and inorganic chemistry is used to identify and solve problems in the mineral industry and in areas, such as energy and environmental impact, that are of community or national importance.

Division of Mineral Engineering

The Division conducts theoretical and practical studies aimed at developing methods for improving and controlling industrial processes. Particular emphasis is placed on processes used for the treatment and handling of ores and mineral products.

Division of Mineral Physics	The Division applies fundamental principles of physics, engineering, mathematics and geology to the identification and solution of problems in the mineral industry.
Division of Mineralogy	The Division develops its expertise in the geological sciences—particularly in geochemistry, mineralogy and petrology—with the aim of solving problems encountered, or expected, in exploration for ore bodies and economic minerals.
Physical Technology Unit	The Unit's research is aimed at solving specific problems associated with the recovery and utilization of coals, the processing of minerals, and the transport in inland waters of trace metals arising from mining activities.

Institute of Industrial Technology

The Institute comprises the following Divisions:

Division of Applied Organic Chemistry
Division of Building Research
Division of Chemical Technology
Division of Manufacturing Technology
Division of Mechanical Engineering*
Division of Protein Chemistry
Division of Textile Industry
Division of Textile Physics.

The Institute conducts scientific and technological research and development aimed at increasing the efficiency, competitiveness and scope of Australian secondary and tertiary industries in relation to both national and international markets.

The Institute's activities include research on:

- purification of water and waste-waters;
- industrial microbiology;
- substitute liquid fuels;
- novel processes and products for application in industry and agriculture;
- utilization of forest and other lignocellulose resources;
- building and design of urban communities;
- safety and comfort in both domestic and industrial environments;
- properties and usefulness of wool as a textile fibre;
- new and improved technology in metals manufacturing.

Division of Applied Organic Chemistry

The Division's particular expertise is in organic chemistry, physical chemistry and polymer science. Its activities are directed to the development of alternative sources of energy, to the study of the action of organic chemicals on biological systems in order to synthesize new pesticides and veterinary drugs, and to the design, synthesis and use of specialty plastics materials and structures for use in industry and commerce.

Division of Building Research

The aims of the Division are, through research and development, to increase efficiency and effectiveness in the building and construction sector of the economy and all the industries and disciplines in this sector; to enhance the potential standard of accommodation for all Australians at work, at play and at home; and to minimize any adverse impacts of the construction sector on the environment.

Division of Chemical Technology

The Division is concerned with the application of chemical technology, engineering and biotechnology to the utilization and processing of resources such as forests, residues from forest and agricultural industries, algae, water and waste-waters. Research areas include:

* This Division will cease to exist on 1 September 1981.

wood science; forest conversion engineering; wood preservation; fibre separation and pulping; development of pulpwood resources; cellulose-based composite materials; the use of chemical and biological systems for the production of chemicals and energy, particularly liquid fuels; the development of agro-industrial systems; and technologies for purifying and recycling water.

Division of Manufacturing Technology

The Division's research is directed to the improvement of the manufacture of fabricated components. The main activity is oriented to metal components, but some research relates to other materials. The work includes the study of processes for manufacture, the integration and control of processes through microelectronic devices, and the engineering analysis and synthesis of product design for manufacture.

Division of Mechanical Engineering*

The Division's engineering research is directed mainly towards the development and efficient harnessing of renewable energy resources, particularly solar energy; the efficient use of energy in transportation and in buildings; improvements to thermal and noise conditions in various living and working environments; and increased efficiency in the cultivation, harvesting and preservation of crops and in the harvesting of trees.

Division of Protein Chemistry

Research in the Division is concerned with the structure, chemistry and biological activity of proteins. The knowledge gained and the techniques developed are used to assist industries based on protein products such as wool, leather and seeds. The Division collaborates with other research laboratories, including Divisions of CSIRO, on problems of a biochemical or biophysical nature relating to animal and plant products.

Division of Textile Industry

This Division's main objective is to improve the utilization of Australian wool in the world textile industry. The work includes studying the relation between the properties of fibres and their performance in textile-processing, improving the operations carried out to convert raw wool into a clean fibre ready for mill processing, developing improved techniques and equipment for the manufacture of yarns, fabrics and garments, devising procedures that reduce the environmental impact of textile-processing, and improving the performance of the final product. Some work is also being done on the testing and processing of Australian cotton.

Division of Textile Physics

The principal task in the Division of Textile Physics is research and development for the Australian wool industry; major efforts are directed towards (i) research on the measurement, specification and handling of raw wool to achieve economies in packaging, transport, marketing and processing and (ii) improvements in processing and

* This Division will cease to exist on 1 September 1981.

end-use arising from new techniques and studies of the physical properties of textile fibres, yarns and fabrics. Non-wool work is confined at present to the use of textiles for filtration, especially of industrial particulates from air and flue gases.

Institute of Physical Sciences

The Institute comprises the following Divisions and Units:

Division of Applied Physics
Division of Atmospheric Physics
Division of Chemical Physics
Division of Cloud Physics
Division of Computing Research
Division of Environmental Mechanics
Division of Materials Science
Division of Mathematics and Statistics
Division of Oceanography
Division of Radiophysics
Australian Numerical Meteorology Research Centre.

The Institute conducts scientific and technological research in the physical, chemical and mathematical sciences aimed at meeting the needs of Australian industry and increasing understanding of the physical environment.

The Institute's activities include research on:

- application of the physical sciences to industrial problems;
- maintenance of the national standards of measurement;
- development of scientific and industrial instrument techniques;
- properties of industrial materials and development of improved materials and chemical and physical processes;
- climate, weather and atmospheric transport of pollutants and other entities;
- physics of interactions between soil, water, plants and atmosphere;
- radiophysics and its application to astronomy, navigation and communication;
- the physical and chemical oceanography of the Australian marine environment, including air-sea interaction;
- application of mathematics and statistics to problems in industry and science; and
- development of advanced computer operating systems and the provision of a central computing service.

Division of Applied Physics

The Division undertakes research in applied physics related to problems in industry and the community, and collaborates with industry in exploiting promising developments. An important part of its work is the maintenance of the Australian standards of measurement of physical quantities. The Division conducts research on the properties of materials and on the physics of the sun. It takes part in international scientific activities in cooperation with national laboratories of other countries under the Metric Treaty, and with countries establishing their own standards.

Division of Atmospheric Physics

The Division's principal object is to determine the characteristics of and the processes within the atmosphere and its interactions with land and sea surfaces in order to provide an improved understanding of weather, climate and atmospheric phenomena generally that may provide a scientific basis for better predictions of weather and climate and for more efficient control of pollution.

Division of Chemical Physics

The Division conducts research directed broadly towards the understanding of chemico-physical phenomena, and encompassing spectroscopy, diffraction studies and solid-state investigations. It seeks to exploit the results of this research in solving scientific and technological problems and promoting technological innovation, particularly in the area of scientific instruments and techniques.

Division of Cloud Physics

The objective of the Division is to develop empirical analyses and physically based parameterizations of cloud and precipitation processes that are pertinent to the prediction of weather and climate. Its research is on the generation of cloud, the development of precipitation, the chemical composition of precipitation and the effects of cloud on radiative transfer.

Division of Computing Research

The Division provides advanced scientific and technical computing services for CSIRO Divisions, government departments and some universities through the CSIRONET computing network. This links the central computer in Canberra with smaller computers in all State capitals and other cities in various parts of Australia. To improve the standard of service available, the Division conducts research concerned with the development and application of advanced computer operating systems, picture processing and graphics, simulation languages and simulation techniques, and data-base management systems.

Division of Environmental Mechanics

The Division conducts physical investigations of energy exchange, heat and momentum transfer, and the movement of natural and introduced substances (for example, water, carbon dioxide, salts and fertilizers) in the environment, with special reference to plants, soils and the lower layers of the atmosphere. It applies the results of these investigations to problems in agriculture, ecology, hydrology, meteorology and industrial processes. Investigations of mathematical aspects of ecology and geophysics are also carried out.

Division of Materials Science

The Division studies the properties, behaviour and utilization of industrially important materials based on metals, alloys, refractory oxides and ceramics. Its work covers the development of catalysts for the synthesis and processing of liquid and gaseous fuels, the development of materials of very high strength and resistance to severe environments, and the study and development of various industrial processes.

Division of Mathematics and Statistics

The Division develops and applies high-level mathematical and statistical methods for the support of scientific and technological research in CSIRO and Australia. The Division is concerned with the entire area of applicable mathematics, including statistical and computational methods. Mathematical models and statistical analysis are used to solve problems arising in research in agriculture, biology, the environment, the physical sciences and industry. The Division provides advisory, consultative and collaborative services on mathematical and statistical problems to other Divisions of CSIRO and some outside bodies. Basic research is conducted on problems in probability, statistics, applied mathematics and computational mathematics, the majority of which arise from the scientific and technological projects of CSIRO.

Division of Oceanography

The Division carries out investigations of the physical and chemical structure, processes and dynamics of the Australian coastal and oceanic waters with the aim of describing and predicting currents, meteorological and climatic influences, biological production, and the effects of human activity.

Division of Radiophysics

The Division conducts research in radiophysics and its application to community and industrial problems. In its radio astronomy program, the fields of research include galactic, extra-galactic and solar system astronomy. As progress in these fields requires advanced observing instruments and techniques, substantial effort is devoted to research in radio, electronics and signal processing. In the Division's Applied Research program, promising applications of this expertise to community problems in general are developed in collaboration with industry.

Australian Numerical Meteorology Research Centre

The Centre is a joint unit of CSIRO and the Department of Science and Technology. It develops numerical models and uses these to study the possible causes and nature of natural and man-induced climate changes, and to improve the accuracy and time-extent of weather prediction by the Bureau of Meteorology. The attainment of these objectives involves the modelling of oceanic as well as atmospheric processes, and the interpretation and use in models of new kinds of observational data, including the development of numerical methods in satellite data utilization.

Bureau of Scientific Services

The Bureau aims to facilitate and promote the transfer and utilization of technology and scientific and technical information for the benefit of Australian science, industry and the community at large, and to foster technical development projects with other nations.

The Bureau consists of the following four units:

Central Information, Library and Editorial Section (CILES)
Centre for International Research Cooperation (CIRC)
Commercial Group
Science Communication Unit.

The Bureau's activities include:

- providing scientific and technical information and publishing, library and data-base services for CSIRO and the community;
- communicating information about CSIRO and its research to a variety of audiences, both technical and non-technical, and liaising with industry;
- encouraging the adoption of CSIRO technical know-how, inventions and technology in industry by the use of patents and licences, contracting out research and development, making grants, and arranging technical conferences;
- planning, coordinating and evaluating CSIRO's involvement in technical assistance programs in developing countries; and
- providing advice to the Executive, Institutes and Divisions on matters of policy related to the Bureau's areas of activity.

Central Information, Library and Editorial Section (CILES)

The Section provides scientific and technical information, library, and publishing services for CSIRO and, where practicable, makes information services available to the wider Australian scientific and technical community, to industry, and to the public. It also participates in a range of activities related to information services in Australia and overseas, and seeks to increase awareness of the importance of scientific and technical information resources and, coincidentally, to assist in the development of an information industry in Australia. An important part of its functions is the development of new computer methods for applications in its areas of activity.

Centre for International Research Cooperation (CIRC)

CIRC is responsible for coordinating the Organization's activities in relation to international science and technology agreements, and formal arrangements with overseas research institutions and the United Nations and other international agencies. It is also responsible for coordinating the Organization's efforts to assist developing countries, for evaluating and implementing project proposals, and for training scientists from developing countries.

Commercial Group

The Group provides specialist advice and administrative assistance within CSIRO on commercial matters relating to patents, know-how, trade marks and other industrial property rights; licences, collaborative R&D and secrecy agreements; and joint ventures and the use of CSIRO's corporate powers.

It is responsible for the administration of the Organization's industrial property portfolio, including the payment of fees to attorneys and others, the provision of regular status reports to the Executive and the Minister, and the maintenance of complete records, and for advising on proposed agreements for the sale, licensing or exchange of CSIRO technology.

The Group also administers the Executive's Central Development Funds, which are allocated by the Committee of Directors for the support of short-term development projects with strong commercial prospects.

Science Communication Unit

The Unit facilitates the communication of information about CSIRO and its research, and of any other scientific and technical information considered appropriate, to a variety of audiences, both technical and non-technical, using such means as publications, films, conferences and displays; provides assistance in a range of cooperative communication projects; and evaluates the effectiveness of communication programs.

Planning and Evaluation Advisory Unit

A Planning and Evaluation Advisory Unit, headed by a Director, assists the Executive in the development of strategies, in priority setting and in the allocation of resources.

The functions of the Unit are to:

- provide advice to the Executive, based on analyses of scientific, economic and social data from both within and outside CSIRO, which will assist the Executive in the discharge of its strategic planning responsibilities;
- provide specialist input to committees of review;
- advise the Executive, Institute Directors and Chiefs on planning, review and evaluation methodology;
- undertake special studies in industrial and economic areas as required by the Executive for strategic planning purposes; and
- advise the Executive on trends in research planning in other countries.

7. Consultative Council and personnel policies

Consultative Council

The Science and Industry Research Amendment Act 1978 provided for the establishment of a Consultative Council 'to consider, and to report to the Executive on, any matter affecting, or of general interest to, the officers of the Organization, including any such matter that is referred to the Council by the Executive'.

The Council comprises a Chairman who is a full-time Member of the Executive, and seven other members, all appointed by the Executive; two representatives of the CSIRO Officers Association; two representatives of the CSIRO Technical Association; one representative of the Administrative and Clerical Officers' Association; one representative of the Australian Public Service Association (Fourth Division Officers); one representative of the CSIRO Laboratory Craftsmen Association; and one representative of other registered organizations whose members include officers of CSIRO.

The Consultative Council's third meeting was held in Canberra on 8 October 1980. Miss C.E. Popham, President of the CSIRO Technical Association, was appointed as Deputy Chairman of the Council following Mr B.G. Cook's retirement from the position. The Council's fourth meeting was held in Brisbane on 15 April 1981.

Much of the work of the Council has been undertaken by its sub-committees. During 1980/81, the sub-committee on Staff Counselling completed its work, submitting its final report to the Council in October 1980. Following recommendations from the Council, the Executive adopted guidelines on staff counselling aimed at enhancing opportunities for communication between staff and their supervisors regarding job satisfaction, career expectations and career development. Special seminars are being held on the objectives of staff counselling, and training in counselling skills is available to supervisors and others involved in counselling.

The Executive also agreed to introduce on a trial basis a personal counselling service to help staff cope with personal problems that affect work performance.

It is expected that the sub-committees on Flexible Working Hours and Technological Change will complete their work in 1981/82. Investigations undertaken by sub-committees on the Employment of Women and on Remote Localities are progressing satisfactorily.

A new sub-committee was formed at the April 1981 meeting to make recommendations on a suitable amenities code for CSIRO. The sub-committee will examine codes and legislation applying to other organizations to determine which aspects of these may be relevant to CSIRO.

Apart from the work of its sub-committees, the Council has considered other items of interest and concern to the officers of the Organization including:

- the impact of staff ceiling and financial restraints on staffing patterns;
- the provision of facilities on CSIRO sites for staff association representatives;
- disciplinary and grievance procedures;
- representation of officers undertaking classification appeals;
- the development of classification guidelines;
- methods of salary payment.

Personnel Policies

Three selected areas of personnel management where there have recently been notable changes in practices are reported on briefly in this section.

Recruitment

The average annual turnover rate for CSIRO staff as a whole is about 17 per cent, the lowest turnover being among research staff, who have a rate of six per cent. These percentages include the turnover of staff who are appointed for short terms to work on research programs funded for defined periods by industrial and other bodies.

The Executive is conscious of the danger of the Organization losing valuable skills and knowledge if turnover reaches too high a level. At the same time, the introduction of new ideas and perspectives into CSIRO has become more important than ever in the present climate of rapid change in programs and priorities. The Executive encourages turnover in appropriate staff categories, particularly by the use of fixed-term appointments (see CSIRO Annual Report 1978/79).

The actual numbers of scientific, technical and trades staff recruited during 1980/81 are shown in the table.

Table 5

Recruitment of scientific, technical and trades staff during 1980/81

Staff group	Number recruited	Recruits as a percentage of total staff in group
Research Scientists	83	5.9
Experimental Officers	136	11.2
Other professional staff	33	12.8
Technical/drafting staff	385	17.5
Trades staff	68	15.2

The classification profile of CSIRO staff has changed recently, the trend being towards a higher proportion of research scientists and experimental officers and a lower proportion of technical, trades and other support staff categories. While there are a number of reasons underlying this trend, which are currently being examined, it is clear that it is due in part to changing technology which has allowed a number of relatively routine analytical, design, construction and other tasks to be carried out automatically. In addition, CSIRO is now receiving an increased amount and range of technical assistance from industry; for example, in gathering data on plant operation and production processes.

In order to recruit the best people it can, CSIRO advertises research scientist positions both nationally and internationally. Other professional positions are advertised nationally, while support positions are advertised on a regional basis. To extend career opportunities and to encourage redeployment of existing CSIRO staff, all positions advertised outside CSIRO are also advertised internally.

Almost half of the research staff appointed to CSIRO are recruited from within Australia. Of those research staff appointed from overseas, about half are Australians who have been studying at an overseas university for a higher degree or who have been gaining post-doctoral experience at an overseas research institution. CSIRO's continuing success depends largely upon the calibre of its research staff. For this reason it has always been the Organization's policy to recruit the highest quality research staff available. As CSIRO undertakes research in a large and diverse range of scientific fields it is often necessary to recruit from the international research community so that this high calibre in all fields can be maintained.

Most professional, technical and trades positions are normally advertised over two adjacent classifications within a designation, for example Research Scientist/Senior Research Scientist. This is because suitability for appointment is to some extent independent of the amount of experience an applicant has had, and depends more on his or her precise research interests and expertise. Appointment levels within the two classifications advertised depend on an assessment of the qualifications, skills, knowledge and achievements of the appointee.

Flexibility is a quality that is highly valued in CSIRO, particularly in the light of the need in recent times for a relatively high level of redeployment and reorientation of staff's interests. The Organization therefore seeks to appoint officers who may eventually progress from their initial work areas to others not necessarily directly associated with their original academic background. Another quality frequently sought in appointees is the ability to apply their academic training to relevant industrial problems.

Although there are generally few areas in which CSIRO has marked difficulty in recruiting professional staff, it currently has a problem recruiting research and professional staff with backgrounds in engineering and geology. Marked difficulties in recruitment or retention of staff in these areas have serious implications for CSIRO since they are central to many of CSIRO's new initiatives (for example, in support of manufacturing industry) and to much important ongoing work. The Executive is examining ways of overcoming these difficulties.

The Executive is also concerned with difficulties in recruiting tradesmen. CSIRO needs experienced craftsmen who are skilled in their particular trade and can demonstrate versatility in related trades areas and an appreciation of the research programs with which they are associated.

In general, tradesmen in industry have enjoyed a salary margin over CSIRO tradesmen which has led to recruitment difficulties for CSIRO. Moreover, the skills acquired by tradesmen while working in CSIRO workshops and laboratories increase their market value. This has resulted in a high turnover of young craftsmen, with a consequent effect on the age distribution of trades staff. Almost half of CSIRO's trade staff are now within 10 years of their likely retirement age.

Promotion Policy

The Executive has long been committed to the provision of adequate rewards for creativity, resourcefulness, initiative and the other qualities which so often underlie successful scientific research. The merit promotion system applying to the majority of CSIRO staff is central to the reward of achievements and performance based on these qualities.

It is possible for research, and other professional, technical and support staff directly engaged in research programs to be promoted solely on the basis of their achievements and performance, without moving out of their specialized research fields, without waiting for positions to become vacant at more senior levels, and without taking on management responsibilities. This allows virtually immediate reward and, probably more importantly, discourages the tendency encountered with other promotion systems for the better performers to abandon their areas of specialization and expertise in order to obtain promotion.

Continuous review of how successfully and how reliably this merit system is operating is essential if it is to continue to motivate staff and to reward those qualities which are central to furthering CSIRO's research. As a result of such review, significant changes have recently taken place in the administration of the promotion system. A significant change has been an increase in the amount of information that is available to individual employees about promotion standards and their own performance and promotion prospects. In addition, considerable progress has been made in documenting promotion criteria more fully, and the Organization's staff counselling procedures are being upgraded and expanded. The provision of more complete information to staff has also been aided by the move, described in detail in last year's annual report, towards proposed promotions being examined and resolved closer to the workface.

Employees who believe that their classification does not adequately reflect their achievements and performance can lodge a classification appeal with the Executive. Procedures for handling classifications appeals have also been improved over the past few years, the normal procedure nowadays being the establishment of an independent classification appeal committee to investigate and report on the appeal.

The promotion system applying to some of the support staff categories that are not directly associated with research differs from that described above in that it is based on classification of positions rather than employees. This applies to clerical/administrative, clerical assistant and similar support designations. Here, promotion takes place mainly through a process in which officers compete for vacant positions bearing a higher classification than that presently held by the individual concerned.

This latter system, like the merit promotion system applying to staff in research teams, is more appropriate to the staff categories to which it applies. It encourages mobility and the acquisition of skills in a wide range of fields, so that staff who reach the more senior levels have a broad knowledge of CSIRO administrative policies and procedures. This is particularly important in many administrative roles, particularly those in Divisions where administrative staff are expected to relieve the Divisional Chiefs of involvement in day-to-day administrative matters.

However, this positional classification system does not replace promotion by merit with promotion by seniority. Demonstrated on-the-job performance is equally the basis for promotion in this system as it is in the merit promotion system. Appeals mechanisms exist which ensure that the best applicant is chosen for each position. These take into account the extent and nature of each applicant's experience and qualifications.

CSIRO Studentships

The Science and Industry Research Amendment Act 1978 introduced a requirement that CSIRO studentships should be confined to research consistent with CSIRO's functions under section 9(a). This amendment followed a recommendation of the Independent Inquiry into CSIRO, accepted by the Government in 1978. The recommendation endorsed the Executive's existing policy requiring postdoctoral studentships to be relevant to research being carried out by CSIRO.

A review of studentship policy was carried out in 1980, with the aim of strengthening ties between research under CSIRO studentships and CSIRO's own research. The review also took account of the studentship scheme's role in promoting interaction between CSIRO and Australian universities, as well as the fundamental question of the role of CSIRO postdoctoral studentships in the development of Australia's scientific and technological manpower.

The major outcome of the review was the replacement of CSIRO's long-standing postdoctoral studentships of one year's duration by a smaller number of awards of two years' duration. The new postdoctoral awards were offered for the first time in 1981.

The first year of an award is tenable in institutions where outstanding opportunities exist for pursuing the research projects concerned, either in Australia or overseas. To ensure a direct benefit to CSIRO, the second year of the award is tenable only in a CSIRO Division or in a university, industry or government department in Australia, for work on an approved joint research project with CSIRO. Requirements for prior consultation with senior CSIRO staff further ensure that proposals for the two year period are in areas relevant to the Organization's research obligations.

The postdoctoral award scheme is administered through a selection committee comprising senior CSIRO and university staff. Approximately 10 awards are made each year.

Apart from the CSIRO postdoctoral award scheme, individual Institutes of CSIRO may fund postgraduate and postdoctoral awards in areas where they are experiencing, or are likely to experience, recruitment difficulties.

8. Staff changes and events

Senior Appointments and Retirements

Mr D.J. Rochford retired as Chief of the Division of Fisheries and Oceanography in September 1980. The Division was subsequently divided into two Divisions, the Division of Fisheries Research and the Division of Oceanography. Dr B.D. Stacy was appointed Acting Chief of the Division of Fisheries Research and Dr A.D. McEwan commenced duty as Chief of the Division of Oceanography for a period of seven years from March 1981.

Mr I.E. Newnham resumed his duties as Director, Institute of Earth Resources, on 23 October 1980 after an eight-month secondment to the Uranium Enrichment Group of Australia, where he served as Director of the Working Committee. Dr R.J. Millington, who had been Acting Director during this period, resumed his position as Chief of the Division of Land Use Research.

Dr M.F.C. Day retired as Chief of the Division of Forest Research in December 1980 and Mr A.G.J. Brown was appointed Acting Chief until May 1981. In June 1981 Dr J.J. Landsberg took up the appointment of Chief of the Division for a term of seven years.

The Division of Process Technology and the Fuel Geoscience Unit were merged to form a new Division of Fossil Fuels from 1 January 1981. Professor A.V. Bradshaw, formerly Chief of the Division of Process Technology, was appointed Chief of the new Division.

Dr P.E. Kriedemann, Chief of the Division of Irrigation Research, was granted one year's leave of absence, to undertake personal research, from 2 March 1981. Dr D.S. Mitchell was appointed Acting Chief of the Division during this period.

Dr H.J. Frith retired as Chief of the Division of Wildlife Research in April 1981. Dr C.H. Tyndale-Biscoe was appointed Acting Chief of the Division.

Mr J. Warner retired as Chief of the Division of Cloud Physics in June 1981. Dr E.K. Bigg will be Acting Chief of the Division from July to August 1981, and Dr M.J. Manton will be Acting Chief of the Division from August 1981.

Mr H.C. Minnett retired in June 1981 as Chief of the Division of Radiophysics. Dr R.H. Frater was appointed Chief of the Division for a period of seven years.

Dr J.M. Gani has resigned from the position of Chief of the Division of Mathematics and Statistics. Dr C.C. Heyde will be Acting Chief of the Division from July 1981.

Dr D.F. Kelsall will relinquish the position of Chief of the Division of Applied Geomechanics from 20 July 1981. Dr K.G. McCracken, Chief of the Division of Mineral Physics, will be

Acting Chief of the Division of Applied Geomechanics from that date. Dr Kelsall remains Chief of the Division of Mineral Engineering.

Mr R.H. Brown was appointed Chief of the Division of Manufacturing Technology for a period of seven years from August 1980.

Dr D.F. Waterhouse is to retire as Chief of the Division of Entomology in August 1981. Dr M.H. Whitten will succeed him as Chief of the Division for a period of seven years from September 1981.

Dr B. Rawlings, Chief of the Division of Mechanical Engineering until 1 September 1981, has been assigned to undertake an investigation for the Executive of agricultural engineering research needs and opportunities.

Mr K.T. Smith succeeded Mr I.C. Bogg as Deputy Secretary (Finance and Administration) on 14 May 1981. Mr Bogg was granted three years' leave of absence from 30 March 1981 to enable him to take up an appointment with the International Civil Aviation Organization.

Calendar of Events

During the reporting year, CSIRO was concerned with a wide range of community, industry and international matters which often engaged the attention of Executive members and senior staff. Major items with long-term policy implications are dealt with elsewhere in this report. The following events have been selected as examples of other developments within the Organization.

July 1980

- Dr W.J.McG. Tegart addressed members of the Automotive Industry Advisory Council on the need for the industry and CSIRO to devise mechanisms for interacting with each other.
- An interim injunction by the High Court of Australia was brought against CSIRO restraining it from proceeding with biological control work against the plant *Echium plantagineum* (known as Paterson's Curse or Salvation Jane).
- Executive members visited Divisions in Canberra and attended a seminar on alternative liquid fuels.
- Dr N.K. Boardman visited the United States for discussions on research priorities and the possibility of staff exchanges between CSIRO and the US Department of Agriculture. He also visited the United Kingdom for discussions with the Agricultural Research Council and led an Australian delegation to the Jubilee Review Conference of the Commonwealth Agricultural Bureaux.
- New slaughter facilities at the Meat Research Laboratory, Cannon Hill, Qld, were opened by the Hon. David Thomson, MC MP, the Minister for Science and the Environment. The

facilities will assist in the development of new techniques and equipment for the meat processing industry.

August 1980

- A data bank providing information on renewable energy was established. Known as the Commonwealth Regional Renewable Energy Resources Information System (CRRERIS), it is managed by CSIRO and financed by the Department of National Development and Energy.
- Professor Paul Berg, Willson Professor of Biochemistry at Stanford University Medical Centre, California, delivered the Ninth David Rivett Memorial Lecture. His subject was 'Molecular Cloning of Genetic Elements: Implications for Basic Medical Research'.
- Dr J.R. Philip addressed members of the Electronics Industry Advisory Council on the need for devising ways in which the electronics industry and CSIRO might cooperate with each other.

September 1980

- Dr J.P. Wild visited the United Kingdom to attend a meeting of the Anglo-Australian Telescope Board in his capacity as Deputy Chairman of the Board, and to represent Australia.
- Executive members visited Divisions in Melbourne and attended a seminar on the maintenance of soil fertility.
- Dr N.K. Boardman visited Greece to give a plenary address at the 5th International Congress on Photosynthesis.

October 1980

- Two open days, known as 'Sirosearch 80', were held at the Division of Irrigation Research, Griffith, NSW. The aim was to inform the agricultural community of the work of the Institute of Biological Resources.
- Mr L.G. Wilson, as Chairman of the Australian National Commission for UNESCO, took part in that body's 21st General Conference in Belgrade.

November 1980

- Dr N.K. Boardman, Mr M.V. Tracey and Mr S. Lattimore were members of the Australian delegation which visited Japan to discuss a science and technology agreement with that country. Dr Boardman also visited South Korea to discuss the question of scientific and technical cooperation between South Korea and CSIRO.
- Dr J.P. Wild opened a Melbourne laboratory at Monash University for the Division of Applied Physics, which has its headquarters in Sydney. The new laboratory enables the Division to provide high-precision calibration and measurement services to manufacturing industry in Victoria.
- Dr W.J.McG. Tegart visited Brazil to investigate areas for future collaboration between CSIRO and Brazilian research institutes. He also visited Mexico for discussions at the National Autonomous University and at the agency responsible for solar energy and water desalination.

- The 1980-81 edition of 'CSIRO Research Programs' was published, providing a comprehensive guide to the Organization's research activities. The directory was made available for sale and was also distributed to selected institutions, including major public libraries.
- Dr J.P. Wild attended the Royal Society's Anniversary Meeting in London, at which he was presented with the Royal Medal.

December 1980

- A three-day residential symposium in Canberra, attended by staff from 30 Divisions and a range of external speakers, focused on the effectiveness of CSIRO's communication activities. Published proceedings are available.
- Executive members inspected research facilities at Culgoora, Parkes and Siding Springs, NSW, and also attended a seminar on astronomy at Parkes.

February 1981

- Two CSIRO research scientists assisted in appraising a multi-million-dollar proposal for the establishment of a silicon wafer fabrication plant in Canberra.
- An agreement on cooperation between the National Library of Australia and CSIRO was announced. The agreement formalized a framework of cooperation to facilitate the efficient collection and dissemination of scientific and technological information.
- Executive members visited Divisions in Sydney and attended a seminar on using physics in the 1980s.
- Siromath, a consultancy for tackling high-level mathematical and statistical problems, was launched in Sydney. Siromath represents the first involvement of CSIRO in the establishment of a private company.
- CSIRO was asked to comment on a suggestion that an agricultural research institute should be established in Australia to undertake priority research for third world countries. The Chairman was later invited to discuss the matter with the Prime Minister and advised that existing research facilities should be used as far as possible.
- A library and seminar complex at the Molecular and Cellular Biology Unit, Sydney, was opened.

March 1981

- CSIRO agreed to become involved in the formation of a Computer Research Board to fund research projects in computer science and engineering. Other funding bodies would be the Department of Defence, Telecom Australia and the Overseas Telecommunications Commission.
- Representatives of the Australian Chemical Industry Council and CSIRO met to discuss interaction between the two bodies. It was agreed that a joint working group should be established to examine forward research planning, especially in relation to chemical feedstocks.

April 1981

- Executive members, other senior staff and members of the Advisory Council visited CSIRO laboratories in Rockhampton, Townsville and Atherton, Qld, and discussed the Organization's activities in northern Queensland with staff and community leaders.
- A one-day seminar for 200 senior industry managers and research directors was held in Melbourne to help improve interaction between CSIRO and manufacturing industry.
- The Tropical Cattle Research Centre at Rockhampton, Qld, was officially opened by the Rt Hon. Mr J.D. Anthony, MP, Deputy Prime Minister. The $5.5M centre will foster research into the breeding and raising of tropical cattle.
- Sir Victor Burley, who retired as Chairman of the CSIRO Advisory Council, was asked to undertake a study aimed at increasing industry liaison and the exchange of staff between the Organization and industry.

May 1981

- A document entitled 'CSIRO Energy Research: Planning and Policy' was produced, describing CSIRO's energy research activities.
- The Executive appointed an Internal Audit Advisory Committee to advise on the Organization's internal auditing requirements and its Internal Audit Charter. This complements moves to adopt systems-based auditing within CSIRO.
- The Chairman received the report of a survey on rehabilitation engineering resources in Australia which was carried out by the National Advisory Council for the Handicapped. CSIRO is in touch with rehabilitation engineering professionals, and is encouraging Divisions to take the needs of the disabled into account when planning research projects.
- CSIRO speakers participated at the 51st ANZAAS Congress, which was held in Brisbane. The Organization also assisted with media relations at the Congress.

June 1981

- CSIRO hosted a seminar in Canberra to foster improved interaction and understanding between senior government staff and industrialists from Australia's high-technology companies. The seminar was sponsored by the Australian Scientific Industry Association.
- Executive members visited the Divisions of Land Use Research, Land Resources Management, and Soils and also attended a seminar on Australia's water resources.
- The commercial company Bioclone Pty Ltd was formed to work in collaboration with CSIRO's Molecular and Cellular Biology Unit and the Garran Institute of Medical Research. The purpose of the company is to provide Australian medicine with cheaper and more specific diagnostic material.

9. Capital works

Buildings

The allocation of resources in 1980/81 to CSIRO for the construction of works and buildings, repairs and maintenance, and the acquisition of land and buildings enabled the Organization to implement progressively a planned and consistent approach to overcoming its backlog of building, maintenance and acquisition requirements.

In particular, support was approved in the 1980/81 civil works program for the construction of the Crop Adaptation Laboratory ($2.9M) and the Materials Science Laboratory ($8.85M). It is anticipated that work on the Materials Science Laboratory will commence in 1982/83. Good progress continued on projects already under construction, details of which are provided at the end of this chapter.

The provision of resources for the maintenance of the Organization's building assets and plant ($5.2M) in 1980/81 was still insufficient to enable the adoption of an economical approach to regular and preventive maintenance that will adequately cover the Organization's needs.

A breakdown of expenditure during 1980/81 indicates that the Department of Housing and Construction spent $49 573 982 on the construction of works and buildings for CSIRO and on maintenance of existing facilities. Of this amount, $35 075 215 was spent on the Australian National Animal Health Laboratory at Geelong, Vic. The Department of Administrative Services spent $215 377 on the acquisition of land and buildings for CSIRO.

Details of progress with major buildings are given below.

Tropical Cattle Research Centre

The laboratories and animal accommodation of the Tropical Cattle Research Centre at Rockhampton, Qld, were opened in April 1981 by the Deputy Prime Minister, the Rt Hon. J.D. Anthony, MP.

The laboratories, animal accommodation and associated site works cost approximately $5.5M. They are in close proximity to the National Cattle Breeding Station, Belmont. The Centre is one of few research facilities which have the combination of breeding farm and laboratories for simultaneous studies of animal physiology, biochemistry, immunology, genetics and nutrition.

Meat Processing and Research Facility (Experimental Animal Slaughter Facility)

The Minister for Science and the Environment, the Hon. David Thomson, MC MP, opened the Meat Processing and Research Facility for the Division of Food Research's Meat Research Laboratory at Cannon Hill, Qld, during July 1980.

The new facility consists of animal holding yards, a slaughtering and dressing area, a follow-on processing area and auxiliary rooms such as chillers and freezers.

The total cost of the project was approximately $800 000. Funds were contributed jointly by the Commonwealth and the meat processing industry through the Australian Meat Research Committee. CSIRO is using the facility to carry out research on improving meatworks technology and increasing the value of by-products.

Australian National Animal Health Laboratory

Satisfactory progress has continued to be made with the construction of the Australian National Animal Health Laboratory (ANAHL) at Geelong, Vic. Actual expenditure in 1980/81 was $35.075M. At current prices the laboratory is estimated to cost $118M.

The project was 54 per cent complete at 30 June 1981. The main building complex had reached roof level with finishing and fit-out operations following at lower levels. Commissioning procedures for the major plant items in the Engineering Services Complex will commence in the latter part of 1981. The administration/scientific support building has also reached roof level and is expected to be complete by January 1982.

The CSIRO Project Team's activities with respect to design and documentation are tapering off. The fit out, commissioning and setting to work phases of the project are now the major focus of attention of the group in its liaison with the Department of Housing and Construction.

Chemical Technology

The Chemical Technology laboratories have been under construction at Clayton, Vic., since July 1980 and are now 40 per cent complete. The project which, at current prices, is estimated to cost $11.4M, is expected to be completed by August 1982.

The recent announcement by the Minister for Science and Technology concerning the formation of a new Division of Cellulose Research and an Industrial Microbiology Unit using the resources of the present Division of Chemical Technology will not change the need for, or the utilization of, the Clayton facility once completed.

Materials Science and Applied Organic Chemistry

In May 1980 Parliament approved the recommendation of the Parliamentary Standing Committee on Public Works that the construction of new laboratories at Clayton for the Divisions of Materials Science and Applied Organic Chemistry should proceed at an estimated cost of $19M. However, as a result of the Review of Commonwealth Functions, funds will not be provided during 1981/82 to allow any construction to commence on the two laboratory complexes. Funding for these two projects is to be considered in the context of formulating the 1982/83 Budget.

Crop Adaptation

The Plant Industry Crop Adaptation Laboratory, costing approximately $2.8M, was commenced early in 1981. Expenditure incurred in the project during 1980/81 was less than expected because of industrial disruption affecting the building industry in the ACT.

On its present schedule it is envisaged that construction of the laboratory will be completed early in 1983.

CSIRO Marine Laboratories	During May 1981 the Parliamentary Standing Committee on Public Works heard evidence from CSIRO and the Departments of Administrative Services and Housing and Construction concerning site selection and the construction at an estimated cost of $10.75M of a marine laboratories complex for the CSIRO Divisions of Oceanography and Fisheries Research at Hobart. It is expected that the hearing of evidence will be completed in early 1981/82 and the Committee's report will be tabled in the House of Representatives during the spring session of Parliament. If approved, it is expected that construction of the new complex on a waterfront site in Hobart will commence in mid/late 1982 and will take two years to complete. Projects costing more than $250 000 which were *completed* during 1980/81 are listed below, with their authorized costs.
Institute of Animal and Food Sciences	**Animal Production**, Rockhampton, Qld—beef cattle laboratory—$5 472 856 **Food Research**, Cannon Hill, Qld—construction of experimental animal slaughter facility—$779 835
Institute of Biological Resources	**Entomology**, Black Mountain, ACT—erection of accommodation for Australian National Insect Collection—$984 787 **Tropical Crops and Pastures**, Kimberley Research Station, WA—construction of block of six 1-bedroom flats—$272 800 **Tropical Crops and Pastures**, Kimberley Research Station, WA—construction of grain handling building—$258 125 **Tropical Crops and Pastures**, Samford, Qld—construction of grass crossing houses—$476 313 **Wildlife Research**, Gungahlin, ACT—construction of biology laboratory and research support building—$923 998
Institute of Earth Resources	**Minerals Research Laboratories**, North Ryde, NSW—construction of rock magnetism laboratory—$747 782 **Minerals Research Laboratories**, North Ryde, NSW—expansion and upgrading of building 24 for energy test rigs program—$981 836 **Land Use Research**, Black Mountain, ACT—construction of joiners', vehicle and instrument workshop—$562 450
Institute of Industrial Technology	**Mechanical Engineering**, Highett, Vic—construction of research support building—$724 227 **Manufacturing Technology**, Woodville North, SA—alterations to building 3—$426 883
Institute of Physical Sciences	**Computing Research**, Black Mountain, ACT—new computer hall—$943 165
Other	**Site Services**, Black Mountain, ACT—construction of site boiler house and reticulation of services—$701 727 **Site Services**, Black Mountain, ACT—construction of site services workshop—$252 005

Projects costing more than $40 000 which were *committed* during 1980/81 are listed below, with their program authorization.

Institute of Animal and Food Sciences

Animal Health, Glebe, NSW—construction of fire isolation measures in laboratory buildings—$70 000
Molecular and Cellular Biology Unit, North Ryde, NSW—alterations to laboratories and associated services in building 12—$795 519

Institute of Biological Resources

Plant Industry, Black Mountain, ACT—erection of crop adaptation laboratory—$2 771 049
Entomology, Black Mountain, ACT—erection of high security quarantine insectary—$815 658
Wildlife Research, Gungahlin, ACT—erection of animal house—$999 740
Plant Industry, Black Mountain, ACT—erection of glasshouse services building and potting shed (stage 2)—$179 960

Institute of Earth Resources

Minerals Research Laboratories, North Ryde, NSW —erection of general purpose laboratory 2—$1 636 082

Institute of Industrial Technology

Manufacturing Technology, Woodville North, SA—alterations to building 2—$686 702

Institute of Physical Sciences

Clayton Site, Vic—extension to David Rivett Laboratory library—$284 297

Other

Black Mountain, ACT—conversion of oil fired equipment to natural gas (stage 1)—$102 215

Other Facilities

Government approval for the construction of an oceanographic research vessel was reported in last year's annual report and tenders have been called worldwide. This is part of an expanded program of oceanography which is discussed further in Chapter 2.

CSIRO proposed the construction of a synthesis radio telescope as a major initiative for the 1980/81 financial year. Funding was not made available in that year and it is planned that a redeveloped proposal be included with CSIRO's 1982/83 new initiative proposals to be submitted for consideration by the Government.

The proposed Australian Synthesis Telescope (AST) is a new generation radio telescope which would provide Australia with a front-line research tool into the 1990s and 2000s for fundamental studies of the Universe. It consists of an array of antennae, some of which are mounted on movable carriages, together with very high-powered computing equipment. The effectiveness of an antenna depends on its diameter. With an array of antennae of approximately 20m diameter, and by changing the relative distances between the antennae, it is possible to 'synthesize' an image of part of the sky. This picture has the same accuracy as that obtained by a simple antenna whose diameter is equal to the length of the array, namely 6km. This is a hundred times the diameter of the Parkes radio telescope and so provides one hundred times the linear detail.

The proposal for the AST comes from the AST Steering Committee, which includes members from all the major Australian astronomical research groups. In its 1979 report 'The Next Generation of Australian Telescopes', ASTEC recommended that 'the Australian Synthesis Telescope (AST) be given the first priority among telescope proposals and that construction be authorized'.

10. Finance

In 1980/81 CSIRO's expenditure from all sources of funds directly available to the Organization totalled $210.9 million and represented an increase of 15% over the 1979/80 level. Approximately 85% ($178 594 000) of the Organization's income was provided directly by the Commonwealth Government. This is consistent with the Government's decision following the recommendation of the Independent Inquiry into CSIRO that CSIRO should continue to be financed, in the main, by a specific Government vote, and that research of general interest to the Commonwealth Government should be funded, as far as possible, through the budgetary appropriation to CSIRO.

The staffing levels of CSIRO's existing programs decreased slightly as a result of a further reduction in the Organization's approved staff ceilings for existing Appropriation-funded research programs. However, the Government provided additional staff ceiling cover to CSIRO to accommodate the expansion of the Government's energy research, development and demonstration program through grants administered by the Department of National Development and Energy.

The table on the following page summarizes the source of CSIRO's funds for 1980/81 and the categories of expenditure.

Expenditure from CSIRO's direct Appropriation and revenue in 1980/81 amounted to $184 922 914, an increase of $22 099 639 (13%) over the 1979/80 period. Of this sum, $5 400 000 was provided to meet increased costs associated with the provision of laboratory equipment, supplies and services. This represented a 10% increase over 1979/80 operating funds and gave CSIRO some respite from the effects of inflation. However, as funding over previous years had not kept pace with inflation, it was still necessary for the Organization to seek out economies wherever possible in order to maintain its existing level of research activities. A further $16 239 000 was provided to meet inescapable salary increases.

The Organization received additional Appropriation Funds to assist the Department of Primary Industry in its role of monitoring and managing the resources of the Australian Fishing Zone, and for increased costs associated with the planning and development of the Australian National Animal Health Laboratory. The Commonwealth Government and the Wool Research Trust Fund provided additional funds for the purchase of fodder for CSIRO flocks and herds in areas of eastern Australia affected by prolonged drought conditions.

The remaining 12% of CSIRO's expenditure ($25 995 688) was from contributions for specific research projects directed to particular industry problems. Specific research projects are an important complement to CSIRO's strategic research but are not undertaken in isolation. Projects funded from external sources are, in general, linked to Appropriation-funded 'core' programs of strategic research. Investigations supported by external funds enable CSIRO scientists to gain first-hand knowledge of problems experienced in industry. Moreover, CSIRO has a clear obligation to assist in promoting innovation in Australia, based on the results of

TABLE 6

Source of funds	Salaries and general running expenses ($)	Contributions to Research Associations and other contributions ($)	Capital works and services and major items of equipment ($)	Total ($)
Appropriation including revenue	178 748 538	1 582 967	4 591 409	184 922 914
Wool Research Trust Fund	7 448 029	–	670 676	8 118 705
Meat Research Trust Account	3 290 796	–	63 082	3 353 878
Wheat Research Trust Account	507 403	–	–	507 403
Dairying Research Trust Account	326 098	–	–	326 098
Fishing Industry Research Trust Account	147 638	–	–	147 638
Oilseeds Research Trust Account	90 472	–	–	90 472
Dried Fruits Research Trust Account	32 099	–	–	32 099
Poultry Industry Trust Fund	62 679	–	7 420	70 099
Chicken Meat Research Trust Account	62 527	–	7 477	70 004
Pig Industry Research Trust Account	30 452	–	122	30 574
NERDDC–Coal Research Trust Account	1 686 524	–	–	1 686 524
NERDDC–Appropriation Fund	1 140 054	–	–	1 140 054
Rural Credits Development Fund	232 729	–	–	232 729
Other contributors	9 894 785	–	294 626	10 189 411
Total	**203 700 823**	**1 582 967**	**5 634 812**	**210 918 602**

its own work. Collaborative investigations with industry are often a most effective way of achieving this.

Approximately half of the funds provided for specific research were contributed by Rural Industry Research Funds, derived from statutory levies on producers and from Commonwealth Government contributions. The balance of funding was provided through grants from the National Energy Research, Development and Demonstration Council (NERDDC), the Reserve Bank's Rural Credits Development Fund, and other contributors.

CSIRO's expenditure from funds provided for specific research in 1980/81 represented an increase of 26% over the 1979/80 level.

AUDITOR-GENERAL'S OFFICE

Canberra House, Marcus Clarke St.,
Canberra City, A.C.T. 2601
P.O. Box 707 – Telephone 48 4711
Telegrams 'Comaudit'
Telex 61653 Comaud

6 October 1981

The Honourable the Minister for
Science and Technology
Parliament House
CANBERRA ACT 2600

Dear Sir

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

In compliance with sub-section 57(3) of the Science and Industry Research Act 1949, financial statements of the Commonwealth Scientific and Industrial Research Organization for the year ended 30 June 1981 have been submitted for my report. These comprise:

Summary of Receipts and Payments
Consolidated Statement of Payments
Statement of Payments – General Research Account
Statement of Payments – Specific Research Account

A copy of the statements, which are in the form approved by the Minister for Finance under sub-section 57(1) (a) of the Act, is attached.

I now report in accordance with sub-section 57(3) of the Act that the statements are in agreement with the accounts and records of the Organization and in my opinion –

- the statements are based on proper accounts and records; and
- the receipt, expenditure and investment of moneys, and the acquisition and disposal of assets, by the Organization during the year have been in accordance with the Act except that moneys were expended from the General Research Account prior to formal Ministerial approval of the estimates of expenditure on 7 July 1980 under sub-section 49(2) of the Act.

Yours faithfully,

(SGD) D. J. HILL

D. J. HILL
ACTING AUDITOR-GENERAL

Summary of Receipts and Payments

(Figures in brackets refer to 1979/80 financial year)

	Funds held 1 July 1980 ($)	Receipts ($)	Total funds available ($)	Payments ($)	Funds held 30 June 1981 ($)
General Research Account	1 202 892 (1 551 342)	184 668 488* (162 474 825)	185 871 380 (164 026 167)	184 922 914 (162 823 275)	948 466 (1 202 892)
Specific Research Account	4 861 409 (4 421 447)	25 699 203 (20 995 864)	30 560 612 (25 417 311)	25 995 688 (20 555 902)	4 564 924 (4 861 409)
Other Trust Moneys**	88 046 (250 244)	2 726 086 (2 030 218)	2 814 132 (2 280 462)	2 598 112 (2 192 416)	216 020 (88 046)
Total	**6 152 347** (6 223 033)	**213 093 777** (185 500 907)	**219 246 124** (191 723 940)	**213 516 714+** (185 571 593)	**5 729 410†** (6 152 347)

* See Note 2
** See Note 3
\+ See Note 4
† See Note 5

J. P. Wild *(Chairman)*

R. Nairn *(Assistant Secretary, Management Services)*

Consolidated Statement of Payments

1979/80 ($)		1980/81 ($)
	Headquarters (including Regional Administrative Offices)	
6 974 242	Salaries and allowances	7 466 473
359 791	Travelling and subsistence	447 621
585 080	Postage, telegrams and telephone	642 614
2 259 702	Incidental and other expenditure	2 863 905
135 803	Advisory Council	186 368
20 589	State Committees	50 487
10 335 207		11 657 468
	Research Programs	
	Institute of Animal and Food Sciences	
137 735	Institute Headquarters	178 965
6 942 190	Animal Health	7 973 769
8 684 504	Animal Production	10 142 320
2 438 952	Centre for Animal Research and Development, Indonesia	2 400 648
7 495 653	Food Research	8 474 947
2 058 685	Human Nutrition	2 223 782
1 347 578	Molecular and Cellular Biology	1 531 565
402 661	Wheat Research	468 852
29 507 958		33 394 848
	Institute of Biological Resources	
158 509	Institute Headquarters	208 991
8 137 328	Entomology	9 307 339
7 743 792	Fisheries and Oceanography	8 747 555
4 830 940	Forest Research	5 410 102
1 692 615	Horticultural Research	2 010 342
1 600 876	Irrigation Research	1 825 908
8 524 964	Plant Industry	10 006 542
6 492 755	Tropical Crops and Pastures	7 311 719
3 036 021	Wildlife Research	3 586 092
42 217 800		48 414 590
	Institute of Earth Resources	
145 814	Institute Headquarters	183 822
2 751 131	Applied Geomechanics	3 173 662
3 960 815	Land Resources Management	4 781 057
3 493 588	Land Use Research	3 939 572
13 865 548	Mining, Minerals and Energy	16 995 098
525 471	Physical Technology	567 833
4 648 326	Soils	5 348 361
29 390 693		34 989 405

1979/80 ($)		1980/81 ($)
	Institute of Industrial Technology	
150 569	Institute Headquarters	200 190
3 155 284	Applied Organic Chemistry	3 271 911
5 552 778	Building Research	6 190 310
3 014 220	Chemical Technology	3 453 899
- *	Manufacturing Technology	2 059 168
2 480 056	Mechanical Engineering	2 940 763
3 181 096	Protein Chemistry	3 650 360
4 381 085	Textile Industry	5 016 539
2 570 328	Textile Physics	3 008 632
24 485 416		29 791 772
	Institute of Physical Sciences	
127 432	Institute Headquarters	223 152
8 987 079	Applied Physics	10 049 338
2 325 681	Atmospheric Physics	2 790 135
450 354	Australian Numerical Meteorology Research Centre	561 519
2 750 926	Chemical Physics	3 184 139
1 735 625	Cloud Physics	2 012 659
3 529 350	Computing Research	4 291 428
671 040	Environmental Mechanics	839 596
3 953 333	Materials Science	2 356 741
2 681 979	Mathematics and Statistics	3 106 246
4 700 353	Radiophysics	5 384 953
31 913 152		34 799 906
	Bureau of Scientific Services	
142 309	Bureau Headquarters	222 988
3 811 796	Central Information, Library and Editorial Section	4 409 092
230 557	Centre for International Research Cooperation	286 628
1 291 170	Commercial Group	1 550 521
1 031 413	Science Communication Unit	1 274 963
6 507 245		7 744 192
2 762 237	Miscellaneous	2 908 642
166 784 501	Total Research Programs	192 043 355
	Contributions	
778 428	Research Associations	877 400
604 856	Other Contributions	705 567
1 383 284		1 582 967

* In 1979/80 expenditure for Manufacturing Technology was integrated with Materials Science (Institute of Physical Sciences)

1979/80 ($)		1980/81 ($)
	Capital Works and Services	
	Buildings, works, plant and developmental	
1 589 485	expenditure	1 140 701
3 286 700	Major items of laboratory equipment	4 449 277
-	Construction of research vessel	44 834
4 876 185		5 634 812
	Other Trust Moneys	
	Remittance of revenue from investigations	
474 524	financed from Industry Trust Accounts	334 376
1 717 892	Other miscellaneous remittances	2 263 736
2 192 416		2 598 112
185 571 593	Total Expenditure	**213 516 714**

J. P. Wild *(Chairman)*

R. Nairn *(Assistant Secretary, Management Services)*

Statement of Payments—General Research Account

1979/80 ($)		1980/81 ($)
	Headquarters (including Regional Administrative Offices)	
6 973 911	Salaries and allowances	7 466 473
355 457	Travelling and subsistence	446 478
585 080	Postage, telegrams and telephone	642 614
2 259 626	Incidental and other expenditure	2 863 905
135 803	Advisory Council	186 368
20 589	State Committees	50 487
10 330 466		11 656 325
	Research Programs	
	Institute of Animal and Food Sciences	
137 735	Institute Headquarters	175 441
6 280 037	Animal Health	7 092 060
6 170 840	Animal Production	6 919 972
6 139 023	Food Research	6 865 785
2 040 822	Human Nutrition	2 189 099
1 346 019	Molecular and Cellular Biology	1 519 624
229 473	Wheat Research	233 796
22 343 949		24 995 777
	Institute of Biological Resources	
158 509	Institute Headquarters	208 991
6 414 624	Entomology	7 101 015
7 540 418	Fisheries and Oceanography	8 368 159
4 743 988	Forest Research	5 305 687
1 640 313	Horticultural Research	1 941 835
1 515 572	Irrigation Research	1 685 168
8 161 706	Plant Industry	9 424 098
5 878 253	Tropical Crops and Pastures	6 673 229
2 810 254	Wildlife Research	3 274 293
38 863 637		43 982 475
	Institute of Earth Resources	
140 777	Institute Headquarters	182 965
1 709 390	Applied Geomechanics	1 919 931
3 848 839	Land Resources Management	4 550 255
3 015 248	Land Use Research	3 467 689
11 923 632	Mining, Minerals and Energy	13 846 855
522 471	Physical Technology	539 363
4 477 596	Soils	5 040 479
25 637 953		29 547 537

1979/80 ($)		1980/81 ($)
	Institute of Industrial Technology	
150 569	Institute Headquarters	200 190
2 866 060	Applied Organic Chemistry	3 073 095
5 417 006	Building Research	6 045 486
2 722 276	Chemical Technology	3 123 079
- *	Manufacturing Technology	2 029 987
2 127 413	Mechanical Engineering	2 357 297
3 175 922	Protein Chemistry	3 649 228
1 982 553	Textile Industry	2 098 676
1 653 284	Textile Physics	1 829 529
20 095 083		24 406 567
	Institute of Physical Sciences	
127 432	Institute Headquarters	223 152
8 987 079	Applied Physics	9 966 566
2 267 360	Atmospheric Physics	2 642 075
434 806	Australian Numerical Meteorology Research Centre	532 006
2 750 926	Chemical Physics	3 181 180
1 688 663	Cloud Physics	1 861 895
3 478 645	Computing Research	4 050 083
668 761	Environmental Mechanics	834 196
3 751 431	Materials Science	2 264 536
2 673 822	Mathematics and Statistics	3 079 434
4 439 772	Radiophysics	5 115 780
31 268 697		33 750 903
	Bureau of Scientific Services	
142 309	Bureau Headquarters	222 988
3 765 242	Central Information, Library and Editorial Section	4 268 410
219 424	Centre for International Research Cooperation	269 167
1 290 544	Commercial Group	1 550 521
985 400	Science Communication Unit	1 196 483
6 402 919		7 507 569
2 750 634	Miscellaneous	2 901 385
147 362 872	Total Research Programs	167 092 213
	Contributions	
778 428	Research Associations	877 400
604 856	Other Contributions	705 567
1 383 284		1 582 967

* In 1979/80 expenditure for Manufacturing Technology was integrated with Materials Science (Institute of Physical Sciences)

1979/80 ($)		1980/81 ($)
	Capital Works and Services	
922 654	Buildings, works, plant and developmental expenditure	904 896
2 823 999	Major items of laboratory equipment	3 641 679
-	Construction of research vessel	44 834
3 746 653		4 591 409
162 823 275	**Total Expenditure**	**184 922 914**

J. P. Wild *(Chairman)*

R. Nairn *(Assistant Secretary, Management Services)*

Statement of Payments—Specific Research Account

1979/80 ($)		1980/81 ($)
	Headquarters (including Regional Administrative Offices)	
331	Salaries and allowances	-
4 334	Travelling and subsistence	1 143
76	Incidental and other expenditure	-
4 741		1 143
	Research Programs	
	Institute of Animal and Food Sciences	
	Institute Headquarters	3 524
662 153	Animal Health	881 709
2 513 664	Animal Production	3 222 348
2 438 952	Centre for Animal Research and Development, Indonesia	2 400 648
1 356 630	Food Research	1 609 162
17 863	Human Nutrition	34 683
1 559	Molecular and Cellular Biology	11 941
173 188	Wheat Research	235 056
7 164 009		8 399 071
	Institute of Biological Resources	
1 722 704	Entomology	2 206 324
203 374	Fisheries and Oceanography	379 396
86 952	Forest Research	104 415
52 302	Horticultural Research	68 507
85 304	Irrigation Research	140 740
363 258	Plant Industry	582 444
614 502	Tropical Crops and Pastures	638 490
225 767	Wildlife Research	311 799
3 354 163		4 432 115
	Institute of Earth Resources	
5 037	Institute Headquarters	857
1 041 741	Applied Geomechanics	1 253 731
111 976	Land Resources Management	230 802
478 340	Land Use Research	471 883
1 941 916	Mining, Minerals and Energy	3 148 243
3 000	Physical Technology	28 470
170 730	Soils	307 882
3 752 740		5 441 868

1979/80 ($)		1980/81 ($)
	Institute of Industrial Technology	
289 224	Applied Organic Chemistry	198 816
135 772	Building Research	144 824
291 944	Chemical Technology	330 820
- *	Manufacturing Technology	29 181
352 643	Mechanical Engineering	583 466
5 174	Protein Chemistry	1 132
2 398 532	Textile Industry	2 917 863
917 044	Textile Physics	1 179 103
4 390 333		5 385 205
	Institute of Physical Sciences	
-	Applied Physics	82 772
58 321	Atmospheric Physics	148 060
15 548	Australian Numerical Meteorology Research Centre	29 513
-	Chemical Physics	2 959
46 962	Cloud Physics	150 764
50 705	Computing Research	241 345
2 279	Environmental Mechanics	5 400
201 902	Materials Science	92 205
8 157	Mathematics and Statistics	26 812
260 581	Radiophysics	269 173
644 455		1 049 003
	Bureau of Scientific Services	
46 554	Central Information, Library and Editorial Section	140 682
11 133	Centre for International Research Cooperation	17 461
626	Commercial Group	-
46 013	Science Communication Unit	78 480
104 326		236 623
11 603	Miscellaneous	7 257
19 421 629	Total Research Programs	24 951 142
	Capital Works and Services	
666 831	Buildings, works, plant and developmental expenditure	235 805
462 701	Major items of laboratory equipment	807 598
1 129 532		1 043 403
20 555 902	**Total Expenditure**	**25 995 688**

J. P. Wild *(Chairman)* R. Nairn *(Assistant Secretary, Management Services)*

* In 1979/80 expenditure for Manufacturing Technology was integrated with Materials Science (Institute of Physical Sciences)

Notes to and forming part of the Accounts for the Year ended 30 June 1981

1. CSIRO's operations are funded principally from Parliamentary Appropriations. Accordingly its main accounts are kept on a cash basis, that is, no account is taken of accruals and only the amounts received and spent in a financial year are brought to account.

2. Receipts to the General Research Account comprise:

	1979/80 ($)	1980/81 ($)
Appropriation–Consolidated Revenue Fund		
Operational	154 000 000	174 594 000
Capital	3 100 000	4 000 000
	157 100 000	178 594 000
Revenue and other Receipts		
General Operations		
Sale of publications	414 756	444 756
Receipts in respect of expenditure in former years	365 531	386 763
Sale of produce, including livestock	485 257	380 319
Royalties from patents	90 902	150 217
Fees for tests and other services	287 918	223 446
Interest on investments	264 123	150 781
Miscellaneous receipts	246 651	297 074
	2 155 138	2 033 356
CSIRONET Operations		
Computing service charges	3 219 687	4 025 268
Receipts in respect of expenditure in former years	- *	14 278 *
Miscellaneous receipts	- *	1 586 *
	3 219 687	4 041 132
	5 374 825	6 074 488
	162 474 825	184 668 488

* Included under General Operations receipts prior to 1980/81.

3. Other Trust Moneys Account is the repository for moneys held temporarily on behalf of other organizations and individuals.

4. Total expenditure comprises:

	1979/80 ($)	1980/81 ($)
Salaries	121 272 104	142 383 507
Travel	6 149 328	7 290 974
Equipment	12 575 421	12 518 775
Maintenance	40 670 456	45 662 686
Capital	4 904 284	5 660 772
	185 571 593	213 516 714

5. Funds held at 30 June 1981 included investments totalling $2 158 200. The comparative figure at 30 June 1980 was $5 162 200.

6. Receipts and payments relating to the provision of CSIRONET computer services are as follows:

	1979/80 ($)	1980/81 ($)
Receipts		
CSIRO users	2 721 324	3 416 175
Other users	3 219 687	4 025 268
Receipts in respect of expenditure in former years	-	14 278
Miscellaneous receipts	-	1 586
	5 941 011	7 457 307

	1979/80 ($)	1980/81 ($)
Payments		
Operational expenditure	6 199 968	7 466 258
Capital expenditure	721 860	636 617
	6 921 828	8 102 875

7. In addition to moneys expended directly by CSIRO, the undermentioned Departments incurred expenditure from Parliamentary Appropriations for CSIRO purposes.

	1979/80 ($)	1980/81 ($)
Department of Housing and Construction		
Repairs and maintenance	4 220 889	4 851 476
Buildings and works	33 386 849	44 722 507
	37 607 738	49 573 983
Department of Administrative Services		
Acquisition of sites and buildings	417 300	215 377

8. During 1980/81 CSIRO joined with Knight Actuaries Pty Limited and The Australian Mineral Development Laboratories in the establishment of Siromath Pty Limited, a Company registered in the State of Victoria, for the purposes of providing a high level mathematical and statistical consultancy organization to industry, commerce, governments, educational institutions and other persons. CSIRO is represented on the Board of Directors and the Management Committee of the Company.

On 30 June 1981 CSIRO exercised its option to purchase a one-third shareholding in Siromath Pty Limited. CSIRO will purchase a $1 share in the Company and make an initial contribution of $17 000 to the working capital of the Company thereby equalling the individual shareholding and financial contribution of the other two parties. An amount of $16 480.83 which is owed to CSIRO for services rendered to Siromath Pty Limited will be retained by the Company as part of CSIRO's contribution to the working capital.

J. P. Wild *(Chairman)* R. Nairn *(Assistant Secretary, Management Services)*

Advisory Council and State Committees

This section has been included by agreement with the Council. Although the Council and the six State Committees have no statutory obligation to report generally on their activities, the Science and Industry Research Act 1949 now requires the Organization to publish advice provided by the CSIRO Advisory Council during the reporting year together with comments by the Executive on that advice.

11. Advisory Council and State Committees-advice and activities

The Advisory Council and most of the State Committees have operated in their reconstituted forms for two years. In the year under review, the Council has met four times and each State Committee at least the same number of times. The names of current members of these bodies and their affiliations are set out in Appendix II. The changes in membership that occurred during the year are reported on later in this chapter.

Advisory Council

The function of the Advisory Council is to furnish advice to the Executive on:

- the objectives that should be pursued by the Organization and the priorities to be followed to achieve those objectives;
- industrial or economic matters that may be of importance in formulating those objectives;
- the identification of the interests of the Australian community that may be furthered by the Organization; and
- any other matter that is referred to it by the Executive for advice.

The Science and Industry Research Act 1949 now requires that advice received from the Advisory Council by the Executive be reported in the Organization's annual report, together with comments on that advice by the Executive. Advice from the Council on two matters, and comments on the advice by the Executive, appear later in this chapter.

During the year, Council has further developed its working procedures and also its arrangements for interaction with the Executive and with CSIRO planning and review procedures.

Council has established the following four standing committees to cover the main sectors of CSIRO's work:

- Mineral, Energy and Water Resources
- Rural Industries
- Manufacturing Industries
- Environment, Renewable Natural Resources and Public Health.

Each committee has met on a number of occasions during the year. The Mineral, Energy and Water Resources and the Manufacturing Industries Committees have prepared advice on energy R&D and manufacturing R&D respectively, and Council has transmitted this formally to the Executive. This advice is presented later in this chapter.

The Rural Industries Standing Committee has been closely involved with CSIRO's Planning and Evaluation Advisory Unit in developing long-term plans for agricultural research. It has also consulted State Committees and other bodies on a number of specific rural research issues and has thus been able to offer informal advice to CSIRO.

The Environment, Renewable Natural Resources and Public Health, and Rural Industries Standing Committees have considered the reports of the reviews of the Divisions of Land Use Research, Land Resources Management, Soils and Wildlife Research and a report by the Western Australian State Committee on new land use options for the south-west of Western Australia. Comments on these have been transmitted to the Executive.

In addition to the areas of interaction between Council and CSIRO mentioned already, Council members have attended Executive Seminars and the opening of the meat research facility at Cannon Hill in Brisbane, and visited the Rockhampton Laboratories. Mr A. Boden, Chairman of the New South Wales State Committee, and Mr J.E. Kolm, Chairman of the Victorian State Committee, have continued as members of the Organization's Manufacturing Industry Committee.

Changes in Membership

Sir Victor Burley retired from the Advisory Council at the end of his term as Chairman on 31 January 1981. Sir Victor was the first Chairman of the reconstituted Council. His association with CSIRO dates from his appointment to the Tasmanian State Committee in 1959. Sir Peter Derham, who was formerly Managing Director of the Nylex Corporation Ltd, was appointed a member of the Council with effect from 28 August 1980. He succeeded Sir Victor as Chairman on 1 February 1981.

Mr K.E. Gibson retired from the Chairmanship of the Queensland State Committee and thus as a member of Council on 15 September 1980. Mr E.P.S. Roberts was appointed Acting Chairman.

The terms of appointment of Mr J.C. Kerin, MP, and Senator A.M. Thomas expired with the termination of the 31st Parliament. Mr B.O. Jones, MP, the Federal Labor spokesman on Science and Technology, replaced Mr Kerin on the Council. Senator Thomas was reappointed.

Mr L.P. Duthie, Secretary, Department of Primary Industry, was appointed with effect from 7 July 1980.

Dr V.A. Brown, Lecturer, Centre for Adult Teaching, School of Education, Canberra College of Advanced Education, was appointed with effect from 9 September 1980.

Mr J.H. Garrett, Deputy Secretary, Department of Finance, who retired in February, was replaced as an observer on the Council by Mr I. Castles, Secretary of the Department.

R&D for Manufacturing Industry

At its meeting in May 1981, Council considered the report of its Standing Committee on Manufacturing Industries. Council's subsequent advice to the Executive on R&D for manufacturing industry (the high priority recommendations are marked *), and the

Executive's response to this advice were as follows:
In relation to R&D for Australian manufacturing industry it is recommended that the Executive adopt, or give greater emphasis to, the following policies:

**1.* *Declare and monitor a policy of selective concentration of CSIRO's resources towards fewer projects. These projects should be selected not only on grounds of scientific and economic merit (as at present), but also on the prospects they offer Australian industry of profitable implementation within a time-scale compatible with industry's resources and need to compete.*

The recommendation is accepted. The principle of selective concentration has been adopted by the Executive for application to CSIRO's research activities generally. The Executive recognizes the need for the time-scales of CSIRO's activities to be compatible with those of industry, and will ensure that this factor continues to be taken into account in the selection of projects.

**2.* *Reiterate its willingness to consider exclusive and confidential R&D cooperation with individual companies operating in Australia on large projects of economic importance, on the basis of equitable and flexible commercial arrangements. Such pooling of resources—scientific, technical, economic and marketing—should be sought whenever it is the strategy most likely to lead to profitable implementation by Australian industry within a time-scale acceptable to industry.*

The recommendation is accepted. Exclusive and confidential cooperation often affords the best means of realizing benefits to the nation as a whole in particular fields of research, and such cooperation will continue to be actively sought in appropriate cases. Except in those few cases where it would defeat the objective of a collaborative project, the Executive will ensure that all Australian firms likely to be interested are given equal opportunities to participate.

**3.* *State and implement a policy of selective research cooperation with innovative small companies which demonstrate the capability to develop Australian, particularly CSIRO, inventions. The objective should be to encourage the growth of new industries without undue concern about preferential treatment between companies.*

The recommendation is accepted, subject to preferential treatment being offered by the Executive to the most appropriate Australian firm, irrespective of size, where this affords the best prospects for bringing research results into the market place. The Executive recognizes both the particular difficulties faced by innovative small firms and the special contribution that such firms can make to the competitiveness of the Australian manufacturing sector. Where such a *firm is selected for a collaborative project, the Executive will continue to ensure that the firm receives adequate support in the form of access to CSIRO know-how and expertise.*

4. Give similar encouragement to CSIRO staff who are prepared to take entrepreneurial risks with the development of CSIRO inventions not taken up by industry.

The recommendation is accepted, subject to the application of the principles applying to Commonwealth employment generally, including the code of conduct relating to private interest and public duty adopted by the Commonwealth Government in 1979. In special cases the Executive will continue to grant leave of absence without pay to officers for limited periods for the purpose of developing a CSIRO invention not otherwise taken up by industry. Officers entering into such arrangements would normally be granted the same benefits of collaboration as would be available to other small, innovative Australian firms.

**5. Seek increased collaboration on projects originating in industry wherever the economic significance of a project justifies it, and publicize its intention to do so.*

The recommendation is accepted, subject to the assumption by the Executive that this recommendation is directed towards projects of national significance. In determining the extent to which CSIRO can undertake collaborative and contract research to assist individual firms on their own projects, the following points must be taken into account:

- *whether CSIRO has unique skills or expertise to contribute, or whether there are private sector contract research laboratories that could undertake the work equally well;*
- *whether there are distinct national benefits associated with such collaboration that would not be realized without CSIRO involvement;*
- *whether the performance of such collaborative research would inhibit CSIRO in the performance of its main role; and*
- *where the economic significance of the project and other factors indicate that CSIRO should enter into a collaborative arrangement, the extent to which commercial charging rates should be reduced because of anticipated widespread benefits.*

**6. Reinforce its efforts at all levels to stimulate industry to define worthwhile research objectives for joint evaluation and selection.*

The recommendation is accepted. Strong industry involvement will continue to be an objective of new research planning procedures being developed by CSIRO.

7. Provide an expanded account to the Council and, through the CSIRO annual report, to the public, of the Organization's commitment to joint projects with industry. Clearly, some Divisions have a greater opportunity than others to enter into joint projects. In these Divisions, at least, the level of resources allocated to such projects should be monitored by the Executive.

The recommendation is accepted. The Organization records in its annual reports and in its publication, CSIRO Research Programs, *the collaborative arrangements on individual programs and sub-programs. Attention will continue to be given to the best means of promoting, monitoring and reporting on the extent of formal collaborative arrangements with industry and drawing attention to the Executive's policy on collaboration. The differing opportunities for Divisions to enter into joint projects noted in the recommendation is recognized and taken into account by the Executive.*

8. Give increased emphasis to techno-commercial aspects in project evaluation and selection procedures. A forceful patent policy should be encouraged in order to maximize the financial and social return to Australia from the joint projects envisaged and to increase Australia's technological self-reliance. Since in modern technologies it will often be a practical necessity for Australian R&D to build on imported know-how, patent and research policies should be designed to facilitate technology transfer and, at the same time, to carve out a significant share of these technologies for Australian industry.

The recommendation is accepted, subject to the following: The Executive recognizes the importance of techno-commercial inputs to project evaluation and selection but these need to be kept in perspective with other criteria; also the Executive supports the effective use of patenting and licensing policies to promote Australia's social, financial and technological objectives and considers its current policies on these matters to be effective. These policies and the Executive policies on CSIRO's research role were set out in the Organization's annual report for 1978/79. The importance of 'imported' technology to the overall level of Australia's manufacturing capability is recognized, and attention will continue to be given to the question of how CSIRO's policies can take proper account of the effects of imported technology.

9. Encourage research associations to identify research objectives in the most research-sensitive sectors, and to facilitate technology transfer.

The recommendation is accepted. The Commonwealth Government has recently announced an enhanced program for the promotion and support of research associations. CSIRO will continue to be represented on the boards of management of these associations and will *continue to encourage technology transfer and the identification of research objectives by these associations.*

10. Develop mechanisms, using its power to form associations with industry if necessary, to provide 'in-house' research support for infant enterprises which develop CSIRO inventions, e.g. by seconding staff from CSIRO.

The recommendation is accepted. The Executive will continue to explore this mechanism to promote the commercial development of CSIRO inventions.

11. Ensure that the terms of reference of committees reviewing appropriate CSIRO Divisions specifically include an examination of the practical achievements of the Division.

The recommendation is accepted. Committees reviewing CSIRO Divisions are asked to assess the quality of the Division's research and its progress towards objectives within each research program, and to comment on the degree of success achieved in transferring the results obtained to potential users.

12. Aim at achieving a more even balance between rewards for practical application and scientific achievement in the administration of personnel and management policies affecting resource allocation and promotion.

*The Executive is shortly to consider proposed promotion criteria to be promulgated to all staff, and will examine this recommendation in the context of its overall criteria. Similarly, note will be taken of the recommendation in the continuing management of the Organization's resources. (*Other aspects of CSIRO's current promotion policy are discussed in Chapter 7.*)*

13. Encourage mobility of staff between Divisions, and between CSIRO and other bodies. Such mobility should be seen to be valued by the Organization.

The recommendation is accepted. The Executive's management policies are consistent with this recommendation.

Energy R&D

At its meeting in May 1981, Council considered the report of its Standing Committee on Mineral, Energy and Water Resources. Council's subsequent advice to the Executive on energy R&D and the Executive's response to this advice is set out below.

Council made the following general comment:

Council recognized that during a period of static (or declining) real resources, any action by the CSIRO Executive to strengthen particular research programs will, of necessity, require it to make difficult decisions about the redeployment of existing *staff and funds, and that this process will be slow and potentially disruptive. Acceptance of redeployment in the energy research area will be assisted by the recognition that the so-called energy 'crisis' is as much an opportunity for Australian research and development as a problem, because of the variety and richness of our natural energy resources. Consequently, not all energy problems need to be tackled in this country with equal vigour, and certain lines of research can be given special emphasis. With greater program selectivity and enhanced forward planning CSIRO can maximize these opportunities for the development of new Australian industries.*

The Executive accepts the two main themes of the Council's general comment, namely that current and foreseeable energy problems represent major opportunities for many Australian industries, and that greater CSIRO program selectivity, guided by forward research planning, is highly desirable.

Council's advice, which is intended to assist the Executive in its review of the CSIRO Energy Research and Development Program, and the Executive's response to this advice were as follows:
1. That the overall level of activity in energy R&D by CSIRO should certainly be maintained, and, if possible, increased, perhaps by internal redeployment of resources.

The recommendation is accepted. The total resources being devoted to energy research in CSIRO are being significantly increased (see Chapter 3).

2. That the CSIRO energy R&D program be consistent with the Government's energy policy objectives as set out in the Government statement tabled in the House of Representatives in November 1977.

The recommendation is noted. The Executive will ensure that consistency with the Government's energy policies is maintained.

3. That the Executive should promote throughout the Organization a policy of selectivity and of concentration of scarce resources in areas of greatest promise. While the desire to have a research capability in all areas offering at least a partial solution to the 'energy problem' is understandable, and is suited to invidivual research interests, the opportunity cost of thinly spread research is too high. Consequently the Council suggests the phasing out of some programs and further concentration of effort in due course. It felt that there were no significant areas at present excluded from the overall CSIRO energy research program in which CSIRO should be active.

The principle of increased selectivity is accepted. The application of this principle to individual programs will be determined in the course of the continuing review of CSIRO's energy program.

4. That in making decisions about redeployment of existing resources, or allocation of new resources, the Executive should give less emphasis to research which can, and should, be done by industry, by universities, or by Commonwealth authorities such as the Bureau of Mineral Resources, Geology and Geophysics. In Council's view, the principal areas to which this comment relates are coal exploration; oil and oil shale exploration; oil recovery; wind energy; and aspects of solar energy. Further detail is contained on pages 2-4 of the minutes of the meeting of the Standing Committee on Mineral, Energy and Water Resources held on 21 January 1981.

*The principle of leaving to industry and other bodies research work more appropriately carried out by them is accepted. This long-standing policy was reaffirmed in the Organization's annual report for 1978/79. (*A more detailed discussion of the particular fields of research suggested by the Council as suitable for phasing down appears later in this chapter in the section headed 'Specific Energy Research Areas'.*)*

5. That in order to achieve an effective redirection of resources it will be necessary for the Executive (both during its review process and subsequently) to ensure that close liaison with other groups, particularly those referred to in paragraph 4 above, is maintained and intensified. Indeed, Council stressed the importance of CSIRO maintaining a general and effective liaison on energy research and development with all other major organisations active in the field.

The recommendation is noted. The Executive believes that existing coordination and liaison arrangements in the energy field, while no doubt always open to improvement, are generally satisfactory. The Executive will continue to improve these arrangements wherever possible.

6. That an important element in planning any future research programs, especially those likely to require capital-intensive development, is an early examination of the economic viability of the project. This will require a review of the implications for each program of Government policies (including environmental policies), the capacity of industry and State Government authorities to make use of the research, the attitudes of industry and State Government authorities to the exploitation of the outcome, and the impact on existing patterns of resources. This assessment of the economic viability should be undertaken as early as possible during the life of each research program to establish whether or not the continuing commitment of resources is justified.

The recommendation is accepted. The criteria listed by the Council are already used in assessing CSIRO's energy research programs, although the relevance of each factor will vary markedly with the *nature of the research program in question. The planning procedures described in Chapter 1 of the Organization's 1979/80 annual report are being developed with the aim of ensuring that these and other relevant criteria are fully utilized in the development of research proposals, and in assessments of their relative priorities.*

7. That the general planning approach adopted by CSIRO is impressive and that, in particular, the estimation of the different time periods within which individual research programs would bear fruit is especially valuable. The approach offers the prospect of ensuring that research projects are in phase with decisions which will be taken about national investment by industry and Governments.

Council's views are noted.

8. That the Executive should examine the possibility of CSIRO undertaking a review of Australian research and development in the area of conservation of liquid fuels, in order to ascertain if there is room for more fundamental approaches, and for the coordination of the present fragmented and often ad hoc *work. Council noted the importance of building up comprehensive information about energy research and development in Australia (such as the Department of National Development and Energy's Compendium of Australian Energy Research, Development and Demonstration Projects) in the interests of achieving the most effective rationalization of activities between CSIRO, other Government agencies, research organizations and industry.*

The recommendation is accepted. The Executive notes that a preliminary review of this question will be undertaken shortly by a firm of consultants under the terms of a contract to be let by the Minister for National Development and Energy on the recommendation of the National Energy Research, Development and Demonstration Council (NERDDC). Dr Tegart, the full-time Member of the CSIRO Executive with responsibility for energy policy matters, is a member of the Technical Standing Committee of NERDDC that developed the proposal for the review, and he will continue to monitor its progress. The consultants' report will help the Executive decide whether a further review will be necessary. The Executive also notes that it has recently published a comprehensive statement of its energy research policies, together with the background papers generated in the course of developing these policies, and will shortly be publishing an updated compendium of its energy research and development programs and projects.

9. That the increasing proportion of total CSIRO energy R&D funds made available through the National Energy Research, Development and Demonstration Council (NERDDC) raised the possibility of undue concentration of NERDDC funds in one area, or one Division, *which could lead to undesirable distortion of research away from the optimum balance between fundamental, strategic mission-oriented, and tactical research appropriate to the Division or to CSIRO in the energy area. Council also noted that, over a period of time, Divisions drawing heavily on NERDDC funds would need to provide additional 'core' funds for overheads.*

Council's views are noted. The problems created by non-Appropriation funding are being kept under review.

Specific Energy Research Areas

In paragraph 4 of its advice to the Executive, the Council referred to pages 2-4 of the minutes of the meeting of its Standing Committee on Mineral, Energy and Water Resources held on 21 January 1981. The substance of the Committee's conclusions relevant to the Council's advice appears below, together with the Executive's comments.

Under the heading 'Exploration' the Standing Committee of Council concluded that commercial interests had adequate incentive for innovation and that, apart from high quality work such as SIROTEM, CSIRO's work in this area should be phased out. The Executive accepts this as a general principle and will ensure that this consideration is taken fully into account in the next phase of its review of energy research programs. It notes, however, that there will continue to be a need for CSIRO to retain an interest in exploration technologies to the extent that they guide basic research into the nature and characteristics of Australian energy resources such as coal, petroleum and oil shale. It also notes that ideas for new exploration technologies can spring from a wide range of CSIRO endeavours, including those which might apparently be quite unrelated to this aim. The Organization has an obligation to be alert to these possibilities and, in appropriate cases, to exploit them to the stage where commercial or other users might adopt them.

Under the heading 'Petroleum Recovery' the Committee took the view that the present CSIRO effort was too small to be viable, and that it should be phased out rather than expanded because industry had a considerable commercial interest in pursuing such work. The Executive accepts that the CSIRO effort in this area is small, but disagrees that the work should be phased out. The program is examining a range of bacteria for their potential to aid recovery of oil from reservoirs by altering the physical and chemical properties of the oil. Two professional staff are engaged in the work which is being undertaken in collaboration with the Bureau of Mineral Resources, Geology and Geophysics, a part of the Department of National Development and Energy. The Executive believes that the program should be allowed to continue for a reasonable period to establish whether or not the approach will be valuable.

Under the heading 'Wind Energy', the Committee concluded that CSIRO's resources could be more effectively deployed elsewhere. The Executive agrees.

Under the heading 'Solar Energy', the Committee concluded that resources presently devoted to large-scale solar engineering, photochemical solar energy storage and low energy greenhouses could now be deployed more appropriately on other energy programs. The Executive agrees.

State Committees

The Science and Industry Research Act 1949 provides for the establishment of committees in each State of the Commonwealth. Special administrative arrangements have been adopted by the Government to enable a similar committee for the Northern Territory to be established during 1981.

The names of the current members of the State Committees, together with their affiliations, are set out in Appendix II.

The functions of each State Committee are:

- to request and receive comments and suggestions in connection with the work of the Organization from persons or associations in the State concerned;
- to keep itself informed of the current and planned work of the Organization and to make that work known to interested persons and associations in the State concerned; and
- to furnish advice to the Advisory Council, having regard to the comments and suggestions received and the information so gained, and in particular, to furnish such advice with respect to any matter that is referred to it by the Advisory Council for advice.

Advice from the State Committees to the Advisory Council provides an important input into the development of CSIRO's research policies.

The work of each State Committee during the year is briefly described below.

New South Wales

During 1980/81, the New South Wales State Committee considered the following matters:

- CSIRO's policy and procedures for the review of research programs and projects;
- the need for Government funding of research associations to remain within the control of CSIRO;
- CSIRO's policy in relation to manpower planning; and
- the possibility of an experienced CSIRO journalist being located in New South Wales.

The Committee has continued to visit new Divisions and Units for discussions with staff about their research. It has also submitted reports on visits to the Divisions of Irrigation Research and Animal Production to the respective Institute Directors and has provided an input to several CSIRO Divisional and subject reviews. In addition, the Committee has proposed a scheme of rewards as incentives for research workers.

The Committee has continued to develop further links with industry. It has adopted a plan to hold a series of half-day seminars with appropriate New South Wales industry groups, has established a link with the NSW Science and Technology Council which should be mutually beneficial, and has continued to have an active involvement in CSIRO's energy program.

Queensland

The Queensland State Committee met formally on seven occasions during the year. CSIRO laboratories in Brisbane and Townsville were inspected. The work being carried out in the Cunningham, Meat Research, Marine, and Davies Laboratories was demonstrated to the members of the Committee. In addition, the Chairman and Director of the Sugar Research Institute met the Committee and outlined the activities and financial arrangements of the Institute, which is partially funded by the Commonwealth through CSIRO.

Members contributed towards the reviews of the CSIRO Divisions of Animal Production, Land Use Research/Land Resources Management, Mechanical Engineering, Applied Geomechanics and Mineral Engineering. Sub-committees met regularly to prepare submissions for these reviews.

During the past year the major thrust of the State Committee was related to the research being carried out in the north of Australia. The Committee met the CSIRO Executive in Townsville and contributed to a seminar held at the James Cook University of North Queensland on the Organization's work in the north. The State Committee expressed concern that the work of the Davies Laboratory was being hampered by the withdrawal of animal scientists from Townsville.

The Committee proposed the secondment of an officer from the CSIRO Division of Building Research to the Queensland State Department of Commercial and Industrial Development, where a need existed for an expert in ceramics to examine the brick-making industry in the State. The secondment is now being arranged.

South Australia

As part of an educational program for its members, the South Australian State Committee visited Divisions in the Adelaide region and took the opportunity of discussing aspects of their work. A meeting of the CSIRO Executive in 1980 in Adelaide provided an opportunity for contact with members of the Executive. The meeting of the Advisory Council in Adelaide on 20 May 1981 provided a further opportunity for members to be involved in Advisory Council business and also for contact at an informal level.

The State Committee has plans for meetings with community leaders, industry groups and other interested people to publicize CSIRO work at appropriate levels. The Committee will promote CSIRO's research whenever opportunities occur.

Tasmania

The Tasmanian State Committee met five times in 1980/81. Up-to-date information on matters of special interest to Tasmania was provided by invited speakers from interstate. A useful background was provided in this way on the treatment of forest residues, and on the current research of the Divisions of Fisheries and Oceanography and possible development of commercial fisheries in the southern ocean. The possibility of cooperative work between CSIRO and the Antarctic Division was examined at a meeting at Kingston. At the same time, the State Committee inspected the new Antarctic Headquarters.

To consider the development of research proposals, three sub-committees were established. These are directed towards rural research, marine research and technology, and minerals and mining. While the main function of these sub-committees so far has been to respond to reviews, they will provide the basis for firm proposals for research expansion.

Victoria

The Victorian State Committee met on seven occasions during the year, and visited the CSIRO Divisions of Textile Industry, Atmospheric Physics and Mechanical Engineering, and the Central Information, Library and Editorial Section.

The Committee has collaborated with the Advisory Council's Manufacturing Industries Standing Committee in the preparation by the Standing Committee of its paper to the Advisory Council on R&D for manufacturing industry. The paper is based on the State Committee's final report presented to the November 1980 meeting of Council.

A sub-committee was formed to provide a Victorian input to a national rural research program, in terms of research consolidation and research priorities. The sub-committee has perused a number of important Victorian State and Commonwealth documents and has been informed by the major industry associations (namely wool, wheat, meat and dairy) of their priorities for research. This investigation has provided the sub-committee with a better understanding of industry priorities. A draft paper on the subject, which takes the association's views into account, is being prepared. The Advisory Council's Rural Industries Standing Committee is being kept fully informed of the Victorian activity in order to prevent duplication of effort.

A member of the State Committee presented a paper to a seminar on 'CSIRO and Manufacturing Industry', which described to representatives of manufacturing industry the role and activities of the Victorian State Committee.

Western Australia

Following sustained representation from the Western Australian State Committee, an Industrial Liaison/Information Officer was appointed to CSIRO in Perth and located at the Regional Administrative Office. The Committee has reviewed industrial R&D programs operated by the National Research Council of Canada and has made a number of recommendations which have been referred to the Executive.

Submissions were made to the committees reviewing the following CSIRO Divisions and Units: Animal Production, Wheat Research Unit, Land Resources Management/Land Use Research, Wildlife Research, Mineral Engineering, Applied Geomechanics and Chemical Technology.

A comprehensive report, 'New Land Use Options for the South-West of Western Australia', was submitted for consideration by the Advisory Council. An earlier report of the State Committee, 'Fresh Fruit and Vegetable Research in North-West Australia', is being revised and up-dated.

The Chairman, Secretary and one member of the Committee are members of a working party on energy research of the State Energy Advisory Council, which is currently preparing a document entitled 'Research Priorities for Transport Fuels from Biomass and Other Sources for WA'.

The Committee has a monitoring role on behalf of the Western Australian Government in the field of iceberg utilization as a possible freshwater resource.

In response to an approach from a group in the agricultural community, the Committee is investigating ryegrass toxicity in the sheep-grazing areas of Western Australia with the aim of developing a strategy that will control toxicity but continue the use of ryegrass as a pasture plant.

Research

The items in this section have been selected to illustrate something of the wide range of CSIRO's research. More comprehensive information can be obtained from Institute annual reports, from the reports published regularly by Divisions and Units, from a variety of other CSIRO publications listed in 'Serial Publications, Monographs, and Pamphlets Issued by CSIRO', and from 'CSIRO Index' which lists the 200 or so papers produced each month by CSIRO scientists. For information regarding any of these publications, please contact:

The Central Information Service
CSIRO
P.O. Box 89
East Melbourne, Vic. 3002
Telephone: (03) 419 1333

12. Cattle production for the tropics

In early 1981, a major new CSIRO laboratory was opened in central Queensland. It is the $5 million J. M. Rendel Laboratory of the Tropical Cattle Research Centre at Rockhampton. The laboratory has housing for experimental animals, as well as modern facilities to study the physiology, biochemistry, immunology, genetics, and nutrition of cattle.

The upgrading of facilities at the Tropical Cattle Research Centre is a recognition of the value of research to the main industry across northern Australia. The northern cattle industry has developed dramatically in recent years. In Queensland alone during the last 20 years the area under sown pasture has increased from 0.85 to 3.25 million hectares, the number of beef cattle has risen from 5.6 million to 11 million, and annual beef production has doubled—from 0.33 to 0.66 million tonnes. Even so, there is a need for increased efficiency if Australian cattle products are to maintain their competitive position on world markets.

The J.M. Rendel Laboratory of the Tropical Cattle Research Centre at Rockhampton, Queensland, which was opened in April 1981.

At the opening of the J.M. Rendel Laboratory are from left: Alderman R.B.J. Pilbeam, Dr J.P. Wild, Dr T.W. Scott and Dr K.A. Ferguson.

Continuing research, development, and investment in tropical pastures must complement the search for, and refinement of, cattle better adapted to the tropical environment. And both pasture development and cattle-breeding aims have to be tailored to the range of diverse environments across northern Australia. Plant introductions from other countries are being made to find better species for each environment; and the use of different breeds of cattle will lead to greater adaptability and improved performance because of the wider gene pool from which superior stock can be selected. In both cases, the new genetic resources need development to suit local conditions.

A major problem with beef and milk production in the tropics is the huge seasonal variation in the availability of feed due to the summer wet and the winter dry seasons. Also, the dry season varies in length and severity. The native pastures consist largely of summer growing species, and consequently stock on these pastures get too little protein and energy for at least several months each year. Much research is aimed at ironing out variations in productivity by producing pastures that maintain quality better over winter, or developing cattle that can grow and produce milk on pastures affected by periodic drought, and can cope with the heat and parasites found in northern Australia.

Pasture Improvement

In 1959, CSIRO formed the Division of Tropical Pastures (now the Division of Tropical Crops and Pastures). Its first Chief, the late Dr J. Griffiths Davies, placed great emphasis on the adapted pasture legume as a source of nitrogen to improve tropical beef pastures. Since then, the history of pasture research in northern Australia has been dominated by the search for legumes that would provide the three- to four-fold increase in carrying capacity that clover and medics have done in temperate areas. All-grass pastures treated with heavy nitrogen dressings give very high beef yields per unit area, but are generally less palatable than legume-based systems.

Since no country in the tropics had developed systems of animal husbandry based on grass/legume pastures, the Division had to introduce wild tropical pasture legumes and select those that showed promise under grazed pasture conditions. Already the nitrogen-supplying capacity of some of the tropical pasture legumes developed compares favourably with that of the best temperate species. Today the Division has the world's largest genetic resource of tropical pasture plants, with over 14 000 individual lines of legumes and grasses.

The first legume to be thoroughly evaluated by CSIRO researchers was Townsville stylo (*Stylosanthes humilis*). This legume grows naturally in tropical South America, and after it was introduced accidentally to the port of Townsville about 1900 it spread rapidly. Its potential value as a pasture legume was soon recognized by a few enterprising graziers, who began sowing it to their advantage.

The plant grows best in hot areas with an average annual rainfall of about 600-1200 mm. In early pasture research it proved suitable for use in Queensland cattle country stretching from Bundaberg to the far north, and in the Northern Territory. The first conclusive demonstrations of its effect in raising stock production were made by CSIRO at Rodd's Bay, Queensland, and at Katherine, Northern Territory.

But although Townsville stylo grows well in many places without fertilizers, improved pastures based on the annual legume tend to be unstable. Researchers found that the instability was due to lack of 'hard seed' (nearly all seed germinates on first rain and can be killed off by subsequent dry conditions), and to the death of the better perennial grasses under increased grazing pressure. These were replaced with low-yielding, lower-quality annual grasses and weeds.

Now, after an intensive period of plant collection, introduction, and evaluation, scientists from CSIRO and State Departments of Agriculture have identified other *Stylosanthes* species that grow better than Townsville stylo over a wide range of environments. These include the perennial Caribbean stylo Verano (*S. hamata*), and Seca, a variety of shrubby stylo (*S. scabra*), both of which are suited to the same sort of areas as Townsville stylo. Varieties of *S. guianensis* such as Endeavour and Cook are more suited to the higher rainfall areas of the north coast, while fine-stem stylo (*S. guianensis* var. Oxley) grows best in the dry sub-tropics and shows particular promise on poor granite soils in the Burnett region of south-east Queensland.

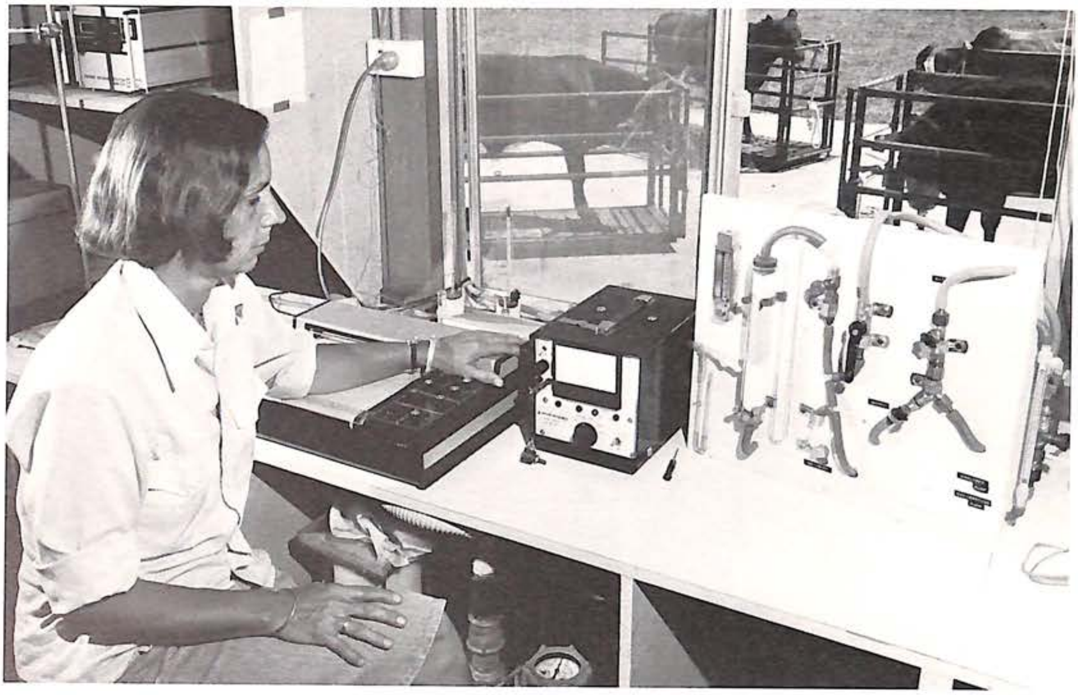
Siratro (*Macroptilium atropurpureum*) is another legume that has been shown to boost beef production considerably in experiments conducted over more than 10 years in the sub-tropics of subcoastal southern Queensland. However, these new Siratro and stylo pastures have not yet been adopted on a large scale by graziers, probably chiefly because of uncertain beef markets since 1973.

There are still some important problems to be solved. For example:

- The feeding value of the introduced tropical grasses is still too low, particularly in the dry season, to meet the special needs of dairy cows and calves.
- No satisfactory tropical pasture legumes have been found yet for the important area of arable clay soils extending from northern New South Wales up to central Queensland.
- There is the interesting problem of relatively poor beef production from unfertilized Verano and Seca stylo pastures, even though these legumes grow satisfactorily without fertilizer on some soils.
- New plant diseases, such as anthracnose of stylos and rust of Siratro, have yet to be combatted.

Adapted Cattle

The first cattle introduced to northern Australia were British breeds (*Bos taurus*), which were stressed by many aspects of the difficult tropical environment besides feed shortages—especially the debilitating effects of heat, and parasites such as the cattle tick, the buffalo fly, and gastro-intestinal worms. The performance of northern herds has since been greatly improved by cross-breeding British cattle with



Dr Virginia Finch of the Division of Animal Production conducting physiological tests aimed at finding out which components of heat tolerance (such as coat type, colour or heat production) can be selected for with minimal loss of productive capacity.

Zebus (*Bos indicus*), the humped cattle of Asia and Africa. Today, just over half the cattle in Queensland, and a higher proportion on the Queensland tropical coast, contain Zebu blood.

The presence of Zebu cattle in Australia dates back to the early days of settlement. Such cattle did well around Sydney but after a time only British bulls were used and the Zebu influence disappeared. However, following the tick invasion towards the end of the last century, the knowledge, from experience in Texas, that Zebu and Zebu-cross cattle were more resistant to ticks than British breeds was put to good use.

The Melbourne Zoo offered two Zebu bulls to the Queensland Government. The offer was refused by the Government but was taken up by graziers, and the two bulls went to northern Queensland about 1910. From that time, various centres of Zebu cross-breeding began to develop.

The spread of Zebus and their crosses led to a wider realization of their advantages. In the early 1930s Dr R. B. Kelley, a geneticist with the then CSIR Division of Animal Health and Production, visited the United States to select suitable Brahman (a Zebu breed) and Santa Gertrudis (containing *Bos indicus* and *Bos taurus* genes) cattle for importation to Australia. This breeding stock was distributed to commercial properties in northern Queensland and studied carefully.

The cattle soon had thousands of descendants, which, along with further importations, greatly increased the amount of Zebu 'blood' in northern Australian herds. Successful new breeds that were formed early by the crossing and selecting of Zebu and the British breeds include the Droughtmaster, the Braford, and the

Brangus, all of which compare well with the American Santa Gertrudis.

In 1952 the Australian Meat Board bought 'Belmont', a 3600 hectare property on the Fitzroy River, to provide facilities for studying the breeding of beef cattle adapted to northern Australian environments. Since 1953, 'Belmont' has been managed by CSIRO on behalf of the owner (now the Australian Meat and Livestock Corporation) and operated as a research station.

Soon after the establishment of 'Belmont', eight bulls and two cows of another Zebu breed, the Africander, were imported for comparison with Brahmans. The researchers developed three main crossbred lines to test: Africander-British, Brahman-British, and Shorthorn-Hereford. Between 1954 and 1964, they built up the numbers of first and second crosses. Then, in the third generation, when the stock contained well-mixed genes from the parent breeds, they began selecting, putting all the emphasis on performance rather than looks.

The all-British cross, the Shorthorn-Hereford combination, turned out to be the best producer when conditions were excellent. But under the stressful conditions imposed by heat, drought, tick and worm infestation, and certain infectious diseases (such as tick-fever and pink-eye), the Zebu crosses held a marked advantage.

The amount of Zebu blood required for good adaptation to any particular tropical environment will depend on how stressful the conditions are there. However, choice of a particular grade of cross is only a starting point—selection must continue towards an optimum combination of genetic characters. Techniques of selection for tick resistance developed at 'Belmont' have been validated and are gaining acceptance in the field. Methods of identifying worm-tolerant animals need much more research. While heat tolerance can be assessed from readings of rectal temperature under appropriate conditions, the scientists are looking for more discriminating criteria such as sweating capacity. They are also following promising leads towards early selection for bull and cow fertility.

One of the problems facing the geneticists is that when they attempt to combine certain desirable attributes there is a likelihood that some will be lost. For example, there is a conflict in breeding for both drought tolerance and high growth capacity; and selecting for growth or for parasite resistance under certain conditions may damage some component of fertility. They are seeking ways around these stumbling blocks.

In the 'Belmont' breeding program, from 1968 onwards the Africander-British line, now known as the Belmont Red, showed particular promise. The Belmont Red is approximately one-half Africander, one-quarter Shorthorn, and one-quarter Hereford. Although the Brahman-British line is superior to the Belmont Red in its resistance to worms, and it has slightly better heat and tick tolerance and a comparable growth rate, it is not as productive because it is not as fertile. As well, it is not as easy to handle.

The research at Rockhampton aims at providing information useful to cattle breeders, with whom the real decisions lie. As the late Dr R. B. Kelley comments in his book 'Native and Adapted Cattle', discussing cattle produced from those imported in the 1930s: 'Judgment was in the hands of the cattlemen who owned the cattle, and those hands held spaying and castrating instruments with which to give effect to their verdicts. If the cattle had not been advantageous, they would have been eliminated.' The same is true today— choices for individual circumstances are being made among the British breeds such as the Hereford and Shorthorn; newer possibilities, such as imported Continental breeds, or crosses between British and Zebu breeds such as the Droughtmaster, Braford, and Belmont Red; and mixes of any of these. More significantly in the long term, decisions determining breed development are being made within breeds and within herds. The quality of these decisions, the definition of goals, and the criteria and the techniques used can all be improved by the extension of research information.

CSIRO made the Belmont Red—a by-product of research—available to the industry because Africander blood was not available elsewhere in Australia, and the breed combined the features of good fertility and temperament with adaptation to the tropical environment. It is being evaluated within the industry, both in collaborative trials and independently. However, the CSIRO tropical dairy breeding program was designed primarily to create a new strain, the Australian Milking Zebu (AMZ), and involved more formal collaboration with a group of dairy farmers from an early stage.

In the formation of the AMZ, Red Sindhis and Sahiwals (Zebu breeds) were crossed with Jersey cows at CSIRO's McMaster Field Station at Badgery's Creek, N.S.W. Succeeding generations were selected for milking ability, with the cooperation of dairy farmers in the Lismore region of northern New South Wales. Later, bulls were also selected for heat tolerance and tick resistance.

In the original environment of northern New South Wales, the AMZs have performed better than Jerseys. Now the breed is being tested in coastal Queensland as far north as Townsville. Here the environment poses far more of a challenge, but the new breed is holding its own.

Although much progress has been made towards alleviating the problems associated with cattle production in the tropics, plenty remains to be done. Despite the advances of the last 20 years, the potential exists to further reduce the fluctuations that occur in the quality of feed, and to improve the ability of cattle to utilize the pastures as well as cope with the stresses of heat, internal and external parasites, and disease. Mineral deficiencies of both plants and animals, particularly phosphorus deficiency, remain a problem. Continuing research is necessary to realize the full production potential of improved pastures and animals.

13. Integrated pest control

The post-war development of potent organic pesticides spoilt both agricultural producers and consumers within Western societies. With DDT and the range of synthetic pesticides that followed it, producers suddenly had at their disposal a degree of pest control which they had never thought possible. In turn, the attraction of unblemished fruit to consumers encouraged the introduction of new standards into the market place, thus reinforcing the trend towards total pest control.

In a short period of time following the Second World War, wormy apples disappeared from the markets, sheep were freed from the worst ravages of sheep blowfly, and the depredations of insect pests against the broad range of man's crops and animals were drastically reduced. Farmers, often with only a single pass of their spray machinery, were able to reduce chronic insect problems to virtual insignificance. But a few insects always survived.

By the early 1950s, reports of insecticide resistance were appearing and once-perfect spray programs began to break down. In many cases, more frequent applications of increasingly toxic and expensive pesticides became necessary.

The realization that the 'one-shot' solution provided by chemicals such as DDT was not a long-term answer to the pest problem, combined with an increasing appreciation of the complex interactions within agricultural ecosystems, led agricultural scientists to look for new strategies to handle pest populations. The concept of integrated pest control, relying on a multi-pronged attack on the pest problem, was a natural consequence of these developments.

Integrated pest control has been defined as 'a pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest population at levels below those causing economic injury'.

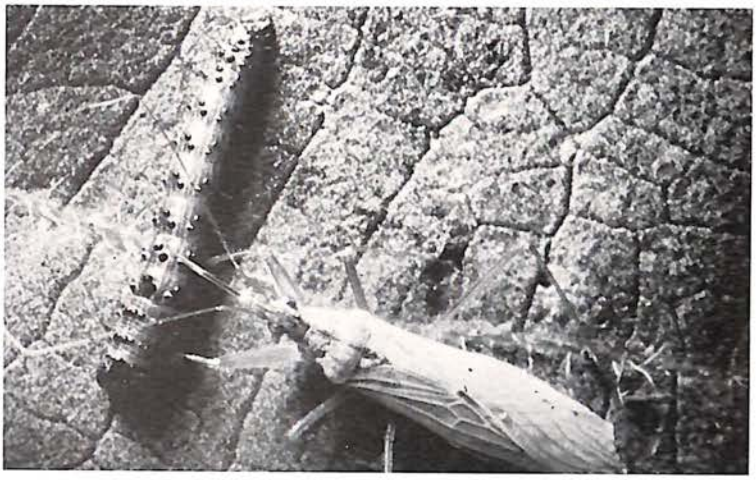
This definition implies that a degree of pest damage can usually be tolerated and that natural factors—weather, parasites and predators—that tend to limit pest populations should be given every consideration when plotting a pest control strategy. Descriptions of several CSIRO research projects that are applying integrated pest control principles in modern farming systems follow.

SIRATAC

Intensive cotton growing is virtually impossible without pest control, and it was one of the first beneficiaries of modern pesticides. Cotton was also one of the first crops to experience a severe counter-attack by resistant insects. In Australia, such resistance was an important factor in the abandonment of cotton growing in the Ord River scheme and has posed a constant threat to the success of cotton in eastern Australia.

The key cotton pest is a *Heliothis* moth whose larvae cause severe fruit drop and reductions in yield. However, cotton is a

Heliothis, *the most serious pest of cotton in Australia, attacking a cotton boll.*



*A damsel bug (*Nabis capsiformis*), one of about 30 predators that attack* Heliothis *larvae.*

fecund and resilient plant and produces many more flowers than can ever hope to mature to harvestable bolls. Even under optimum conditions only 30% of the flowers will contribute to the final yield, so quite large flower and fruit losses can be tolerated. The problem is guarding those bolls that will contribute to a profitable harvest.

Acting on *Heliothis* are over 30 predators and parasites as well as a number of disease agents. In addition, the weather has a significant influence on insect development and mortality. In the field hot, dry weather desiccates the insects, while heavy rain knocks eggs and young larvae off the plants.

Scientists from CSIRO and the New South Wales Department of Agriculture have sought to take maximum advantage of these natural control factors by devising a computer-based pest management system, called SIRATAC, for determining exactly when insecticide must be applied to prevent unacceptable crop damage. By integrating a plant growth model with observations of pest population levels and meteorological data, the computer predicts the courses of both insect and plant populations and tells the operator whether a spray is necessary to ensure economic yields. If insecticide applications are limited to such times, the chemicals are used more efficiently, development of pesticide resistance is slowed, and environmental pollution is reduced.

Comparing SIRATAC-managed and commercial fields

	1978-79 (one site)		1979-80 (mean of four sites)	
	SIRATAC	commercial	SIRATAC	commercial
area involved (ha)	14	14	360	360
pesticide applications	11	16	6	10
costs ($ per ha)	120	245	95	150
lint yield (bales per ha)	7.1	7.4	6.8	6.7

Fields managed using SIRATAC gave virtually the same yields as commercial cotton fields. However, costs and numbers of insecticide applications were much lower.

As well as relying on conventional or 'hard' chemical sprays for a high kill whenever necessary, the SIRATAC program makes allowances for the use of a 'soft' spray—a viral insecticide—which does not provide such a high kill rate. However, the insect virus has no effect on the predators and parasites which prey on *Heliothis* and a 30-40% *Heliothis* mortality, caused by the virus, may be all that is needed to tip the balance in favour of the cotton plant.

Over many seasons of testing, SIRATAC-managed cotton has performed just as well as conventionally-managed cotton but often with only half the number of sprays. The incorporation of insect-resistant cotton varieties into the scheme will help reduce the need for pesticides even further. In addition, moves are already under way to introduce soil management and irrigation sub-models into the larger program. When this occurs, SIRATAC will be converted from simply a pest management system to a crop management system which makes the best use of our knowledge about cotton and its needs. The farmer will tap into this system through the use of a home computer and a connecting telephone call to a central computer.

Wheat Storage

The Australian wheat industry has been highly dependent on insecticides for the control of pests in stored grains. However, increased costs, the development of resistance and the demands of our export markets are forcing change onto the industry. CSIRO is actively assisting in this transition.

The Australian wheat industry has a zero tolerance for grain storage pests. This situation arises mainly through our position as one of the world's leading grain exporters; because of this, the Australian wheat industry is oriented to the specifications and demands of the export market. High on the list of specifications is complete freedom from the many pests which attack stored grain. Also, there is an increasing demand by importers for grain carrying extremely low pesticide residues.

Sealing a silo before fumigation with carbon dioxide to destroy stored-grain pests.

Since the pest threshold for stored grain is zero, there is no role for the parasites and predators of pest species in the control programs. A further limitation is that any pest control procedure must slot into the grain handling procedures currently in use. Despite these difficulties, research is leading to the integration of chemical and physical techniques in a total control package.

It has been found, for example, that when certain insecticides are used on cooled grain, the lowered temperatures both enhance the toxicity of the pesticide and reduce its breakdown rate. The cool temperatures also slow pest proliferation with the overall result that less insecticide is needed to provide effective control. If grain held in store for several months is cooled to even lower temperatures by refrigerated aeration, effective insect control is achieved with no insecticide at all. (At temperatures of 15-18°C, the reproduction of most grain storage insects is halted in dry grain.) Refrigerated aeration is being developed to suit any type of storage anywhere in Australia and can be integrated in the storage system with the carbon dioxide or high temperature techniques described below.

Scientists are also concerned with the development and testing of new insecticides as well as the reformulation of existing ones in order to slow the development of resistant species. In addition, old and novel fumigants are being tested for effectiveness.

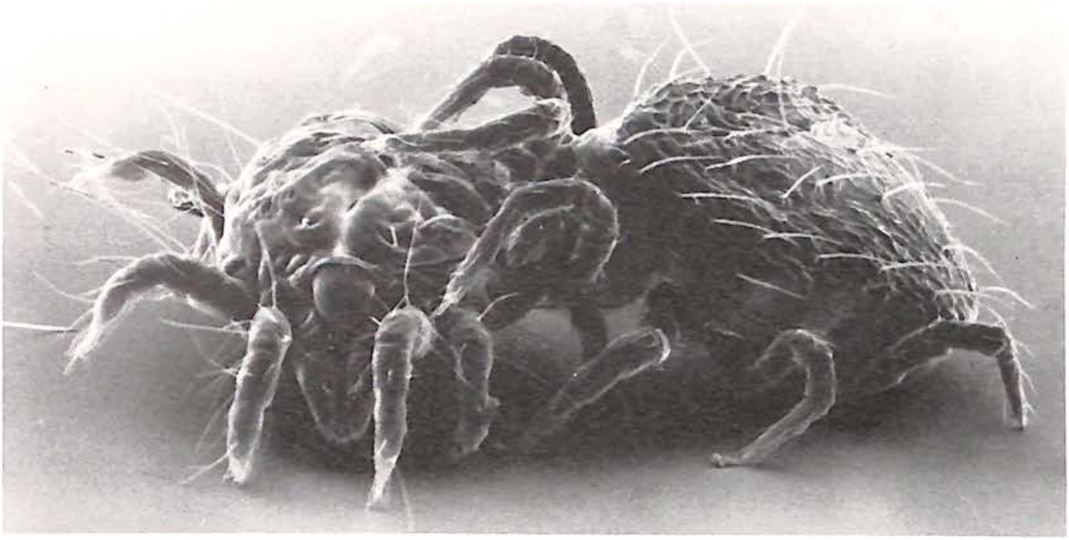
One approach under investigation is the use of carbon dioxide to suffocate grain pests. However, a problem with its use as a fumigant is the leaky nature of many of the grain stores. Sealing trials involving the widely used horizontal sheds are in progress and results to date indicate that it is technically and economically feasible to make the structure sufficiently gas tight. Meanwhile, in the case of the more easily sealed vertical, steel grain silos, carbon dioxide is in limited routine use for insect control.

High temperatures can also be used to control insects. Using the very rapid and efficient transfer of heat that can be provided by fluidized beds, the temperature of wheat can be raised quickly to a sufficient temperature to kill the insects without affecting the germination or milling and baking properties of the grain. Such a procedure can be incorporated into the conveyor systems at country depots or export terminals. Currently, the wheat industry is collaborating with CSIRO in assessment of the technique, and a 50 tonnes per hour continuous flow pilot plant is being constructed.

Orchard Mites

While the development of pesticide resistance may be highly desirable for individual insects, sometimes such resistance can be manipulated for the benefit of man. This has been achieved in apple orchards, where the widespread use of the new generation of pesticides not only increased resistance within the target populations of codling moths but also had other rather disastrous side-effects. Mites which had once been held in check by predators suddenly proliferated as serious new pests of apples because the pesticides being used against codling moth drastically reduced the predator populations. As a result, a whole new array of pesticides had to be incorporated into spray programs. Subsequently, a new cycle of miticide resistance/miticide development began.

In 1972 a predatory mite, *Typhlodromus occidentalis*, that feasts on the main mite pest, the common two-spotted mite, was introduced from North America. This predatory mite had been selected on the basis of its resistance to many of the insecticides in common use for the control of codling moth. Since its release into



The predatory mite Typhlodromus occidentalis *makes a meal of the twospotted mite,* Tetranychus urticae. T. urticae *is a major orchard pest in Australia.*

an orchard in Canberra over eight years ago, mites have caused virtually no leaf damage there, and high quality fruit continues to be produced without the use of any miticidal sprays.

Another pesticide-resistant predatory mite was introduced in 1977, from New Zealand. Called *Typhlodromus pyri*, its favourite prey is the European red mite. Field trials involving *T. pyri* alone, and in combination with *T. occidentalis*, have shown that excellent control of mites is now possible and the need for miticides has been sharply reduced. The use of predatory mites has reached the commercial stage with the release of *T. occidentalis* in orchards throughout Victoria and New South Wales.

On an Australia-wide basis, release of these predatory mites promises potential savings on miticides of about $4 million per annum. In addition, development of pesticide resistance within two-spotted and European red mite populations should be drastically slowed and may, in fact, cease to be a problem.

Cattle Tick Control

Another important target of integrated pest control is the cattle tick of northern Australia. Reduced weight gains, anaemia and even death of severely infested cattle make cattle tick control a high priority issue. However, reliance on chemical dips for control has itself resulted in a plague of problems.

The cost of dipping can outweigh the value of the extra meat when beef prices are low, and problems of pesticide contamination of meat can arise. In addition, the ticks typically develop resistance to a new chemical within 4-6 years of its introduction. Since cattle that are kept tick-free never get a chance to develop immunity to the ticks, when breakdown in chemical control occurs the results can be catastrophic.

Pasture spelling is an effective alternative control technique, but is not practicable for most producers. The costs of fencing and the reductions in pasture quality that accompany spelling can outweigh the benefits of liveweight gain. The introduction of tick-resistant cattle, based around zebu breeds, has eased the problem substantially. However the cattle's resistance varies throughout the year, economic losses can still be severe, and cattle dips must still be used.

Research is leading to the development of improved methods for dealing with the cattle tick. For example, studies on the mode of action of the most commonly used cattle dips and improved testing methods are making it possible to detect the appearance of any resistance within tick populations almost as soon as it occurs. This allows the early marshalling of alternative chemicals and extends the useful life of the ever-changing but limited chemical arsenal.

On the host side, new techniques allow scientists to measure tick resistance and its heritability in different cattle breeds. This helps determine the best way of using the natural resistance of zebu-cattle to upgrade the overall resistance of herds.

Providing a broader approach to the problem, a computer model has been developed to define the complex interactions within the beef production systems of northern Australia. This model makes allowances for the ways in which cattle immunity varies with breed, season and the nutritional status of the animals, and integrates these factors with the effects of climate on tick populations. By doing sums involving the effectiveness and cost of various control strategies and the price of beef, the model can make recommendations on the best option for the producer.

Recommendations flowing from the use of this model have been widely adopted throughout south-eastern Queensland. Here, the program recommends the use of half-zebu animals, which provide the best combination of tick resistance and weight gain, combined with a minimal dipping program through autumn, instead of the customary spring and summer treatments. This dipping program should markedly slow the development of pesticide resistance as few ticks would survive both dipping treatments and the ravages of winter.

The cattle tick model, like the SIRATAC program and the other schemes described above, is built upon a basic knowledge of the pest and host and of the dynamics of pest-host interaction. Such knowledge was in short supply in earlier days, leading to a reliance on the cheap and easy 'one-shot' solution provided by pesticides such as DDT. In the 1980s it is obvious that we still need pesticides to maintain high levels of animal and plant production but, fortunately, today's pest target is much more carefully defined, the 'bullet' is smaller, and our aim is increasingly more accurate.

14. Wool processing

Wool benefits Australia's economy, not only through its export earnings, which in 1979/80 exceeded $1700 million, but also through the employment opportunities created by the infrastructure that services the wool industry. It is important, therefore, that Australia does what it can to ensure that the demand for wool is maintained and where possible increased, both by promotion and by research aimed at making wool more competitive with other textile fibres.

By far the largest wool research effort in Australia takes place in CSIRO. Research is directed towards improving sheep and wool production and making wool more competitive as a textile fibre throughout the world. Approximately sixty per cent of CSIRO's wool research is funded directly by the Commonwealth Government. Most of the remainder is financed through the Wool Research Trust Fund which is derived from a levy on wool growers and a pro rata contribution from the Government. In 1979/80 CSIRO received nearly $4 million from the Trust Fund for textile research. Although CSIRO determines how it spends the bulk of this money, it is responsive to comments and suggestions from the Australian Wool Corporation's research and advisory committees. The committees visit the Organization's laboratories regularly, and meet with CSIRO each year to examine progress in wool research.

Promotion of wool, which is undertaken by the Australian Wool Corporation and the International Wool Secretariat involves a good deal more than conducting advertising campaigns; it also involves providing technical service and design advice to textile and product manufacturers and transferring new products and processes, such as those developed by CSIRO, into commercial use.

Wool's natural properties of softness, excellent moisture absorbency, resilience and warmth undoubtedly stand it in good stead in its competition with other fibres. However, it has major disadvantages in that it shrinks and is attacked by insects. Furthermore, other important properties such as wrinkle recovery, abrasion resistance, and resistance to burning may need enhancing for certain purposes.

When it comes to processing, wool also has a number of disadvantages compared to synthetic fibres. Wool fibres are not uniform in their diameter, length, crimp frequency and fibre strength. Furthermore, between shearings, wool becomes contaminated with grease, grass seeds, burrs, other vegetable material, and dust. The production of yarn from wool therefore calls for special procedures.

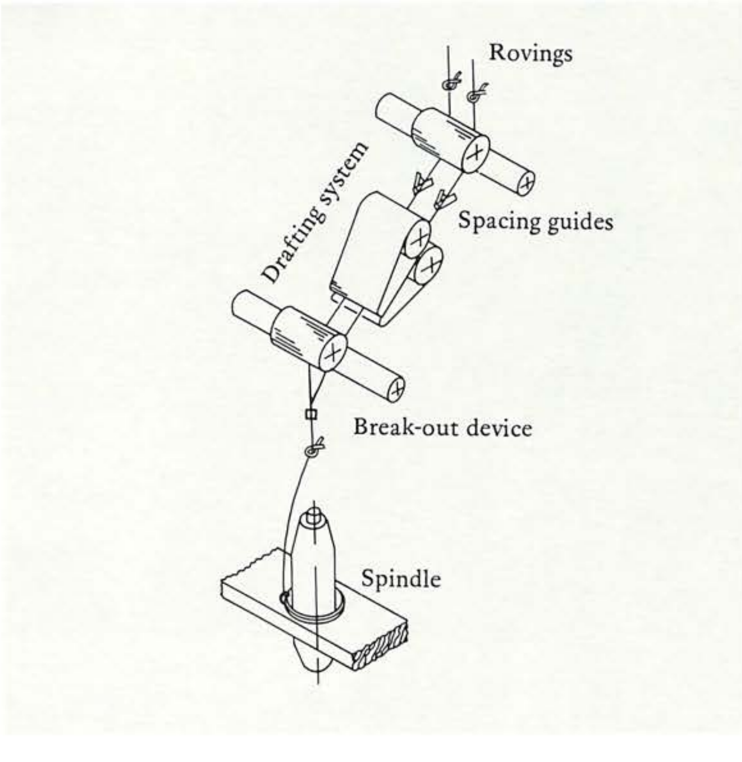
This article describes some of the ways in which CSIRO scientists are trying to improve the processing and performance of wool so that it can continue to compete successfully with synthetic fibres.

Spinning

Before scoured wool can be spun it must be carded, gilled and combed to separate the wool fibres, line them up, and remove short fibres and vegetable matter such as burrs and seeds. While research by CSIRO has led to improvements in these processes, the Organization has for many years now, concentrated on spinning because spinning accounts for roughly half the cost involved in producing yarn from greasy wool.

During the 1960s and early 1970s CSIRO, in collaboration with Repco Ltd., developed the self-twist spinning machine, which uses a novel system of applying twist to bind the fibres together to form a yarn. The latest version of the spinner spins at 300 metres per minute, 15 to 20 times faster than a conventional spinning machine. Development is now complete and the machine is being marketed worldwide by Repco's agents Platt-Saco Lowell Ltd.

Further research on spinning by CSIRO has led to the development of Sirospun. This process, which has been taken to the commercial stage by a consortium consisting of CSIRO, the International Wool Secretariat and Repco Ltd, enables the spinning and twisting operations involved in the production of two-fold yarn to be carried out in one stage on one machine. This has led to major improvements in productivity compared with the conventional approach, as twice the quantity of two-fold yarn can be produced from a given number of spindles. Moreover, wool worsted yarn can now be spun at speeds approaching those of synthetics. Sirospun yarns can withstand the tension applied during spinning better than conventional single yarns, allowing finer yarns to be spun. It has been useful in the



The Sirospun system for producing a worsted weaving yarn in a single operation on a modified ring-spinning frame.

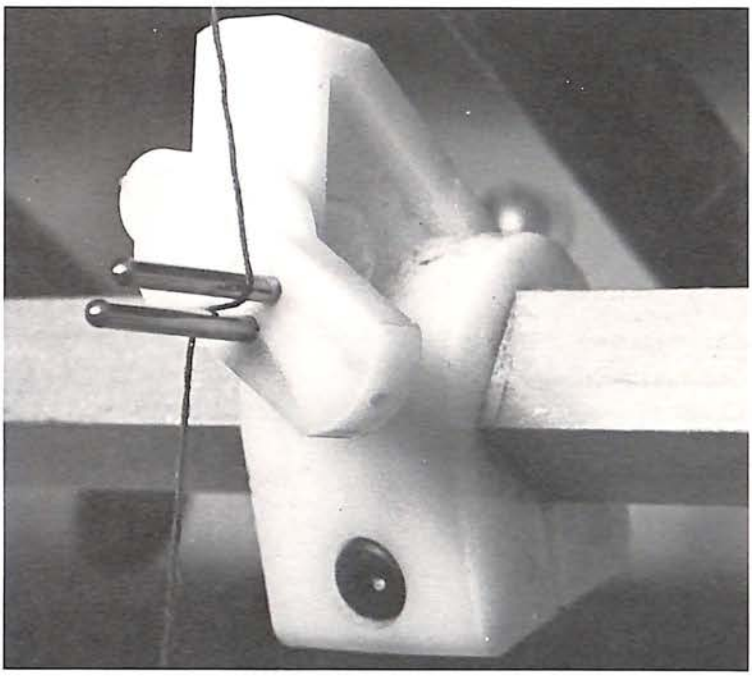
development of light-weight fine-wool dress and shirting fabrics, particularly suited to the European spring and summer. The technology can be introduced either by a relatively inexpensive adaptation of existing spinning frames or it can be built into new equipment. The process is now being introduced worldwide.

Short-staple wool processing

While world wool production has remained relatively static, its share of the world fibre market has declined. Machinery-makers are therefore becoming less inclined to produce equipment that can process wool alone. More than 90 per cent of the spinning equipment now in use throughout the world is designed for short fibres such as cotton. These machines can also handle synthetic fibres since these can be cut to any length, but they are not so suited to processing the longer fibres of wool.

CSIRO has therefore developed several simple machinery modifications to increase the range of wool types that can be processed by cotton machines and these have been adopted by several mills with encouraging results. The modifications involve cutting a small recess in some of the rollers, adjusting machine settings, and using different lubricants. These changes enable wools of longer length to be processed without having to cut or break the fibres.

A range of types of wool of varying fibre lengths up to 55 mm have been successfully processed by means of the modified machinery, without cutting or breaking. With 40-mm wools, good-quality yarns have been obtained at a cost lower than that of similar yarns



An important part of the Sirospun system is this simple 'breakout' device, which prevents the formation of single-strand yarn if one of the two strands breaks or runs out.

made on the worsted system. Wools in blends with various synthetics and with cotton have also been assessed.

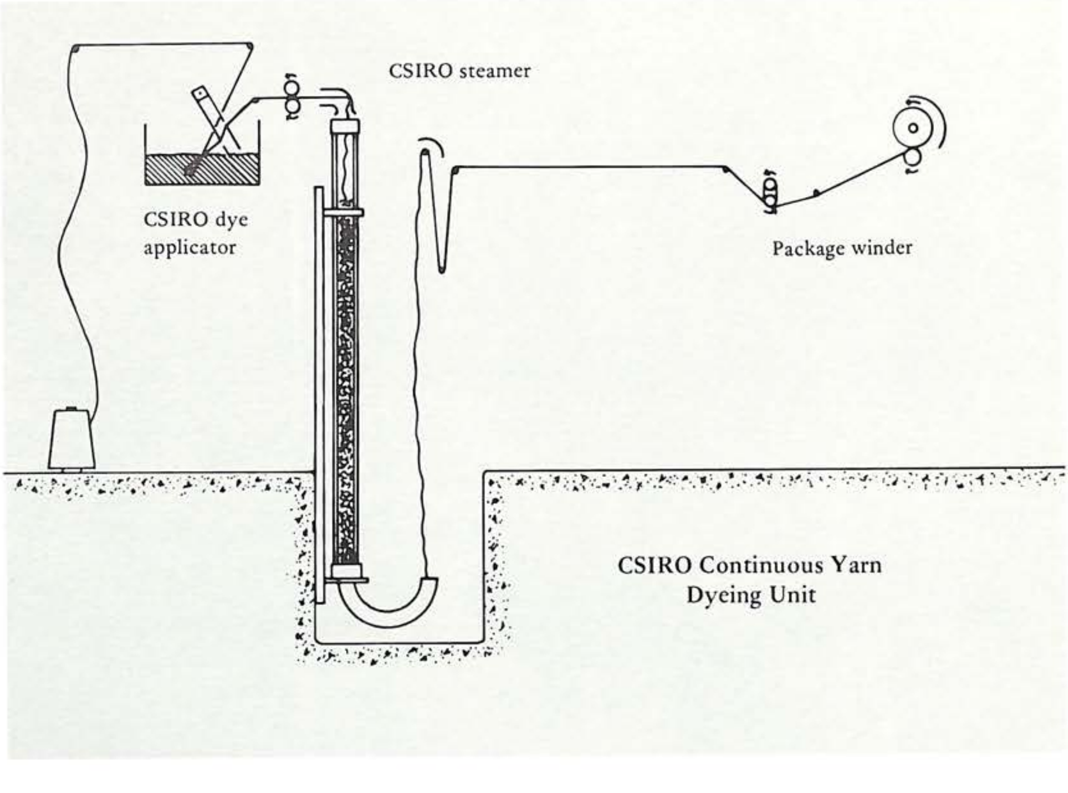
Simplified techniques for straightening, cutting and breaking the fibre are also being investigated using mathematical models to assess alternative procedures. It is hoped that it will be possible to produce the required shorter fibres direct from scoured wool or from the sliver produced from a carding machine without having first to process the wool to the top stage.

Work is also under way on the development of methods for dyeing and finishing wool on short-fibre machines to produce fabrics with traditional worsted characteristics.

Colouration

Traditionally the dyer has relied on highly experienced colourists to formulate the mixtures of dyestuffs that will give the colours specified by his customers. But now, better understanding of colour theory and developments in instrumentation have made it possible to measure the colour of a small sample and compute a recipe that will give the required colour or a very close match.

CSIRO has developed computer programs for the application of these techniques to wool and wool dyes and is collaborating with the International Wool Secretariat which offers a colour prediction service to the world's wool-textile industry.



CSIRO Continuous Yarn Dyeing Unit

When wool is dyed by traditional methods, the yarn must be kept in the boiling dye liquor for a long time to ensure that the fibres swell sufficiently to allow adequate uptake of dye. This prolonged exposure to heat may weaken the fibres and so reduce the life of the fabric made from them.

CSIRO has developed two continuous-dyeing machines that have reduced the dyeing time for loose wool and tops from one or two hours to 15 minutes. These machines not only reduce damage to the fibre, they also achieve significant savings in energy. The principle of rapid dyeing is being applied to the development of a new machine that is capable of applying dye liquor uniformly to woollen yarn at speeds of 500 m/min. The first prototype has been installed in an Australian mill for evaluation.

In collaboration with the International Wool Secretariat, CSIRO has examined several different models of the jet-dyeing machines used to dye synthetic fabrics, to see how suitable they are for wool. A report has been prepared for industry on how the various machines can be used to process wool and fabrics containing wool.

There has been a trend in recent years towards the dyeing of yarns that have been wound in packages because this involves less steps. CSIRO is looking at ways of minimizing the losses of strength and bulk of wool yarns dyed in this way.

Wool-polyester blend fabrics are currently dyed using one type of dye for the wool component and another for the polyester. This can lead to cross-staining of the wool by the polyester dyes, uneven dye distribution and loss of strength of the wool. Since one way of overcoming this would be to use the same type of dye for both fibres, a range of dyes is being studied to assess the factors which determine their distribution between wool and polyester fibres.

Printing of wool also has special problems. Unlike other fibres it must be treated with chlorine before printing to allow adequate penetration of the dyes. Moreover, only small quantities are processed at one time and this places it at an economic disadvantage. The research undertaken by the Organization aimed at solving these problems was discussed in the 1979/80 CSIRO Annual Report.

A major disadvantage of wool which has undermined its usefulness in certain applications, particularly in babies' wear and curtaining, is the damaging effect of sunlight. Sunlight causes yellowing of the wool (which is particularly apparent in bleached or pastel-dyed wools) and, eventually, loss of strength. CSIRO has shown that this is caused by ultraviolet radiation attacking certain amino acids in wool proteins.

Various chemicals have been examined for their protective effect, for example, ultraviolet absorbers and photostabilizers, which preferentially absorb the radiation and 'de-activate' the excited amino acids before permanent change occurs. Unfortunately, no practical treatment has yet been found which gives significant protection against yellowing. However, several components which roughly halve the rate of strength loss have been discovered and long term testing on curtain and upholstery fabrics is in progress.

Shrink-resist treatment of wool

When a wool fibre is examined under a microscope, one of the most obvious features is the overlapping scales on its surface. These scales are responsible for the shrinkage of wool textiles. When a woollen garment is being washed the fibres move about. Because of the orientation of the scales, the fibres move preferentially in one direction. The scales also act like minute barbs, causing adjacent fibres to lock together. This one-way movement and the locking together of the fibres leads to shrinkage.

The textile industry uses the following three approaches to prevent shrinkage;

- degradation of the surface by chemical treatment, usually with chlorine;
- chemical degradation combined with resin application; and
- application of resin alone.

When chlorination alone is used, the scales are degraded, thus reducing the tendency for the fibres to move and lock together. The big disadvantages of this approach are the loss of weight of the wool textile (as much as 20 per cent in some cases) and the difficulty of controlling the chemical degradation, which can give weaker textiles.

In 1966 CSIRO discovered that a relatively mild chlorination treatment modified the surface tension of fibres sufficiently to allow a commercially available resin, Hercosett 57, to spread over the fibres to form a film covering the scales. The film prevents the scales and adjacent fibres from locking together, and as it swells in water, only a small amount is needed to achieve the desired effect. This chlorine-Hercosett process is applied to wool at the top stage, and it is now used throughout the world for knitting yarns and is the basis for the International Wool Secretariat's and the Australian Wool Corporation's Superwash labelling program for machine-washable wool.

The demand for a shrink-resist treatment for wool fabric led to the development in 1976 of a resin-only process, Sirolan BAP. In this process, a mixture of two resins is applied uniformly to the fabric which is then heated. This causes fibres to bond together, preventing shrinkage. The process is now in use in 18 countries.

While the chlorine-Hercosett process and the Sirolan BAP process enable wool to be shrink-resisted satisfactorily in either top form or fabric form, the treatments that are available for garments are not so satisfactory. They rely on chlorination, which weakens the fabric, or on the application of resins from drycleaning machines, which restricts the availability of the treatment. Accordingly, CSIRO is turning its attention to developing a resin-based process suitable for application by garment-dyeing machines, which are more widely available.

Such a process requires resins which, when applied in large volumes of water relative to the volume of wool, will be adsorbed uniformly on the wool and, on heating, bond the fibres together, without adversely affecting the good natural properties of the wool. Several different resin systems are being investigated and new types of polyacrylates appear particularly promising. They could be suitable for fabric treatment as well as for garments, and may be relatively cheap. CSIRO is collaborating with industry to scale up the use of these polymers to a commercial level.

Mothproofing

In Australia, the three main pests of wool—the case-bearing clothes moth, *Tinea metonella*, the common clothes moth, *Tineola bisselliella* and the variegated carpet beetle, *Anthrenus verbasci*—have developed a strong resistance to dieldrin which until about five years ago was widely used as a moth-proofing agent. Other moth-proofing agents are effective at present but are more expensive, and there is no reason to expect that they will remain effective and environmentally acceptable.

Organophosphates—a relatively cheap and commonly used class of agricultural insecticides—are efficient at killing wool pests, have low toxicity to mammals and have limited environmental impact. Unfortunately they are not sufficiently reactive with the wool fibre, they break down under light and they are lost during washing. These problems have been overcome by attaching a chemical grouping to the organophosphate molecule which enables the insecticide to react with the wool fibre and become an integral part of its chemical structure. In this form, they are inactive. However, when the fibre is eaten by the insect the chemical grouping is removed in the digestive system, the insecticide is released, and the insect is killed. Several chemical companies are now evaluating the chemical potential of these insecticides, and the Organization is investigating various aspects of their manufacture and use under industrial conditions.

In addition, CSIRO is involved in evaluating new commercial moth-proofing agents and helping the industry to determine the correct application levels and the best conditions for application.

Wrinkle recovery

In most types of fabric, wool recovers from wrinkling better than any other textile fibre, but there is still a need to improve the wrinkle-resistance of light-weight wool fabrics.

All of the current treatments that improve wrinkling behaviour have drawbacks. In the laboratory, the wrinkle-recovery of wool can be improved by a simple treatment, termed annealing. This involves heating followed by slow cooling, but most of the improvement is lost when the garment is subsequently washed or steam pressed. Recent research has suggested that the improvement is mainly due to physical changes in the fibre, although there is also evidence of some slight chemical change. Chemical treatments that stabilize the annealed state are being sought.

CSIRO has also been concerned with the development of test methods for the wrinkling performance of wool fabrics, and many of the results of this work have been used to establish international tests for use in the quality control of wool and wool-blend fabrics sold under the Woolmark and Woolblendmark labels.

Flammability

In its natural state, wool is highly flame-resistant and its resistance is more than adequate for most situations. However, for some applications, such as protective clothing and aircraft furnishings, it needs treatment to ensure that it meets the required standards. The International Wool Secretariat has developed such a treatment, entailing application of chemicals containing the metals zirconium or titanium, but there are some problems in its industrial use. CSIRO is studying the location of these metals on the fibre to improve our knowledge of the thermal behaviour and the flame-retardant properties of the treated wool.

Studies of the various aspects of the flammability of textiles have led to the formulation, through the Australian Standards Association, of the Children's Nightwear Standards, which are now well established, and to the development of a fire-hazard test method for carpets. CSIRO has also made important contributions to the development of international test methods through the relevant working groups of the International Organization for Standardization.

Abrasion resistance

Wool is weaker than many other textile fibres, and this is revealed in the poor resistance to abrasion of some wool fabrics. The Organization is therefore attempting to develop economic industrial methods for improving wool's performance while retaining its natural properties. To do this it has been essential to obtain an understanding of how a fibre breaks when it is flexed or rubbed against other fibres, and subsequently to develop laboratory tests for abrasion resistance which realistically relate to wear in service.

Treatments have been established which, in laboratory tests, appear to increase abrasion resistance significantly. Before scaling up the treatments for industrial testing, trials are being done to ensure that the improvements are achieved in practice.

15. Mineral exploration

The search for minerals in Australia has entered a new phase, with much of the continent already surveyed for the outcropping or near-surface deposits that currently provide the country's mineral wealth. Although the emphasis in mine development will continue to be on such deposits, the search for new occurrences will be directed increasingly towards deposits covered by thick overburden or buried deep in bedrock and having no obvious surface expression.

The cost of locating and recovering deep minerals will be high, so, to ensure that their minerals remain competitively priced in the international market, Australian companies must adopt the most effective methods at all stages of their operations, including exploration for new resources to maintain future supplies. Without intensive and innovative research, it is by no means assured that Australia's position as a major exporter of varied mineral commodities will be preserved for very long. Considerations of projected demand and the rate at which deposits are being worked out can lead to the view that 50 significant metallic ore bodies will have to be discovered in Australia in the next two decades if this position is to be maintained.

Mineral exploration in Australia has been hampered because the exploration concepts and technology that evolved in the northern continents are often not directly applicable to the radically different Australian geological environment. The ability of geologists and research scientists, whose laboratory is effectively the entire continent of Australia, to apply novel concepts and technology to the often daunting task of exploration has contributed significantly to Australia's modern mineral wealth. During the past two decades, CSIRO research in mineral exploration has emphasized the need for Australian solutions to Australian problems. The Organization has made significant contributions to understanding the distinctive geological environment and the processes of ore formation, and has made a number of important advances in exploration technology, employing methods adapted to the intensely weathered Australian terrain.

Both the diversity of and the level of activity in mineral exploration today suggest that the most recent surge in exploration activity will prove more durable than booms centred on Northern Territory uranium in the 1950s, and Western Australian nickel in the late 1960s. Exploration investment has reached record levels and there has been an upsurge in sponsorship of exploration research. CSIRO has successfully developed close links with industry to ensure that research is relevant to the industry's needs, and that technology is transferred effectively. The fact that exploration companies have been supporting some quite esoteric research projects indicates that the industry is becoming aware of the importance of directing research towards the location of hidden mineralization.

Recognizing the limitations of purely geological techniques in the Australian environment, CSIRO has developed skills in allied disciplines, most notably in geophysics and geochemistry. Studies divide broadly between those aimed at identifying regions of potential mineralization (strategic research), and those concerned with finding orebodies within such regions and defining their nature and extent (tactical research).

Formation of Orebodies

Knowledge of the relationships between mineralization and specific geological environments, and of the factors controlling the formation of orebodies, is vitally important to company exploration geologists. Research on existing orebodies can indicate strategies for locating repetitions, or for identifying potential new mineral provinces. CSIRO has a long tradition of research into ore genesis, dating back to the creation of its forerunner, the Council for Scientific and Industrial Research. Its scientists have contributed to the documentation and understanding of virtually all significant Australian orebodies and many lesser mineral deposits.

CSIRO has evolved a multi-disciplinary approach in which geological, mineralogical, geochemical and isotopic studies of representative orebodies are combined with theoretical and experimental studies to interpret ore-forming processes and to derive diagnostic features for particular types of orebodies. In the recent past, special efforts have been devoted to:

- nickel deposits in Western Australia;
- Yeelirrie-type uranium deposits in calcrete in Western Australia;
- the Jabiluka uranium orebody in the Alligator Rivers region of the Northern Territory;
- copper mineralization in the Mt Isa district;
- copper-lead-zinc sulfides associated with volcanic rocks in the eastern States; and
- the Pilbara iron ores.

In addition, CSIRO investigators are studying other metals that are in demand such as gold and tin, and strategic ores such as chromite, which are not currently produced in Australia. Much research is conducted jointly with company geologists familiar with the orebodies under consideration.

Research on ore genesis requires expensive instrumentation whose capital cost is beyond the reach even of larger companies. CSIRO has assembled an extensive range of analytical equipment, much of which also services its research programs on geochemical methods for mineral exploration. A recently purchased mass spectrometer allows isotopic measurements to be used in resolving problems relating to ore formation, for example by providing information that can be used for determining the age of mineralization or indicating its source, transport mechanisms and the conditions of ore deposition. CSIRO is installing a particle accelerator at its laboratories in the Sydney suburb of North Ryde which will offer new prospects in chemical analysis of minerals. Samples bombarded with heavy particles will reveal details about their composition and crystalline structure as well as their age and key diagnostic information for identifying and characterizing mineral deposits. The method will enable detection of ultra-low levels of trace elements that carry information relevant to both genetic studies and exploration. The Organization believes it is appropriate to make these costly facilities available to mining and exploration companies through collaborative research projects.

Exploration by Remote Sensing

Because much of Australia has only a sparse vegetation cover the resultant exposure of many of its geological features has provided an exceptional opportunity to minimize exploration costs through the use of remote sensing techniques. NASA's Landsat satellites have provided images of the continent that enable city-based geologists to direct ground-survey teams to promising regions for rock sampling. With a day in the field costing as much as six office days, this approach can result in substantial savings.

Early images of the Australian terrain were of poor quality because image generation and analysis systems developed for the relatively uniformly-toned landscapes of North America could not cope with the greater contrasts of Australia's surface. However, the novel computer techniques developed by CSIRO for recovering detail produce images of exceptional clarity. Where research in the USA emphasized the use of computers for image analysis, CSIRO took advantage of Australia's better geological exposure and adapted the skills of geologists already trained in airphoto interpretation.

Australia's expertise in Landsat technology has been tacitly acknowledged in the sale of CSIRO techniques and images back to the US Government and to several US companies. In Australia, six companies have installed their own Landsat viewing systems, and $0.5m worth of CSIRO-enhanced images are sold annually through licensed companies. Companies maintain secrecy on exploration successes, but these figures point to the probability that Australia leads the world in the practical use of Landsat imagery for mineral exploration. In the 1980s the challenge will be to apply Landsat-derived remote sensing technology to the direct detection of potential mineralization by low-flying aircraft.

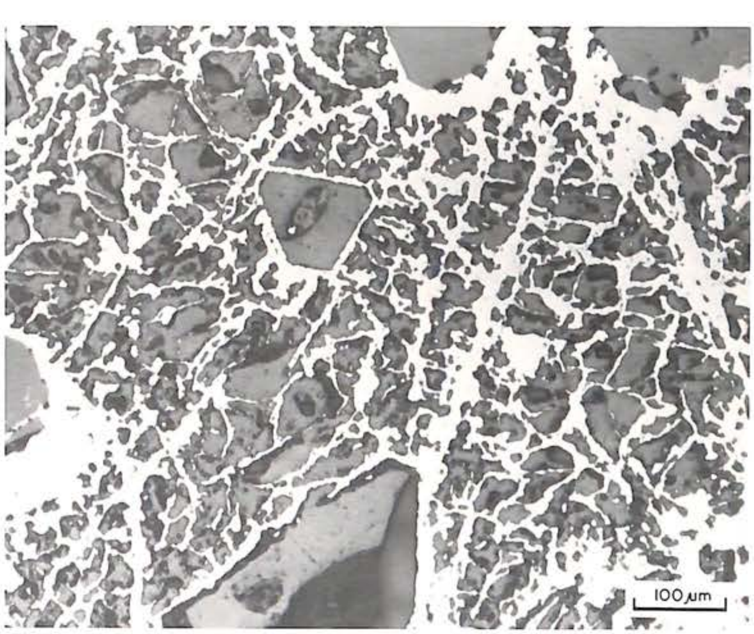
Chemical Detection of Orebodies

Until now, CSIRO's research on geochemical exploration methods has emphasized the problems created by weathering in the search for outcropping orebodies. Although much of Australia's land surface is relatively well exposed, it is deeply weathered, so that surface evidence of mineralization is commonly faint and difficult to interpret. Australian exploration geologists face difficulties not generally encountered by their counterparts in the northern continents, where recent glaciation and tectonic events provide greater exposure of fresh rock. However, weathering can also have beneficial effects, causing surface dispersal of the ores. Chemical analyses of samples from systematic surveys are more likely to indicate enlarged areas with a chemistry characteristic of an orebody.

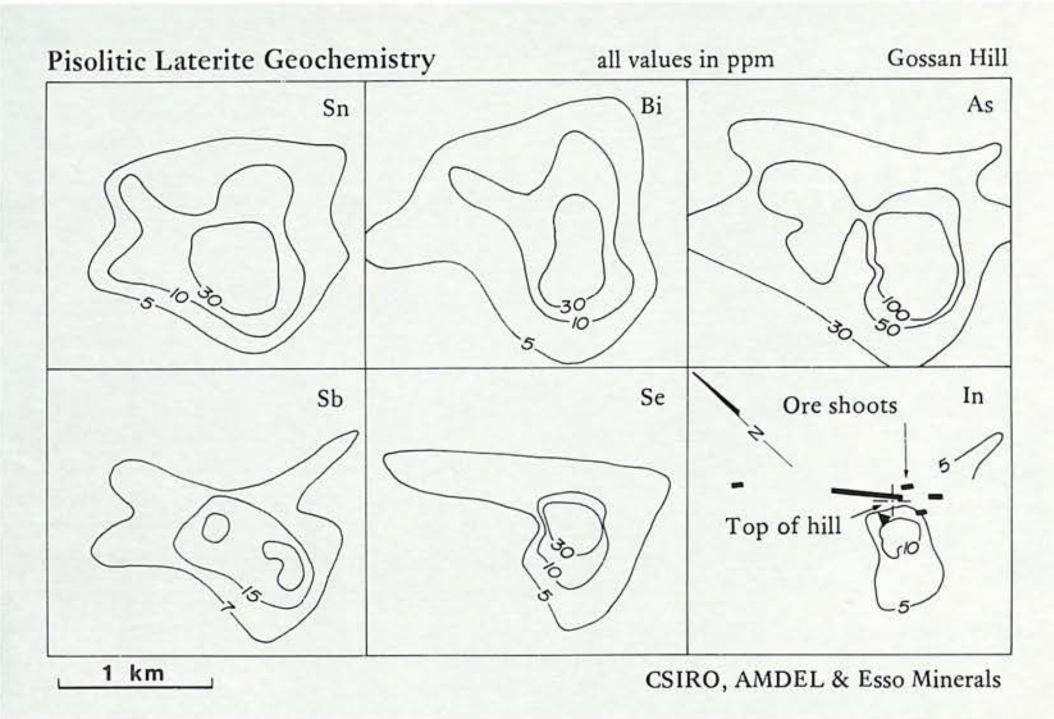
Geochemical methods—using traces of chemicals associated with particular ores—have been widely applied in Australian mineral exploration in the past two decades. The development of methodologies, however, has tended to be piecemeal without an obvious underlying theme, in part reflecting the diversity of mineral deposits and their weathering processes. With support from the Australian Mineral Industries Research Association (AMIRA), CSIRO has examined the diverse geochemistry of mineralizations in the Australian environment and the processes involved in ore genesis and weathering. A recent publication 'Conceptual Models in Geochemistry', has resulted from cooperation between CSIRO scientists and geochemists and geologists from the exploration industry and tertiary institutions. It comprises a representative set of 52 exploration case histories, assembled from largely unpublished data, from which nine idealized models for the Australian landscape have been derived as an aid to further exploration.

The presence of sulfide orebodies near the surface in Australia is commonly indicated by outcrops of gossan, an often nondescript brown rock produced by weathering of the upper part of the orebody. CSIRO has made detailed geochemical studies of gossans, directed at the problem of distinguishing those associated with economic mineralization from similar brown rocks formed over barren iron sulfides or from various types of ironstone.

Another approach to characterizing gossans, which is being developed by CSIRO in collaboration with AMIRA, is the use of subtle variations in lead isotope ratios. Gossans associated with ores have specific isotope patterns, while isotope ratios in barren ironstones are variable and unsystematic.



This photomicrograph of a polished section of gossan from the Whim Creek copper-zinc deposit in Western Australia shows the characteristic cellular structure preserved by leaching of the original massive chalcopyrite-sphalerite-pyrite (sulfide) assemblage by weathering, and its replacement by haematite. The technique indicates the presence of an orebody.

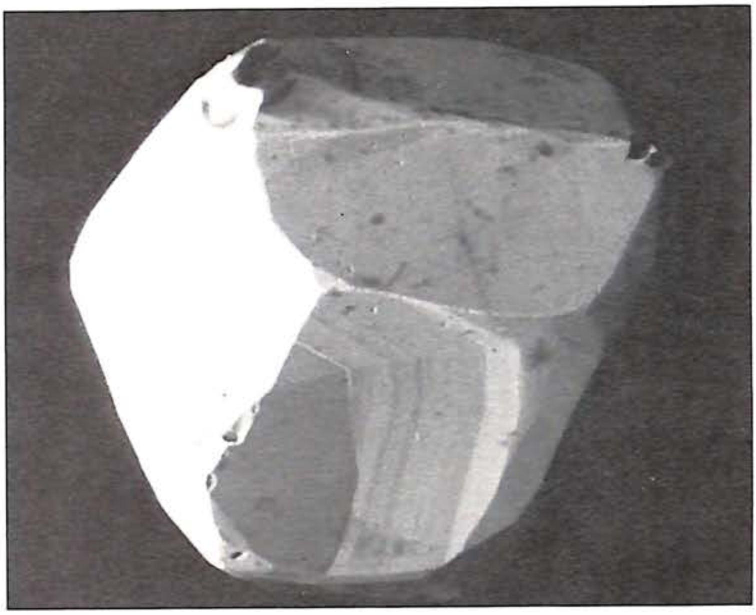


Maps of anomalously high concentrations of the elements tin, bismuth, arsenic, antimony, selenium and indium occurring in laterite surrounding a base metal gossan at Golden Grove in Western Australia. These trace elements can be found at much greater distances from the gossan than the major ore elements, resulting in much larger exploration targets.

Field studies and laboratory simulations of weathering processes have enabled the chemistry of gossans to be interpreted to indicate which type of deposit occurs beneath and whether it is likely to be economic. A theory that accords well with observation in the field suggests that sulfide deposits may behave as electrochemical cells that 'self-weather' to produce a characteristic surface chemistry.

It has been found that 'pathfinder' trace elements are often better indicators of ore potential than the actual metals being sought. In Australia, many areas with mineral potential are covered by a hard, iron-rich weathered crust called laterite, which obscures the underlying geology. CSIRO has shown that telltale assemblies of pathfinder elements occur in laterite overlying the Golden Grove orebodies in Western Australia. This low-cost approach to exploration, which can involve taking less than one sample per hectare, is suited to a wide variety of buried orebodies and promises to provide information about the mineral potential of large tracts of land that are mostly unexplored.

Looking to the future, CSIRO is increasing its activity in applying geochemical methods to the search for buried orebodies–those covered by younger rock layers or masking features such as floodplains, inland drainage channels and windblown sands–and blind orebodies–those completely concealed within bedrock. Geochemical methods are particularly effective in the search for hidden ore bodies if traces of chemical features of the ores or host rocks extend through the cover and can be identified in samples from the surface, or from shallow exploratory drill holes. In the



A crystal of platinum arsenide separated from Kambalda nickel ore. Although only about 0.2 mm in diameter, sufficiently large numbers of these crystals occur in ore to suggest they may be recovered economically in the ore treatment circuit. Previously platinum was thought to be dispersed only in atomic quantities throughout the ore, preventing its recovery. Discovery of this discrete phase by CSIRO opens the way to production of millions of dollars' worth of this element.

immediate future, much exploration activity will still need to be directed to the search for ore extensions in the vicinity of known mineralization, using geochemical indicators to find drilling targets.

CSIRO is investigating the use of features called primary dispersion haloes which may occur in rocks surrounding hidden orebodies. Distinctive groupings of elements or telltale ratios between isotopes of a single element, detected through drilling or by analysis of surface samples, may indicate the presence of an orebody. Amid a diverse array of ore types, priority is being given to haloes around tin deposits associated with granites and skarns in eastern Australia, and to base metal sulfide deposits within volcanic rocks in Tasmania.

In association with AMIRA, CSIRO is investigating other novel techniques for locating buried and blind orebodies.

One area of promise is hydrogeochemistry–the analysis of water that may have been in contact with deep mineral deposits. Overseas research has emphasized the usefulness of stream and lake waters, but because of the relative scarcity of perennial surface water in Australia, research is being directed to underground water. Australia is fortunate in having springs and station bores available for sampling waters which potentially drain extensive areas and which circulate to depths where they might contact concealed orebodies.

Instrument Development

CSIRO is developing portable instruments for the rapid determination of important characteristics in groundwater. One such instrument is a portable analyser capable of detecting very low levels of metals in groundwater. Another, which is under development, is a downhole probe for measuring the acidity, oxidation potential and salinity of water, data which provide a basis for interpreting the chemical message in the water sample.

Concealed orebodies may also be detectable by the presence of vapours emanating upwards as a result of reactions between water and the deposits, and either entering the atmosphere or binding to surface minerals. CSIRO has developed a portable instrument for detecting anomalous concentrations of one such mobile element, mercury, which is a trace element associated with various ore types. SIROMAN (CSIRO Mercury Analyser), now undergoing commercial development by SIE Australia Pty Ltd in Brisbane, is based on the atomic absorption principle.

Field tests have shown that the use of mercury alone as a volatile 'pathfinder' element is complicated by environmental influences that affect its mobility. CSIRO is thus moving towards a multi-component approach in which other mobile elements and vapours might be used in combination. Weathering products such as sulphur dioxide, hydrogen sulfide and carbon dioxide offer possible pathfinders to metallic sulfide deposits. Another gas, helium, has wider potential because it is also associated with natural gas deposits and uranium ores. Development is proceeding on a portable helium analyser.

A portable polarographic analyser developed and constructed by CSIRO in Perth rapidly analyses groundwaters or solutions of minerals for the presence of base metals and gold at levels below the parts-per-million range. The instrument is believed to be the first of its type in the world, and has attracted international interest. Discussions are proceeding with a potential commercial manufacturer.

Analysing Geological Samples

The ability to obtain precise, highly sensitive, cost effective analyses is vital to geochemical exploration. Improvements in analytical methodology promise substantial savings in future exploration costs. The invention by CSIRO of atomic absorption spectrophotometry was a major factor in the expanded application in Australia of geochemical exploration methods in the 1960s and 1970s.

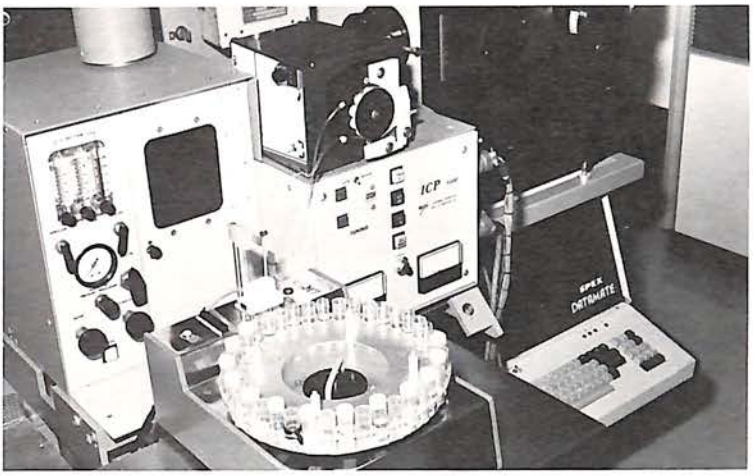
The Organization regards the development and testing of analytical instruments as an important contribution to the exploration industry. Several examples, particularly portable analysers of several types, have already been mentioned. Another versatile technique is plasma-excited optical emission spectroscopy, which promises revolutionary changes in the scope and cost of geochemical exploration. Application of this method to typical geochemical samples is being investigated, and in association with the Australian Mineral Development Laboratories (AMDEL), a set of standard rock, ore and soil samples has been prepared by companies employing the method.

Physical Properties of Orebodies

The late 1970s saw a major advance in tactical exploration technology with the development of SIROTEM (CSIRO Transient Electromagnetics), a device for detecting orebodies buried at depths of up to 100 metres. SIROTEM relies on the fact that a metallic orebody, being electrically conductive, will betray its presence through an induced magnetic signal if an electrical current is passed through it. Overseas devices employing a similar principle proved incapable of detecting an orebody's signal against background electromagnetic 'noise' caused by the high level of conductive salts in Australian soils. SIROTEM represents a new concept, the product of basic studies, in which a portable computer is used to sift out the orebody's signal by averaging out the results of several thousand extremely rapid pulses sent into the orebody.

Design and development of a prototype took only two years, and in 1977 SIROTEM was released to industry through the Adelaide-based company, Geoex. SIROTEM offers a 50-fold increase in sensitivity over previous instruments, and has rapidly become a workhorse of geophysical exploration in Australia. More than 35 units have been made and many have been sold overseas. Development is proceeding on an even more sensitive device which should be capable of detecting orebodies at depths of up to 300 metres.

The greater sensitivity of SIROTEM has stimulated other research. Firstly, it has provided a research tool par excellence for conducting research into the electrical properties of Australian soils and rocks, and this in turn has assisted exploration geophysicists to interpret their field surveys better. Secondly, it has necessitated the development of improved mathematical techniques for the interpretation of field data. With the assistance of 16 mining companies and the Australian Mineral Industries Research Association (AMIRA), CSIRO has set up a mathematical modelling program based on a modern 'largemini' computer.



CSIRO uses this new direct reading optical spectrometer for the rapid analysis of up to 40 elements at a time. Dissolved samples from the vials are sprayed into a chamber where a high temperature electrical discharge excites their component elements to produce spectra for analysis.

While SIROTEM is ideal for many ores, there are some that are not sufficiently conducting to be detected. Another electrical technique, called induced polarization (IP), permits their detection. In recent years, therefore, CSIRO has sought to improve the utilization of IP in the Australian environment for both mineral and petroleum exploration.

The earth's magnetic field gives the exploration geophysicist one of his most fruitful insights into the rocks and minerals buried under the ground. Consequently, CSIRO has established a world-standard rock magnetism laboratory at North Ryde. The magnetic properties of minerals, and the methods for measuring magnetic properties of rocks have been studied, and a method has been developed to determine the temperature experienced by rocks in the far distant past. The magnetic properties of rocks also betray the past wanderings of our continent across the earth's surface, and the CSIRO laboratory has shown that Australia appears to have been formed from a number of smaller prehistoric land masses with mineral formations occurring in zones where they were once joined to other continental fragments. Determining the ancient positions of these pieces may yield clues to mineral explorers. Rock magnetic studies are also assisting mineral companies to narrow down search options through elucidation of regional geological histories.

Nuclear physics also offers the mineral explorer a number of techniques that both increase his ability to detect buried orebodies and reduce his exploration costs. A good example is the use of the isotopes of radium in the exploration for uranium. CSIRO has developed a technique based on solid state physics to differentiate the various isotopes, which provides an indication of the presence of uranium nearby.

Nuclear physics also provides the means of obtaining more information from the drill-holes that the explorer must make at great cost. CSIRO has developed a series of tools that use gamma rays and neutrons to measure the mineral content of the rock surrounding a borehole. These tools, christened Sirolog, have been licensed to two Adelaide companies for commercial manufacture.

16. Standards of measurement

Man's need to know 'how many?' and 'how much?' seems to have kept pace with his technological progress. Measurement gives the answers to these questions, originally via the unaided human senses and brain, now by means of instruments and techniques which provide greater sensitivity, range, accuracy, precision and speed.

All measurements involve comparing a particular characteristic with a standard value. Standards have ranged from the length of a king's forearm, or the length of a certain piece of metal, to the wavelength of a particular type of light. In all cases, the measurement is limited by the accuracy with which the standard has been determined.

These days, our society owes much of its sophistication to the fact that standards, and hence measurements, can be determined with very little uncertainty, that is, with a high degree of precision. Nowhere has this been more apparent than in manufacturing industry, where the manufacture of goods ranging from supersonic aircraft to paper clips requires accurate machines and properly controlled processes. Industry achieves this degree of accuracy only by being able to make precise measurements when and where they are needed. Because standards, and hence measurements, are based on universally accepted definitions, technical information and manufactured products can move freely around the world.

To give some indication of a nation's current dependence on measurement, the United States spends an estimated six per cent of its Gross National Product on making measurements. All developed countries have evolved national measurement systems to ensure that measurements throughout the country are consistent and in the best possible agreement with measurements in other countries. A vital component of each national system is a National Standards Laboratory whose main functions are to maintain accurate standards of measurement for a wide range of physical quantities and to provide the nation with a first-level calibration service.

The international arrangements for promoting uniformity of measurements are, in fact, relatively old when compared with modern industry. In 1875, 17 nations signed the Metric Treaty which established an international laboratory near Paris and a system of committees to determine uniform units and standards of measurement. Now, 45 member nations participate in the Metric Treaty, including Australia. Responsibility for the maintenance of Australia's physical standards of measurement rests with the Division of Applied Physics, based at the National Measurement Laboratory in the Sydney suburb of Lindfield.

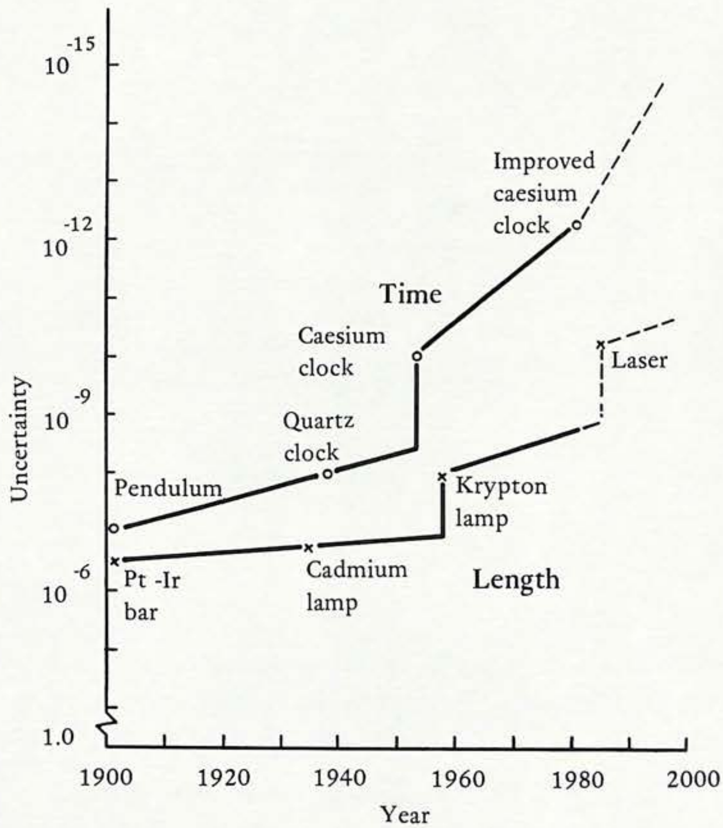
Standards of Physical Quantities in Australia

Until the turn of the century, standards of measurement in Australia mostly concerned quantities of use in commerce, and these were then expressed in units such as the pound, yard and gallon. Each State maintained its own standards, with little attempt being made to compare the standards with each other. With the development of scientific work and secondary industry after World War I, politicians and industrialists realized that deficiencies in standards of measurement were causing considerable problems.

Since World War II, the needs of a more sophisticated society have made the existence of a standards laboratory even more essential to Australia. The Weights and Measures (National Standards) Act was passed in 1948, requiring CSIRO to maintain, or cause to be maintained, standards for all the physical qualities for which there are legal units of measurement. In addition, the maintenance of Australia's standards of measurement was included in the Science and Industry Research Act as one of the functions of CSIRO.

These statutory obligations were carried by the CSIRO National Standards Laboratory between 1938 and 1974, when an amalgamation of the two component Divisions resulted in a change of name to the National Measurement Laboratory. This name was changed to the Division of Applied Physics in 1979 to reflect more closely the Division's wider role in applied physics research relating to problems in industry and the community.

Improvements in the standards of time and length



M. J. Mulcahy, PhD, Head, Special Services Branch, Department of Conservation and Environment, Western Australia

J. B. Oliver, FAIM, General Manager (Projects), Western Mining Corp. Ltd

W. T. Peart, Managing Director, Vickers Hoskins Pty Ltd

J. Shepherd, BSc, Farmer and Agricultural Scientist

Professor R. Street, DSc, FAA, Vice-Chancellor, University of Western Australia

J. P. Brophy, MBE (*Secretary*), Regional Administrative Officer, CSIRO, Perth

Tasmanian State Committee

Professor P. Scott, OBE, PhD (*Chairman*), Pro Vice-Chancellor and Professor of Geography, University of Tasmania

J. R. Ashton, BCivilEng, Commissioner, Hydro-Electric Commission, Tasmania

Professor D. Caro, OBE, PhD, LLD, Vice-Chancellor, University of Tasmania

M. C. P. Courtney, Editor, Launceston 'Examiner'

R. J. Downie, Grazier

P. J. Fountain, BSc, Director, Tasmanian Department of Agriculture

A. G. Kemp, AASA, Managing Director, Kemp & Denning Ltd

J. B. Piggott, CBE, LLB, Senior Partner, Piggott, Wood & Baker

J. G. Symons, BE, Former Director of Mines, Tasmania

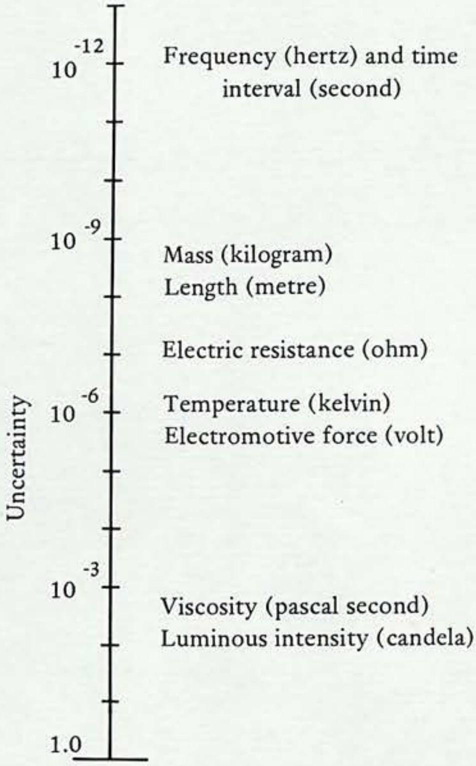
P. T. Unwin, DipFor, MIFA, Chief Commissioner, Forestry Commission

Captain D. M. Waters, MSc, Principal, Australian Maritime College

B. Wilson, MSc, Research Manager, Goliath Portland Cement Co.

G. B. Stirk, BSc (*Secretary*), Officer-in-Charge, CSIRO Tasmanian Regional Laboratory

Accuracy of measurement of some of the standards maintained by the Division of Applied Physics



A major function of the Division continues to be establishing and maintaining standards of measurement of physical quantities and disseminating them by means of a calibration service. This work inevitably gives rise to considerable expertise in applied physics, and the Division applies this expertise to other lines of physical research to broaden its support for the community.

For a laboratory of its size, the Division of Applied Physics (under its former titles) has an enviable record of significant advances in physical metrology. The technology explosion after World War II provided quite exceptional research opportunities which the Division was able to take full advantage of: it was in the process of setting up its own standards for the first time and therefore not restricted by traditional methods.

Primary standards developed by the Division can be separated into three categories. The first and oldest of these categories is the material standard, for example, a metal bar given an assigned length or weight. Several of these quantities were originally maintained by the Division: now only the standard of mass is maintained in this fashion. The majority of standards fall into the second category based on the properties of atoms, molecules, elements or compounds, properties that are stable with time, recoverable in the event of damage or loss, and readily available. An example of this type of standard is the caesium-beam atomic clock, which uses a specified resonance of caesium atoms as a reference for a quartz-crystal oscillator. Into the third category fall those standards that are based on assigned values of fundamental physical constants: the calculable capacitor, devised in the Division and now an international standard, is an excellent example, capacitance being related to length by the speed of light.

Using these techniques, the Division measures such quantities as electrical resistance and potential with an uncertainty of less than one part in ten million, establishes the wavelength of a laser beam to ten parts in a million million, and determines intervals of time with an uncertainty of less than one part in a million million.

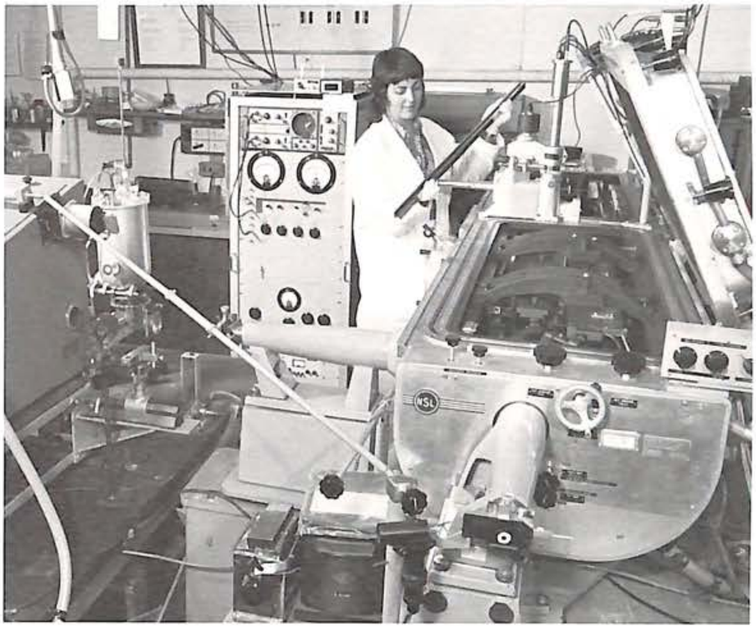
The Division maintains Australia's standards for the physical quantities shown in Table 1. In addition to these, CSIRO has authorized the Australian Atomic Energy Commission and the Australian Radiation Laboratory of the Commonwealth Department of Health to maintain the Australian standards for quantities relating to ionizing radiation, such as radioactivity, exposure, and absorbed dose. It has also authorized the Division of National Mapping of the Department of National Development and Energy and Telecom Australia to maintain working standards of time interval and frequency, and atomic clocks in those organizations and in the Division of Applied Physics are compared regularly.

The Division moved to the present National Measurement Laboratory at Lindfield in 1978. Designed to meet the highest international standards of measurement, the new laboratory experiences minimal vibration and interference from electromagnetic radiation from outside sources, and laboratory temperature can be maintained to within half a degree centigrade. In addition to its Lindfield headquarters, the Division has branches in Melbourne and Adelaide to make its expertise available to local industry.

The Division has a policy of restricting its calibration activity, wherever possible, to the reference standards of other laboratories, and of promoting the development of a national calibration network. In this network, Divisional scientists collaborate closely with the following organizations:

- The National Association of Testing Authorities (NATA). Through its laboratory accreditation scheme, NATA now includes over 1100 member laboratories in industry, government and education. NATA requires the measurements of its members to have effective traceability to the national standards where this is appropriate. Many NATA laboratories also act as secondary calibration centres.
- The National Standards Commission and the States' Weights and Measures authorities. These authorities are largely concerned with the legal aspects of metrology encountered in commerce, and with consumer protection. Together with a large number of verifying authorities appointed under the Weights and Measures (National Standards) Act, they facilitate the

application of the national standards to the needs of commerce. The Defence Calibration Committee. This Committee coordinates the calibration requirements and policies of the defence services and the related government laboratories and factories. CSIRO's responsibility in this area has been considerably increased since 1978 when the Department of Defence ended its own program on first-level standards. By agreement between CSIRO and the Department, the Division of Applied Physics became the principal calibration laboratory for defence purposes.



The metre is defined in terms of the wavelength of a particular orange-red radiation emitted from a Krypton-86 discharge lamp. The standard of length at the Division of Applied Physics is maintained by means of an interferometer in which line scales can be compared directly with this wavelength. Developments in stabilized lasers indicate that they can provide wavelength standards of greatly improved reproducibility and are being investigated further.

Principal physical quantities for which standards are maintained by the Division of Applied Physics

Length	Time interval	Luminous flux
Angle	Frequency	Illuminance
Mass	Electromotive force	Luminance
Volume	Electrical resistance	
Density	Electrical capacitance	
Force	Electrical inductance	
Power	Temperature	
Pressure	Viscosity	
Acceleration	Luminous intensity	

The Division also maintains standards for many other physical quantities, including those relating to hardness, hygrometry, acoustics and magnetism.

Thus, measurements made by manufacturers, scientific laboratories and other sections of the community can be traced to the national standards through several avenues.

In the interests of overseas trade, the Division collaborates with national standards laboratories overseas, both directly and through the Metric Treaty. The Division has also responded to the needs of countries in the South-east Asian/Pacific region by providing guidance and assistance to them in developing their measurement systems. On behalf of the Division, CSIRO has:

- negotiated with the Australian Development Assistance Bureau a three-year contract for providing national laboratories in regional countries with relevant advice, training and calibrations; and
- accepted, for the period 1980-83, the role of Coordinator for the Commonwealth Science Council's Regional (Asia/Pacific) Metrology Program, and has agreed to host a major review conference in 1982.

Uses of Measurement Technology

The accuracy of standards usually improves in two ways: either as a result of fundamental advances in physics which lead to spectacular leaps forward or through opportunities afforded by new technology which lead to less spectacular but still significant advances. Both types of progress have been evident in the history of metrology.

For example, when the period of rotation of the Earth determined the standard of time, the best attainable accuracy of one part in 10 million then satisfied users. The accuracy of atomic clocks then made a dramatic improvement, increasing initially by a factor of 1000. At the time, this new accuracy seemed far greater than required by the principal users. Scientists soon developed new, and previously unforeseen, uses in other technological areas for the higher accuracy standards. This work on standards of frequency and time by the Division and other national standards laboratories includes applications in surveying, navigation (Omega and other military and civil systems), astronomy, very long-base line interferometry (for example, in measuring continental drift), and high-speed digital communication.

Application of measurement technology by the Division of Applied Physics has not only involved the use of the standards themselves, but also the know-how gained while working in this demanding research area. In this way, the Division can be credited with first introducing cryogenics (very low temperature) technology to Australia through its research on temperature standards at very low temperatures and on related solid-state research.

The Division has helped Australia maintain a leading position in radioastronomy. It applied modern techniques of engineering metrology, developed during work on standards of length, to CSIRO's 64-metre radio telescope at Parkes, NSW. Operated by the Division of Radiophysics, this radio telescope was originally built for use at a wavelength of 21 centimetres, with a reflecting dish geometrically suited to that wavelength. Scientists from the Division of Applied Physics devised a precise measurement system which guided modifications to the dish, extending the radio telescope's capability to wavelengths of only a few millimetres.

Research on the Josephson junction, a device operated at cryogenic temperatures to provide the standard volt, has led to two applications. Firstly, methods have been developed in the Division for comparing electric currents with an unprecedented accuracy. Secondly, the Josephson junction is being examined as a possible improved microwave detector for use in radio telescopes in a joint program with the Division of Radiophysics.

Of a less esoteric nature, but equally important to Australia, the expertise developed by researchers in measuring standards of mass, volume and density has been applied to the measurement of oil flow in Bass Strait. The Division of Applied Physics has acted as a consultant in this area.

In keeping with its broader orientation towards industry, the Division has been able to apply techniques and skills developed through its research in standards to investigations of problems encountered in industry. One such investigation has been to determine the effects of heat produced by head-light beams of coal-mining machines in use by the New South Wales Department of Mines. Several fires had been attributed to the ignition of cellulous material either by radiant heating from the beam or by direct contact with a lamp lens. Studies were conducted on lens temperatures of, and irradiances produced by, lamps currently in use; the Division recommended that the use of a certain class of lamps be discontinued.

Another application in the field of optics was a study of special optical thin films, the production of which is essential for

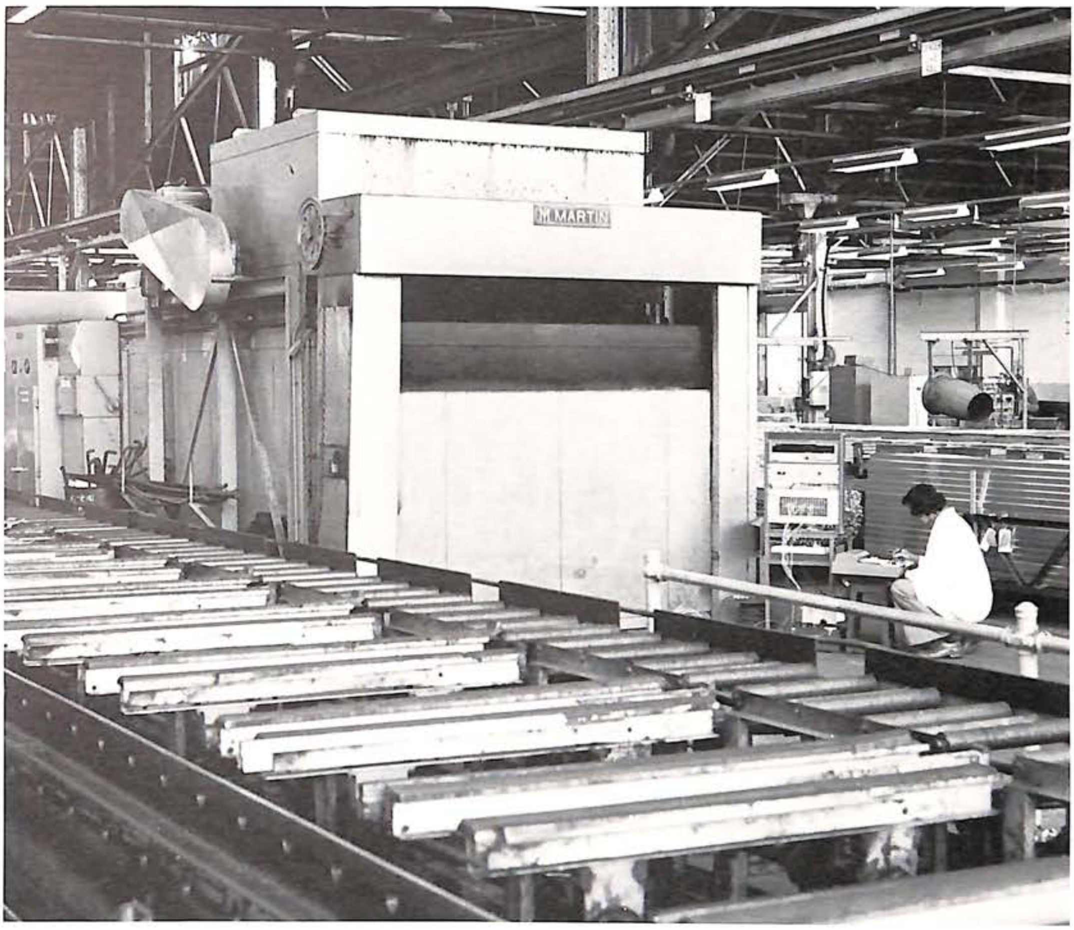
The calculable capacitor used as a basis for electric impedance standards.

Measuring the temperature distribution in an industrial furnace. An extremely accurate knowledge of the temperature distribution within an industrial furnace is often essential for the heat treatment of products, for evaluating the efficiency of energy utilization in a furnace installation or for understanding the reasons for product failures. The Division of Applied Physics makes in situ *measurements of temperature distributions within furnaces to help solve a great variety of industrial problems.*

high-precision laser metrology in standards research. Thin film surfaces have been produced for Sola Optical Australia Pty Ltd in Adelaide for their commercial version of a high-resolution, servo-controlled interferometer previously designed by the Division of Applied Physics. Specialized coatings have also been prepared for the Anglo-Australian Telescope, and assistance with the coatings of spectacle lenses has been given to firms such as OPSM Industries Ltd.

Extensive experience in temperature and humidity research has enabled the Division to advise Leeton Steel Pty Ltd on the design of a system that automatically controls forced ventilation in wheat silos. The absorption of moisture by grain had caused the demolition of a silo and the loss of some 5000 tonnes of wheat.

The deterioration of the surface finish of extruded aluminium when the speed of extrusion was increased during the long production runs presented the Division with another temperature-related problem. No commercially available instrumentation existed which could measure and record the temperature of an aluminium section immediately on exit from a press. A light-weight contact thermo-



couple, in which the measuring junction was embedded in a graphite button, was subsequently developed. A series of measurements taken during actual production indicated that no direct correlation existed between surface deterioration and surface temperature. More recent research has resulted in the development of a non-contact, multi-wavelength pyrometer capable of measuring the temperature of hot, moving surfaces. The pyrometer achieves this by measuring the energy radiated from the surface. When coupled with knowledge of the type of surface, the temperature can be calculated.

Another problem that the Division has solved is the calibration of miniature ceramic-encapsulated platinum resistance thermometer elements, which are capable of excellent accuracy over a very wide range of temperatures. In the past, calibration of these devices was only possible with the use of very expensive equipment. A new a.c. resistance bridge has been developed in conjunction with Leeds and Northrup (Australia) Pty Ltd, and is now manufactured and distributed by that company.

Other devices developed by the Division include an inexpensive leakage detector for microwave ovens, now manufactured under licence to CSIRO, and a portable standard cell enclosure marketed by Elmeasco Instruments Pty Ltd both within Australia and overseas.

Investigations involving electrical expertise include modifications to a commercially-produced capacitance bridge used in electrostatic precipitation in smelters, advice on the construction of ratio transformers designed to assist in the calibration of instruments, elimination of static electricity in bulk cement, and measurement of large currents which occur during the operation of a furnace.

In the area of engineering metrology, the measurement of surface roughness has found application in wheel-bearing failure in diesel locomotives. Bearing failure occurred in heavily laden wheel bearings immediately after being put into service by Hamersley Iron Pty Ltd in Western Australia. The cause of the failure was determined as being due to incorrect roughness of the bearing surface brought about by inadequate measuring techniques during manufacture. Another application of the Division's expertise in surface roughness was the development of a non-contacting optical instrument for recording the profiles of working surfaces on sugar-cane rollers during normal crushing operations.

Thus, the accumulated expertise developed by the Division of Applied Physics in more than 40 years as Australia's national standards laboratory is being harnessed for the benefit of all sections of manufacturing industry. Continuing work in developing standards of measurement will ensure that Australian industry can take advantage of some of the most sophisticated measurement techniques in the world.

Appendices

Appendix I

Executive Members and senior staff

The following is a list of Members of the Executive, Directors of Institutes, Chiefs of Divisions and Officers-in-Charge of Units, together with senior staff of Central Administration, Overseas Offices and Regional Administrative Offices.

EXECUTIVE

Chairman and Chief Executive

J.P. Wild, CBE, ScD, FTS, FAA, FRS

Full-time Members

N.K. Boardman, ScD, FAA, FRS
W.J.McG. Tegart, PhD, FTS

Part-time Members

D.P. Craig, DSc, FAA, FRS
W.L. Hughes, CBE, DPhil
H.M. Morgan, LLB, BCom
R.K.R. Morris, BComm
P.D.A. Wright

INSTITUTE OF ANIMAL AND FOOD SCIENCES

Director	K.A. Ferguson, PhD, FTS
Divisions	**Chiefs**
Animal Health	A.K. Lascelles, PhD
Animal Production	T.W. Scott, PhD
Fisheries Research	B.D. Stacy, PhD (*Acting*)
Food Research	J.H.B. Christian, PhD, FTS
Human Nutrition	B.S. Hetzel, MD
Units	**Officers-in-Charge**
Centre for Animal Research and Development	R.H. Wharton, PhD, FAA
Molecular and Cellular Biology	G.W. Grigg, ScD
Wheat Research	E.E. Bond, MBE, ARMTC

INSTITUTE OF BIOLOGICAL RESOURCES

Director	M.V. Tracey, AO, MA, FTS
Divisions	**Chiefs**
Entomology	D.F. Waterhouse, AO CMG DSc FAA FRS
Forest Research	J.J. Landsberg, PhD
Horticultural Research	J.V. Possingham, DSc, FTS
Irrigation Research	D.S. Mitchell, PhD (*Acting*)
Land Resources Management	R.A. Perry, MSc, FTS
Land Use Research	R.J. Millington, PhD, FTS
Plant Industry	W.J. Peacock, PhD, FAA
Soils	A.E. Martin, DAgrSc
Tropical Crops and Pastures	E.F. Henzell, DPhil, FTS
Wildlife Research	C.H. Tyndale-Biscoe, PhD (*Acting*)

INSTITUTE OF ENERGY AND EARTH RESOURCES

Director	I.E. Newnham, AO, MBE, MSc, FTS
Divisions	**Chiefs**
Applied Geomechanics	K.G. McCracken, DSc, FTS (*Acting*)
Energy Chemistry*	P.G. Alfredson, PhD
Energy Technology*	D.C. Gibson, PhD (*Acting*)
Fossil Fuels	Professor A.V. Bradshaw, BSc, FTS
Mineral Chemistry	D.F.A. Koch, PhD, FTS
Mineral Engineering	D.F. Kelsall, PhD, FTS
Mineral Physics	K.G. McCracken, DSc, FTS
Mineralogy	A.J. Gaskin, MSc, FTS
Unit	**Officer-in-Charge**
Physical Technology	E.G. Bendit, PhD

INSTITUTE OF INDUSTRIAL TECHNOLOGY

Director	Professor Emeritus H.W. Worner, AO, DSc, FTS
Divisions	**Chiefs**
Applied Organic Chemistry	D.H. Solomon, DSc, FTS, FAA
Building Research	F.A. Blakey, PhD
Chemical Technology	H.G. Higgins, DAppSc, FTS
Manufacturing Technology	R.H. Brown, BMechE, SM
Mechanical Engineering**	B. Rawlings, PhD
Protein Chemistry	W.G. Crewther, DSc
Textile Industry	D.S. Taylor, PhD, FTS
Textile Physics	A.R. Haly, DSc

INSTITUTE OF PHYSICAL SCIENCES

Director	J.R. Philip, DSc, FAA, FRS
Divisions	**Chiefs**
Applied Physics	J.J. Lowke, PhD
Atmospheric Physics	G.B. Tucker, PhD
Chemical Physics	L.T. Chadderton, DSc
Cloud Physics	M.J. Manton, PhD (*Acting*)
Computing Research	P.J. Claringbold, PhD
Environmental Mechanics	D.E. Smiles, DScAgr
Materials Science	J.R. Anderson, ScD
Mathematics and Statistics	C.C. Heyde, DSc, FAA (*Acting*)
Oceanography	A.D. McEwan, PhD
Radiophysics	R.H. Frater, PhD
Unit	**Officer-in-Charge**
Australian Numerical Meteorology Research Centre	D.J. Gauntlett, PhD

BUREAU OF SCIENTIFIC SERVICES

Director	S. Lattimore, BSc, ARCS
Units	**Officers-in-Charge**
Central Information, Library and Editorial Service	P.J. Judge, MA
Centre for International Research Cooperation	A.F. Gurnett-Smith, BAgrSc
Commercial Group	P.A. Grant, FRMIT
Science Communication Unit	B.J. Woodruff, BSc(For) (*Acting*)

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* Will be established on 1 September 1981.
** Will cease to exist on 1 September 1982.

PLANNING AND EVALUATION ADVISORY UNIT

Director	D.E. Weiss, OBE, DSc, FTS, FAA

OFFICE OF THE EXECUTIVE

Executive Secretary	L.G. Wilson, AO, MSc
Deputy Executive Secretary	J. Coombe, OBE

FINANCE AND ADMINISTRATION

Secretary	H.C. Crozier, BA
Deputy Secretary	K.T. Smith, BCom, AASA

PERSONNEL

Secretary	K.J. Thrift, BA
Deputy Secretary	(*To be appointed*)

OVERSEAS OFFICES

Minister (Scientific) London	A.E. Pierce, CBE, DSc
Counsellor (Scientific) Tokyo and Seoul	T.D. Grace, PhD
Counsellor (Scientific) Washington	R.D. Brock, PhD

REGIONAL ADMINISTRATIVE OFFICES

Brisbane	D.B. Thomas, BA
Canberra	G.A. Cave, BCom, AASA
Melbourne	W.C. Hosking, AASA, ACIS
Perth	J.P. Brophy, MBE
Sydney	T.C. Clark, AASA, ACIS

Appendix II

Advisory Council and State Committee members

ADVISORY COUNCIL

Chairman

Sir Victor Burley, CBE, BE, (until January 1981), former Resident Director of Cadbury Schweppes Pty Ltd

Sir Peter Derham, BSc, FAIM, FDIA, (since February 1981), former Managing Director, Nylex Corporation Ltd

Chairmen of State Committees

A. Boden, BSc, *Chairman*, Hardman Chemicals Pty Ltd (*New South Wales*)

L. C. Brodie-Hall, CMG, AWASM, Company Director (*Western Australia*)

K. E. Gibson, BSc, (until September 1980), former Managing Director and Deputy Chairman of ACF & Shirleys Fertilizers Ltd (*Queensland*)

E. P. S. Roberts, CMG (*Acting Chairman*) (since October 1980), Grazier (*Queensland*)

J. E. Harris, BEng, Managing Director, Adelaide & Wallaroo Fertilizers Ltd (*South Australia*)

J. E. Kolm, IngChemEng, Consultant and Company Director (*Victoria*)

Professor P. Scott, OBE, PhD, Pro Vice-Chancellor and Professor of Geography, University of Tasmania (*Tasmania*)

Other members

Professor L. M. Birt, CBE, DPhil, Vice-Chancellor, University of Wollongong

V. A. Brown, MSc, PhD, (since September 1980), Lecturer, Centre for Adult Teaching, Canberra College of Advanced Education

N. S. Currie, CBE, BA, Secretary, Department of Industry and Commerce

Sir Peter Derham, BSc, FAIM, FDIA, (from August 1980 to January 1981), former Managing Director, Nylex Corporation Ltd

L. P. Duthie, BCom, (since September 1980), Secretary, Department of Primary Industry

J. L. Farrands, PhD, FTS, Secretary, Department of Science and Technology

Professor F. J. Fenner, CMG, MBE, MD, FAA, FRS, former Director, Centre for Resource and Environmental Studies, Australian National University

Professor P. T. Fink, CBE, BE, FTS, Chief Defence Scientist, Department of Defence

J. H. S. Heussler, Grazier

B. O. Jones, MA, LLB, ACTT, MP, (since May 1981), Member for Lalor

Professor P. H. Karmel, AC, CBE, PhD, LLD, DLitt, Chairman, Tertiary Education Commission

J. C. Kerin, BA, MP, (until February 1981), Member for Werriwa

G. A. Letts, CBE, DVSc, Director, Conservation Commission of the Northern Territory

Sir Ian McLennan, KCMG, KBE, DEng, Chairman of companies and former Chairman of Broken Hill Proprietary Co. Ltd

J. A. Michael, BE, Executive Director, Association of Professional Engineers of Australia

B. W. Scott, DBusAdm, Managing Director, W. D. Scott and Co. Pty Ltd

Senator A. M. Thomas, Western Australia

A. J. Woods, BEc, Secretary, Department of National Development and Energy

Observers

Professor Sir Geoffrey Badger, AO, DSc, FTS, FAA, Chairman, Australian Science and Technology Council

I. Castles, OBE, BCom, (since May 1981), Secretary, Department of Finance

J. H. Garrett, OBE, BCom, (until February 1981), Deputy Secretary, Department of Finance

J. P. Wild, CBE, ScD, FTS, FAA, FRS, Chairman, CSIRO

Secretariat

G. D. McLennan, BCom, Secretary

R. M. G. Brown, BA, Assistant Secretary

Mrs B. Magi, Administrative Assistant

STATE COMMITTEES

New South Wales State Committee

A. Boden, BSc (*Chairman*), Chairman, Hardman Chemical Industries Pty Ltd

D. G. Badger, PhD, Consultant

C. S. Barnes, PhD, Manager, Chemistry, Biotechnology Australia Pty Ltd

W. J. Hucker, OBE, Chairman, Air Programs International Pty Ltd

D. J. McGarry, BSc, Managing Director, Australian Oil & Gas Corp.

D. G. MacLennan, PhD, Chairman, Biotechnology Australia Pty Ltd

H. E. Mitchell, Assistant General Secretary, Miscellaneous Workers Union

C. H. Monk, AM, FIE, FAIM, Chairman, New South Wales Board of Education

G. R. Peart, MRurSc, Agricultural Consultant

D. A. J. Swinkels, PhD, Minerals Process Research Manager, Broken Hill Proprietary Co. Ltd

N. R. Tieck, Company Director and Consultant

N. A. Whiffen, FRACI, MSc, Managing Director, Nethel Pty Ltd

T. C. Clark, AASA, ACIS (*Secretary*), Regional Administrative Officer, CSIRO, Sydney

Victorian State Committee

J. E. Kolm, IngChemEng (*Chairman*), Consultant and Company Director

J. D. Brookes, MC, MSc, Director of Conservation, Ministry for Conservation, Victoria

A. J. Farnworth, MBE, PhD, Chief General Manager, Australian Wool Corporation

A. G. Gibbs, AO, BE, Chairman, Victorian Railways Board

R. Gottliebsen, Assistant Editor, Australian Financial Review

Professor K.H. Hunt, FTS, MA(Oxon), Professor of Mechanical Engineering, Monash University

F. C. James, MSc, Dean, Faculty of Applied Science, Royal Melbourne Institute of Technology

J. A. Kelly, Executive Member, Cattle Council of Australia

Sir Oscar Meyer, OBE, FAIM, (until January 1981), Chairman, West Gate Bridge Authority

Sir Lawrence Muir, VRD, LLB, Senior Partner, Potter Partners

E. F. Sandbach, BA, BSc, Director Research, Telecom Australia

S. D. M. Wallis, BComm, AASA, ACIS, Managing Director, Australian Paper Manufacturers Ltd

J. A. Pattison, MBE, AASA (*Secretary*), Divisional Secretary, Division of Building Research, CSIRO

South Australian State Committee

J. E. Harris, BEng (*Chairman*), Managing Director, Adelaide and Wallaroo Fertilizers Ltd

D. Andary, OBE, FAIM, Chairman, Berri Co-operative Packing Union Ltd

R. D. Bakewell, FAIM, (until July 1980), Permanent Head, Department of Economic Development

Sir Ben Dickinson, MSc, Company Director and Mining and Energy Consultant

J. M. Kerin, JP, United Farmers and Stockowners Association

M. Knapman, General Manager, Corporate Engineering, Simpson Ltd

J. C. McColl, MAgrSc, Director-General, Department of Agriculture, South Australia

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P. T. Unwin, DipFor, MIFA, Chief Commissioner, Forestry Commission

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B. Wilson, MSc, Research Manager, Goliath Portland Cement Co.

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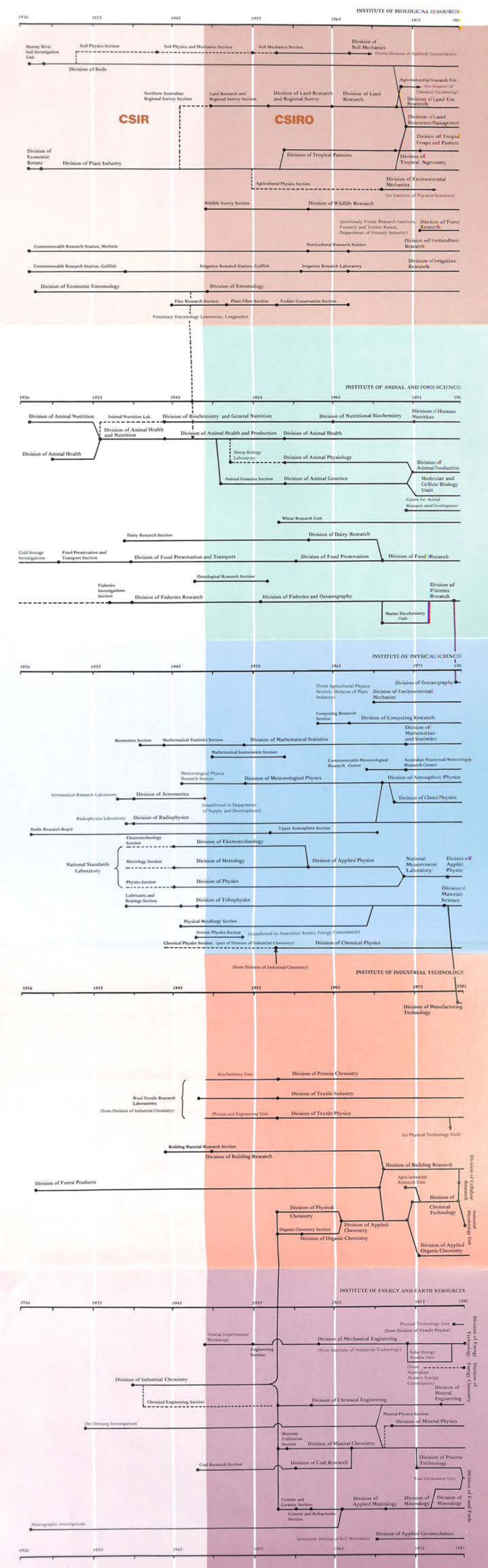
Appendix III

Structural evolution of CSIRO

The insert chart shows the origins of CSIRO's Institutes and their constituent Divisions and Units.

The historical development of each organizational entity is shown, together with changes. The dates of these changes are indicated by dots. Broken lines represent readily identifiable entities within a Division which became Independent Units or Divisions. Much of the information presented in the chart has come from 'The Historical Directory of Council for Scientific and Industrial Research and Commonwealth Scientific and Industrial Research Organization 1926 to 1976' which was compiled in 1978 in association with the preparation of an official history of the Organization.



 Appendix III Structural Evolution of CSIRO

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