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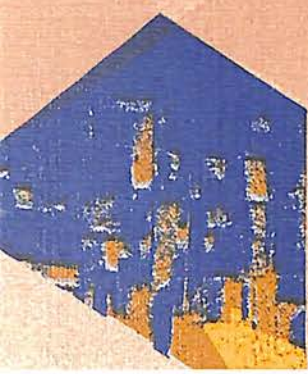
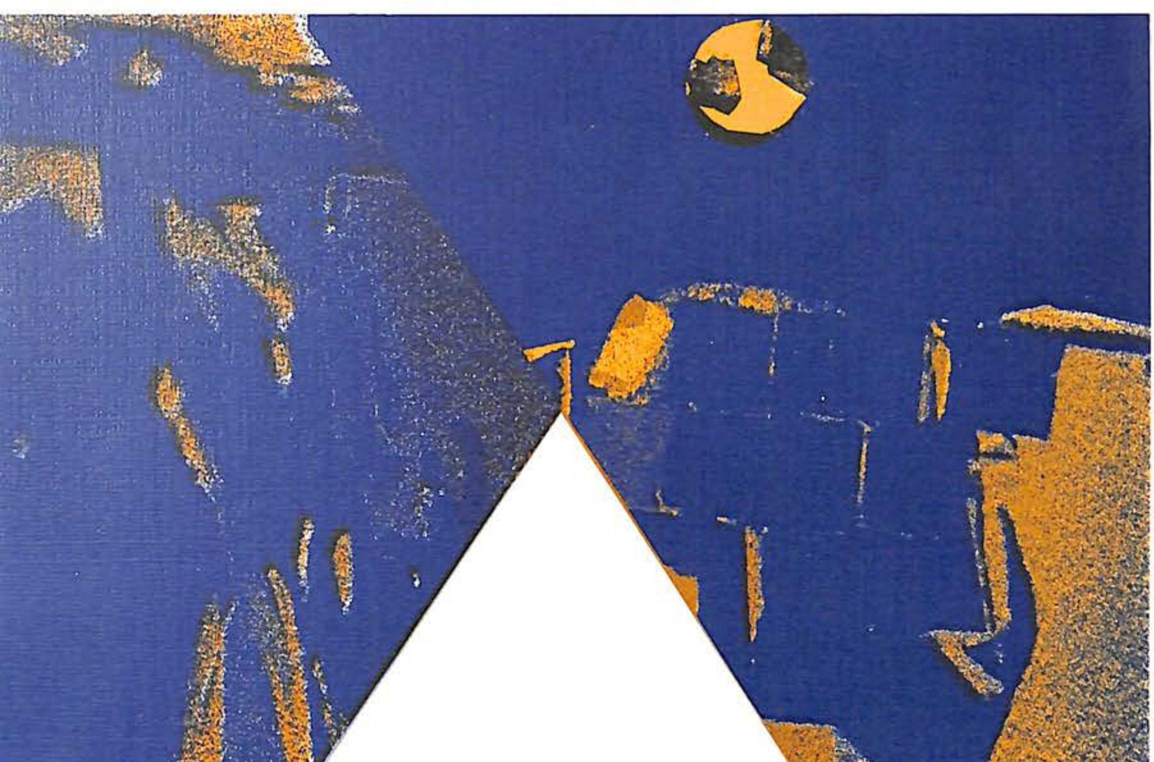


# CSIRO Annual Report 1979/80



Commonwealth Scientific and Industrial Research Organization, Australia

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# CSIRO Annual Report 1979/1980

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COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

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

The Executive of CSIRO has pleasure in submitting to you, for presentation to Parliament, its thirty-second annual report. 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

Last year's annual report covered a period which ended only six months after the enactment of the new legislation which reorganized CSIRO and recast its role. The present annual report therefore covers the first full year of operation under the amending Act. And for the first time in the history of the Organization its publication will be accompanied by the issue of six companion volumes which describe the work of the five newly formed Institutes and the Bureau of Scientific Services. By this means I believe the interested reader is in a better position than before to obtain a comprehensive view of the scope of the Organization's policies, research and progress. For the reader who wants to know at a glance how our research resources are deployed among the wide spectrum of sciences and technologies, a fold-out summary is provided in the back of this report.

To those who follow the fortunes of CSIRO the first question that may come to mind is 'how is the new system working out?' In my personal opinion, the restructuring of the Organization into Institutes has been a marked success and the credit for this success goes to the Institute Directors and Chiefs of Division alike. Chiefs continue to be the Organization's main research leaders and they retain the autonomy to fulfil this role, traditional in CSIRO since the days of Sir David Rivett. Yet Chiefs are now much less isolated. They meet frequently with their fellow Chiefs to discuss a variety of questions of common interest, including the co-ordination of inter-Divisional programs. Furthermore, a massive amount of management responsibility previously handled by the Executive—which of necessity became preoccupied with detail—is now shared between the Institutes.

Another improvement that has resulted from the new Act and associated Government decisions is in the breadth of advice which the Executive receives on the areas of research which it undertakes. Thus the new independent Advisory Council, under the Chairmanship of Sir Victor Burley, is now in full swing, as is the internal Planning and Evaluation Advisory Unit. Evidence of their work will be found in these pages. The year has also seen the setting up of the six State Committees, which are beginning to set about their task with vigour and enthusiasm. These developments strengthen an already extensive system of committees and contacts by which the Organization monitors the research requirements of the nation.

We are consciously moving towards a more open, more outgoing, mode of operation. Nowadays, the numerous committees that are set up to review the Organization's activities and advise on senior appointments very frequently have strong representation from outside the Organization and often from outside the country. Contacts with government departments are being strengthened, and opportunities to make oral presentations to bodies such as the Australian Manufacturing Council and the Industry Advisory Councils have been extensively developed.

Executive meetings themselves are assuming a new image. They are no longer confined to Canberra, but are held at different locations across the country such as Perth, Adelaide, Melbourne, Sydney, Armidale, Brisbane and Hobart. These visits give the Executive an opportunity of meeting Divisional staff in their research environment, and evening functions have been arranged to allow exchanges of views with political, government, business and academic leaders. A new system of bi-monthly Executive seminars has also been introduced, covering scientific and managerial topics vital to the Organization.

The year has seen a number of major initiatives. One of these has been to strengthen our research effort for the benefit of manufacturing industry: a new Division of Manufacturing Technology has been formed, built initially upon existing resources. It has laboratories in Melbourne and Adelaide and will be extended to Sydney when resources become available. The Division's research programs will include the processing of metals and plastics and modern techniques such as computer-aided manufacturing.

Another major initiative is in the area of marine science, and this follows promptly the proclamation of the legislation on the 200-mile Australian Fishing Zone. The Government has accepted a proposal to build what will be known as the CSIRO Marine Laboratories to be located at Hobart. The Laboratories, which will replace those now located at Cronulla, N.S.W., will house two Divisions, one of Fisheries Research and one of Oceanography. Marine science has been identified by the Executive as having high priority for future expansion. The Government has also agreed to a start on the acquisition of an oceanographic research vessel.

Other areas of research receiving special scrutiny at the present time include energy, especially the development of alternative liquid fuels, and micro-electronics, including the introduction into Australia of the capacity to design and construct very large scale integrated (VLSI) systems. The Executive's short list of high priority programs also includes water and soil research, and biotechnology.

By any standards CSIRO must be seen as a very special and valuable national resource. Its considerable budget, enlarged in recent years to nine digits largely by inflation, emphasizes the need for scrupulous accountability to the Parliament. The strengths of CSIRO continue to be its wide interdisciplinary nature, its flexibility to adapt to change, and its insistence on excellence. It is controlled by an Executive which strives to balance the present needs of industry and other community interests with a vision of the future that stems from creative science.

The most valuable resource of the Organization is the intellect, innovation and imagination of its scientists. They must have their feet firmly on the ground, perceive the research needs of the world around them, and continually be aware of the relevance of what they are doing. Yet, too, must they be searching for new ideas and new inspiration: be free to detach themselves from the workaday world; and give informed imagination full rein.

JP Wild

J P Wild
Chairman

# 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. This 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 annual statements of the distribution of research effort which form the first component of this response have been designed primarily to meet the statutory obligation to report on all research policies annually. For this purpose, the term 'policy' has been interpreted as referring to the selection by the Organization of particular research objectives from amongst all those possible within its statutory charter, and to the relative levels of financial and manpower resources devoted to the pursuit of these objectives. A statement for any particular year will provide a baseline from which changes in emphasis in the following year can be measured. Therefore, statements over successive years will provide a basis for reporting on developments in research policy. The statement for 1979/80 is presented in Chapter 2.

Statements of specific research policies form the second component of the response and are designed to amplify progressively the policy considerations underlying the choices and relative priorities summarized in the first component. The initial statement of general policies appeared in the 1978/79 Annual Report and set out the framework within which decisions relating to specific areas of research are made. Major developments in these policies in the reporting year 1979/80 relate to new procedures for determining research policy at the broad, or strategic, level and the adoption by the Executive and the Advisory Council of a procedure for consultation on research policies. These matters are reported on in Chapter 1 and in the section entitled Advisory Council and State Committees. Policies relating to specific areas of research are being developed progressively. It is expected that it will take about five years to cover the whole of the Organization's research effort at this level of detail. This year, statements relating to marine science and to manufacturing industry have been prepared and are presented in this section, together with reports on research reviews that have been completed or are in progress.

# 1. Strategic research planning

Arising from the Government's consideration in 1978 of the Report of the Independent Inquiry into CSIRO, the Organization has a specific obligation to develop further its procedures for setting research priorities at the broad or strategic level. The purpose of this chapter is to outline progress with this task.

The procedures being developed are designed to meet a range of objectives, which include:

- identifying national goals relevant to the planning of general scientific research on behalf of the Commonwealth;
- providing scientists and potential users with a meaningful voice in the setting of broad priorities for this research; and
- presenting a clearer picture of the pattern of CSIRO research activities and how they relate to the achievement of national goals.

This last objective has assumed greater importance with the incorporation into the Science and Industry Research Act 1949 of new reporting obligations, particularly those requiring the Organization to report specifically on its research policies. The statements of research policy in this Report stem either from Divisional and subject reviews or from policy matters raised by the Advisory Council and considered by the Executive. It is expected that when the new procedures become established, they will be the main source of statements of research policy at the broad level.

Strategic planning has always been one of the Executive's prime management tasks, but the continued growth and increasing diversity of Australian industry, the growing complexity of social interactions and of institutions, and the explosion of scientific and technological knowledge have added considerably to the magnitude and complexity of this task. The report of the Independent Inquiry into CSIRO and the Government's decisions on it, including those relating to the changed role of the Advisory Council and the establishment of a Planning and Evaluation Advisory Unit, reflected the need for a more structured and systematic approach by CSIRO to the Organization's overall research planning.

Planning systems already exist in industry and commerce and, to a lesser extent, in particular fields of research. As none of these has proved readily adaptable to the special needs of CSIRO, the development of an appropriate system will be exploratory. The nature of the Organization's role makes the determination of priorities particularly complex for a number of reasons. One reason is that CSIRO's legislative charter is designed to meet an unusually wide diversity of needs. Numerous factors that affect the Australian community and the structure of its industry must be taken into consideration in determining these needs. Another reason is that the outcome of scientific research, particularly strategic research, is inherently difficult to predict. 'Strategic', in this context, refers to work tending towards the basic or fundamental end of the research and development spectrum; and it is at this end that uncertainties become greatest.

The system being developed will provide a formal framework for identifying and analysing the factors that influence research priorities at the broad or strategic level. It will require structured participation by people both within and outside the Organization who can perceive research needs and opportunities, and thus will permit closer involvement by research workers and potential users of research in decision-making. However, it will not displace the free interchange of views that characterizes informal approaches to the establishment of research priorities. These approaches will continue to provide valuable inputs to Executive thinking.

## Classification of Research Effort

A system for classifying research programs is being devised so that a more consistent approach can be adopted when describing and assessing the distribution of the Organization's research activities. There is no ideal system of classification and the one now under development will require modification from time to time to tailor it to the changing pattern of the Organization's research. It will encompass and categorize the full range of activities that CSIRO can undertake in terms of the Organization's prime function of conducting research to assist industry and to further the interests of the Australian community. In addition, it will provide a link between areas of industry and community interest and the research programs that relate to them in a way that will facilitate greater involvement of potential users of CSIRO research in the strategic planning process. As will be explained later in this chapter, it will also provide the structure for a comprehensive series of reviews.

The basis of the new system of classification is the division of the Organization's research into sectors corresponding broadly to the main fields of research which the Science and Industry Research Act 1949 prescribes as appropriate to CSIRO. The sectors chosen were: *rural industries*; *mineral, energy and water resources*; *manufacturing industries*; and *community interests*. Each of these sectors is divided into a number of sub-sectors which, in turn, are divided into research areas. Where possible, research that is relevant to Australian industry has been classified in a manner consistent with the Australian Standard Industrial Classification (ASIC). ASIC is normally used as the basis for grouping together industrial and commercial activities with common features as an aid to decision making, particularly at the national level.

Decision making about scientific research must also take into account common features in various technologies and this factor has particularly influenced the grouping of activities at the research area level within the CSIRO classification.

The new system of classification has been used as the basis for Table 1 in the next chapter and for the chart on Distribution of Research Effort at the back of this Report. The chart shows an inner circle, representing the main research sectors, surrounded by three rings, representing sub-sectors, research areas and research programs. The Executive's role will be to make decisions relating to the composition and the relative sizes of the four main research sectors, and the respective sub-sectors and research areas into which they are divided. This will define the strategy that Directors, Chiefs and senior research staff will then implement in research programs.

## Planning Procedures

In recent years the Executive has made increasing use of both subject and Divisional reviews as an aid to planning (see Chapter 5). Subject reviews are usually directed towards identifying the research needs of a section of industry and the research opportunities relevant to those needs or towards the opportunities offered by a major new technology. Divisional reviews have focused on the work of a particular Division or Unit of CSIRO.

Within the new system of strategic planning, a comprehensive series of reviews at the sub-sector level will ultimately take over the role of those subject reviews that are aimed at defining research needs relevant to particular industries or community interests. Divisional reviews will be directed more towards assessing and improving the effectiveness with which research is carried out within the broad priorities established by the Executive.

However, while the new system is under development, subject and Divisional reviews will provide important inputs to sub-sector reviews. It is also envisaged that there will continue to be an occasional need for reviews, outside the context of strategic planning, of the research implications of major new technologies.

The new reviews will be conducted within a framework determined by various external policies and constraints, such as industry policies and the availability of resources, and internal management guidelines, such as those relating to the need to maintain a proper balance between strategic research, tactical research and development.

The exact procedures to be followed will vary from case to case, but a typical review would involve the following steps:

1. Consultation both within and outside CSIRO to obtain the following information:
   - the social and economic factors relating to a particular industry or community interest;
   - the views of representatives of industry and community interests on where they think there is a need for research to be undertaken; and

. those areas of research that are seen by scientists as having the potential to increase the economic effectiveness of existing industries, to create new industries, or to increase the well-being of the community, and that offer a reasonable expectation of success.

2. On the basis of the information on research needs and opportunities obtained in step 1, preparation of a draft report on the relative merits of the different areas of research that might be pursued in the short, medium and long term. Areas of research that might appropriately be undertaken by CSIRO and imbalances in the Organization's research effort would be identified provisionally at this stage.

3. Circulation to Institutes, Divisions and Units, sub-committees of the CSIRO Advisory Council, and representatives of industry, Government agencies and other interested bodies of discussion documents outlining these provisional conclusions and the background to them.

4. In the light of the feedback obtained from step 3, provisional determination by the Executive of the areas of research where work should be initiated, expanded, contracted or terminated, followed by formal consultation with the CSIRO Advisory Council.

5. Publication by the Executive of a research policy statement, and transmittal of detailed guidelines to Directors, Chiefs and senior research staff.

Until the first cycle of sub-sector reviews has been completed, it may not be possible to move to the next stage in the development of the system. This further stage will integrate these reviews into a comprehensive and unified assessment of the Organization's research priorities. It is expected that a cycle of sub-sector reviews will take about five years to complete. Until this next stage is implemented, less formal procedures will continue to be used to assess the need for adjustments in the Organization's overall priorities.

The Planning and Evaluation Advisory Unit will play a key role in assembling the inputs required under the new procedures and providing advice based on the analysis of scientific, economic and social data from both within and outside CSIRO. Strategic planning will form the basis of interactive planning between the Organization and the CSIRO Advisory Council. The Council will be the prime source of external comment on planning papers prepared in the course of reviews. The role of the Advisory Council and its relationship with CSIRO are discussed in more detail in Chapter 11.

The Planning and Evaluation Advisory Unit is currently assembling and analysing material relevant to the manufacturing industry sector and the energy and agriculture sub-sectors. In the case of energy, a discussion document has been prepared and circulated to interested bodies for comment. In the other two cases, information is being sought on the relevant social and economic factors, the areas that might benefit from Australian research and the scientific opportunities available.

# 2. Distribution of research effort

This chapter sets out the current distribution of the Organization's research effort and briefly describes areas of research designated for expansion.

## Current Distribution of Research Effort

The distribution of financial and manpower resources to categories of research embodies two important aspects of research policy. These are the selection and definition of research objectives, and the relative priorities assigned to those objectives. This distribution is presented in two main ways. Table 1 and the chart at the back of the Report show the distribution according to the system of research classification that is being developed for strategic planning (see Chapter 1). Table 2 and the material immediately following it show the distribution according to the research objectives of the Organization's Institutes, Divisions and Units.

The nature of strategic research is such that in many cases a single research program can benefit a number of different industries simultaneously and provide other community benefits as well. However, apportionment of research programs which are relevant to two or more categories has not been attempted in Table 1 or the chart. Each research program conducted by CSIRO during 1979/80 has been allocated only to the research category to which it is primarily relevant. For example, the oceanography programs of the Division of Fisheries and Oceanography have been allocated to the sub-sector 'Knowledge and Management of the Natural Environment', even though they are also highly relevant to the 'Fishing' sub-sector.

Table 2 is followed by statements of the research objectives of Institutes, Divisions and Units. Taken together, these objectives and Table 2 provide an overview of CSIRO's research priorities from a perspective which reflects the historical growth of the Organization. The creation and reorientation of Divisions and Units to meet particular national needs has constituted a primary expression of the Organization's research policies over the years. Divisions and Units are reviewed regularly and these reviews provide the main stimulus for major reorientations. The creation of separate Divisions of Fisheries Research and Oceanography are reported on in Chapter 3 and the creation of a new Division of Manufacturing Technology is reported on in Chapter 4. Research reviews are reported on in Chapter 5. A still more detailed account of CSIRO's research objectives and the resources allocated to them can be found in the publication 'CSIRO Research Programs 1980/81'.

| TABLE 1 | % of Total Research Expenditure | | % of Total Direct Professional Staff | |
|---|---|---|---|---|
| **Rural industries** | | | | |
| **Agriculture** | | | | |
| Plant improvement | 2.4 | | 1.8 | |
| Plant physiology and biochemistry | 2.3 | | 2.6 | |
| Soil fertility and plant nutrition | 2.5 | | 2.3 | |
| Agricultural systems | 4.4 | | 3.4 | |
| Management of crop and pasture pests and diseases | 3.3 | | 2.8 | |
| Livestock production | 6.7 | | 6.2 | |
| Livestock health | 4.3 | | 3.0 | |
| Land assessment | 0.1 | | 0.2 | |
| Agricultural engineering | 0.4 | | 0.4 | |
| | | 26.4 | | 22.7 |
| **Forestry** | | | | |
| Production | 2.0 | | 1.7 | |
| Management | 2.0 | | 2.0 | |
| Harvesting | 0.3 | | 0.3 | |
| | | 4.3 | | 4.0 |
| **Fishing** | | | | |
| Resource assessment | 3.6 | | 2.2 | |
| | | 3.6 | | 2.2 |
| Total – Rural industries | | 34.3 | | 28.9 |
| **Mineral, energy and water resources** | | | | |
| **Mineral resources** | | | | |
| Exploration | 2.2 | | 2.6 | |
| Mining and beneficiation | 3.1 | | 3.8 | |
| Environment | 0.4 | | 0.4 | |
| | | 5.7 | | 6.8 |
| **Energy resources** | | | | |
| Coal | 2.1 | | 2.1 | |
| Petroleum and oil shale | 0.4 | | 0.5 | |
| Substitute liquid fuels | 3.2 | | 2.9 | |
| Renewable energy | 0.9 | | 1.1 | |
| Energy storage and conservation | 0.6 | | 0.7 | |
| | | 7.2 | | 7.3 |
| **Water resources** | | | | |
| Water management | 1.8 | | 2.1 | |
| Water technology | 0.5 | | 0.6 | |
| | | 2.3 | | 2.7 |
| Total – Mineral, energy and water resources | | 15.2 | | 16.8 |

| TABLE 1 continued | % of Total Research Expenditure | | % of Total Direct Professional Staff | |
|---|---|---|---|---|
| **Manufacturing industries** | | | | |
| **Resource-based manufacturing industries** | | | | |
| Food processing | 5.4 | | 6.6 | |
| Textiles | 5.7 | | 5.3 | |
| Hides and leather | 0.3 | | 0.2 | |
| Forest products | 1.5 | | 1.4 | |
| Basic metal products | 1.2 | | 1.4 | |
| | | 14.1 | | 14.9 |
| **Small technology-intensive industries** | | | | |
| Electrical and electronic equipment and instruments | 1.6 | | 1.9 | |
| Advanced materials | 1.3 | | 1.3 | |
| Specialty polymers | 0.5 | | 0.4 | |
| Chemical, pharmaceutical and veterinary products | 2.2 | | 2.1 | |
| | | 5.6 | | 5.7 |
| **Industrial machinery and equipment** | | | | |
| Materials processing technology | 1.3 | | 1.1 | |
| | | 1.3 | | 1.1 |
| **Standards** | | | | |
| Physical and mechanical quantities | 1.3 | | 1.1 | |
| Electrical quantities | 1.8 | | 1.7 | |
| Thermal and optical quantities | 1.4 | | 1.3 | |
| Properties of solids, liquids and gases | 1.1 | | 1.1 | |
| | | 5.6 | | 5.2 |
| Total – Manufacturing industries | | 26.6 | | 26.9 |
| **Community interests** | | | | |
| **Knowledge and management of the natural environment** | | | | |
| Fauna | 3.0 | | 2.9 | |
| Flora | 0.8 | | 0.9 | |
| Land | 4.6 | | 5.2 | |
| Oceans | 1.5 | | 0.9 | |
| Atmosphere | 1.6 | | 2.4 | |
| Environmental protection | 1.4 | | 1.3 | |
| Astronomy | 2.9 | | 2.6 | |
| | | 15.8 | | 16.2 |
| **Tertiary industry** | | | | |
| Building and construction | 3.1 | | 3.8 | |
| Mathematics and statistics | 1.7 | | 3.3 | |
| Computing | 1.5 | | 2.2 | |
| Information services | 0.1 | | 0.2 | |
| | | 6.4 | | 9.5 |
| **Public health** | | | | |
| Human nutrition | 1.4 | | 1.4 | |
| Industrial hygiene | 0.3 | | 0.3 | |
| | | 1.7 | | 1.7 |
| Total – Community interests | | 23.9 | | 27.4 |
| 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 | | 3.3 | |
| Division of Animal Production | 5.5 | | 4.7 | |
| Division of Food Research | 4.9 | | 5.8 | |
| Division of Human Nutrition | 1.3 | | 1.4 | |
| Centre for Animal Research and Development | 1.6 | | 0.5 | |
| Molecular and Cellular Biology Unit | 0.9 | | 0.9 | |
| Wheat Research Unit | 0.3 | | 0.3 | |
| | —— | 18.9 | —— | 16.9 |
| **Institute of Biological Resources** | | | | |
| Division of Entomology | 5.2 | | 4.4 | |
| Division of Fisheries and Oceanography | 4.9 | | 3.3 | |
| Division of Forest Research | 3.1 | | 2.8 | |
| Division of Horticultural Research | 1.1 | | 1.2 | |
| Division of Irrigation Research | 1.0 | | 1.1 | |
| Division of Plant Industry | 5.4 | | 5.2 | |
| Division of Tropical Crops and Pastures | 4.0 | | 2.8 | |
| Division of Wildlife Research | 1.9 | | 1.8 | |
| | —— | 26.6 | —— | 22.6 |
| **Institute of Earth Resources** | | | | |
| Division of Applied Geomechanics | 1.7 | | 1.5 | |
| Division of Land Resources Management | 2.5 | | 2.5 | |
| Division of Land Use Research | 2.2 | | 2.7 | |
| Minerals Research Laboratories | 9.0 | | 10.6 | |
| Division of Soils | 2.9 | | 3.5 | |
| | —— | 18.3 | —— | 20.8 |
| **Institute of Industrial Technology** | | | | |
| Division of Applied Organic Chemistry | 2.1 | | 2.0 | |
| Division of Building Research | 3.5 | | 4.6 | |
| Division of Chemical Technology | 2.0 | | 2.1 | |
| Division of Manufacturing Technology | * | | * | |
| Division of Mechanical Engineering | 1.5 | | 2.0 | |
| Division of Protein Chemistry | 2.0 | | 2.4 | |
| Division of Textile Industry | 2.9 | | 2.1 | |
| Division of Textile Physics | 1.7 | | 1.6 | |
| | —— | 15.7 | —— | 16.8 |
| **Institute of Physical Sciences** | | | | |
| Division of Applied Physics | 5.6 | | 5.6 | |
| Division of Atmospheric Physics | 1.5 | | 1.7 | |
| Division of Chemical Physics | 1.7 | | 2.2 | |
| Division of Cloud Physics | 1.1 | | 0.9 | |
| Division of Computing Research | 2.6 | | 2.9 | |
| Division of Environmental Mechanics | 0.4 | | 0.6 | |
| Division of Materials Science | 2.6 | | 2.9 | |
| Division of Mathematics and Statistics | 1.7 | | 3.0 | |
| Division of Radiophysics | 3.0 | | 2.7 | |
| Australian Numerical Meteorology Research Centre | 0.3 | | 0.4 | |
| | —— | 20.5 | —— | 22.9 |
| **TOTAL** | | **100.0** | | **100.0** |

* The Division of Manufacturing Technology was formed on 1 April 1980. The figures for this Division are included with the figures for the Division of Materials Science in the Institute of Physical Sciences.

Tables 1 and 2 give figures on the distribution of CSIRO's research effort in 1979/80 in terms of expenditure on research and numbers of professional staff involved in research. The chart at the back of the Report presents diagrammatically the information in Table 1 in terms of professional staff only. The expenditure figures cover all sources of funds under CSIRO control; they include industry and other contributory funds, but exclude funds expended by Commonwealth departments on behalf of the Organization. The professional staff figures were calculated on the basis of numbers actually employed on 31 December 1979. Detailed expenditure figures for Divisions and Units are provided in Chapter 10 of this Report.

The distribution of research resources depicted in Table 1 differs from that shown in the corresponding table in the 1978/79 CSIRO Annual Report. The main variations are due to the re-locations of research programs made in the course of refining the definitions of categories in the classification. The variation in the energy classification, however, reflects a real change, stemming from the injection of nearly $2m in new funds from NERDDC (the National Energy Research, Development and Demonstration Council).

## Expansions in Research Effort

The following areas of research have been designated by the Executive as having high priority for expansion:

- marine science, particularly oceanography
- energy
- manufacturing technology
- land and water
- biotechnology
- biological control.

Research policies for marine science and manufacturing technology are discussed in Chapters 3 and 4 of this Report. Policies for energy research were described in detail in Chapter 5 of the 1978/79 CSIRO Annual Report. Top priority for expansion continues to be accorded to research which will delay the predicted fall in the supply of indigenous petroleum or alleviate its effect in the shorter term, and to research which will reduce in the longer term Australia's dependence on natural petroleum.

The areas of land and water research were selected for expansion in response to increasingly serious problems associated with Australia's soil and water resources. These include soil erosion, reductions in soil fertility and increases in salinity. The reviews of water research and of the Divisions of Land Use Research, Land Resources Management, and Soils, described in Chapter 5, are expected to lead to specific research proposals aimed at meeting these problems. Work on adapting plants to cope with adverse soil and water conditions will also be increased.

Biotechnology is the term used to describe the utilization of biological organisms in industrial processes and the genetic modification of organisms to produce new plants and animals. It is aimed at more effective production techniques and new products in such diverse fields as food, fuels, pharmaceuticals, chemical feed stocks, waste recycling and pollution control. Recombinant DNA technology is providing the main impetus for expansion in the area of biotechnology. This involves the introduction of new genetic material into cells and the replication of this material through the normal processes of cell growth and division. Specific research proposals will be indentified in a review of biotechnology scheduled to start in 1981.

Biological control is the introduction of naturally occurring organisms such as insects or viruses to control weeds and insect pests. These methods complement or provide alternatives to the use of chemical pesticides. CSIRO's work in this area has continued to expand over the past five years.

The broad objectives and fields of research of the various CSIRO Institutes and their component Divisions and Units are given in the following pages. A more detailed account of the objectives of current CSIRO research may be found in the publication 'CSIRO Research Programs 1980-81'.

## Institute of Animal and Food Sciences

The Institute comprises the following Divisions and Units:

**Division of Animal Health**
**Division of Animal Production**
**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 and the quality and safety of human foods, and obtaining a better understanding of the relationships between human diet and health.

The Institute's research includes work on:

- control of animal diseases;
- nutrition, reproduction, genetics and management of livestock;
- 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 deals mainly with the animal health problems of the grazing sheep and cattle industries, although some relates to those of the poultry and pig industries. Most of the work is on bacterial, viral and parasitic diseases. More basic studies are concerned with genetic selection for disease control, especially control of internal parasites of sheep and cattle. The Division is also carrying out immunological studies to improve vaccines and vaccination procedures.

**Division of Animal Production**

The Division aims at assisting 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 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, life-style and human health.

**Centre for Animal Research and Development**

The Centre is a joint Indonesian-Australian project conducted by CSIRO on behalf of the Australian Development Assistance Bureau (ADAB). Its general aim is to conduct animal research and development activities designed to improve the efficiency with which meat, milk and eggs are produced, while taking into account the need to optimize the role of livestock in mixed farming systems.

The intergovernmental agreement between Indonesia and Australia states that the major undertaking under this project shall be the establishment at Ciawi of a new animal research laboratory and associated buildings conducive to problem-solving research of the highest standard, with the long-term view of staffing it fully with Indonesian scientists trained to carry out first-class research.

With the completion of the construction program, the first part of this undertaking has been completed. Twenty-seven young Indonesian scientists have been sent to Australia to undertake higher-degree training, as a step towards achieving the long-term staffing objective.

The Centre's research is concentrated on nutrition, reproduction and genetics.

**Molecular and Cellular Biology Unit**

The Unit's research is concerned with the control of animal cell growth and development and with DNA replication, repair and mutation. Applications include the production of reagents and the development of techniques useful for diagnosis and therapy in animals and man.

**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 and Units:

**Division of Entomology**
**Division of Fisheries and Oceanography**
**Division of Forest Research**
**Division of Horticultural Research**
**Division of Irrigation Research**
**Division of Plant Industry**
**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 agricultural, forestry and fisheries 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 biological control;
. biology of native and introduced birds and mammals in the context of pest control and conservation;
. oceanography of Australia's coastal and oceanic waters;
. biology of the major fisheries and its application to the development of improved methods of management.

**Division of Entomology**

The Division carries out wide-ranging biological and chemical research aimed at elucidating the roles that insects—useful and harmful—play in the balance of life. The knowledge gained is applied to the control of major insect pests and to the solution of other entomological problems. Other applications include the biological control of land and water weeds.

**Division of Fisheries and Oceanography**

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. Studies of the biological, chemical and physical oceanography of coastal and oceanic waters aim at providing an understanding of their dynamical behaviour, productivity, sensitivity to pollutants, and general ecology.

**Division of Forest Research**

The Division is concerned with the long-term use of Australian forests—both conifer plantations and the native eucalypt forests—for wood production, water supply, wildlife conservation and recreation. Broad areas of research include harvesting, genetics and tree breeding, taxonomy, ecology, forest protection (from fire, disease and insect pests) and forest assessment.

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| Division of Horticultural Research | The aim of the Division's research is the genetic improvement of woody perennial horticultural crops in Australia. These include a range of subtropical and tropical fruit and nut species and grapevines. 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 general concern of this Division is to improve production of irrigated crops. Broad areas of research include water management for efficient irrigation; development of ecologically sound methods for wastewater utilization; alleviation of root-zone problems associated with rising saline groundwater; studies of irrigated crop nutrition, with particular emphasis on nitrogen utilization; breeding of oilseed crops; and development of energy-saving methods for greenhouse cropping. |
| 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 Tropical Crops and Pastures | The Division conducts research on field crops and pastures in tropical Australia, broadly defined as the lands north of 30°S latitude but excluding the arid zone. In pasture research, the emphasis is on beef production. The central aim is development of new legume-based pastures, together with definition of the effects of environment and management on their growth and productivity. The Division's irrigated and dryland crop research is mainly concerned with developing grain-legume and other crops that are new to Australian agriculture, and improving the performance of grain sorghum and soybeans at lower latitudes. |
| Division of Wildlife Research | The primary concern of the Division is the biology of birds and mammals, both native and introduced, in relation to pest control and conservation. 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 in animal ecology, behaviour and physiology, and to show how this knowledge may be applied in the management of wildlife populations. |

## Institute of Earth Resources

The Institute comprises the following Divisions and Units:

- **Division of Applied Geomechanics**
- **Division of Land Resources Management**
- **Division of Land Use Research**
- **Division of Mineral Chemistry**
- **Division of Mineral Engineering**
- **Division of Mineral Physics**
- **Division of Mineralogy**
- **Division of Process Technology**
- **Division of Soils**
- **Fuel Geoscience Unit**
- **Physical Technology Unit**

The Institute conducts scientific and technological research relating to the more effective definition, utilization and management of Australia's resources—atmospheric, land, water, mineral and energy.

The Institute's activities include research on:

. locating, evaluating, defining and characterizing Australia's earth resources;

. planning the recovery, development and effective use of Australia's earth resources, consistent with appropriate conservation of the environment;

. the balanced management of Australia's earth resources for such uses as mining, agriculture, urban development and recreation.

**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 Land Resources Management**

The Division conducts research directed towards the better management of land and water resources. This includes investigations of environmental and social implications of current and alternative management methods in pastoral, agricultural, forested and near-urban areas, and the development of methods for processing, appraising and communicating information to assist decision-makers.

**Division of Land Use Research**

The Division has the broad object 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 utilizing information on resources. To this end, it is engaged in research concerned with resource surveys, resource evaluation for various possible uses, and resource allocation planning techniques. The research also includes investigations aimed at achieving a better understanding of relevant physical, biological and socio-economic processes.

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| Division of Mineral Chemistry | The Division uses its expertise in physical and inorganic chemistry to identify and solve problems of the mineral industry, and related problems in areas of community or national importance such as the environment and energy. |
| 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 applies its expertise in the geological sciences—particularly in geochemistry, mineralogy and petrology—to the solution of problems encountered, or expected, in exploration for ore bodies and economic minerals. |
| Division of Process Technology | The Division uses its expertise in chemistry, physics and engineering to improve existing processes and develop new ones for the treatment of fossil fuels and minerals. It also seeks to elucidate and, where possible, ameliorate any adverse environmental consequences resulting from the production, treatment or use of these resources. |
| Division of Soils | The Division studies the physical, chemical, mineralogical and biological properties, and the geographical distribution, of Australian soils, and applies the knowledge gained to solve problems in crop and pasture production. Its research also covers soil conservation and reclamation, and knowledge in this area is utilized as an aid in agricultural, urban and regional planning, and pollution control. |
| Fuel Geoscience Unit | The Unit carries out research in geology and materials science aimed at improving methods of exploring for hydrocarbons and characterizing coal and oil shales. It also seeks to improve methods for extracting fossil fuels, assessing their suitability for various end uses, and using them without deleterious environmental effects. |
| 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 and Units:

- 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:

- water utilization and reclamation;
- conservation of oil;
- renewable sources of energy;
- novel processes and products for application in industry and agriculture;
- utilization of forest 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, 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 in all the industries and disciplines in this sector; enhance the potential standard of accommodation for all Australians at work, play and at home; and 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 and biotechnology to the utilization and processing of resources such as forests, residues from forest and agricultural industries, algae, water and wastewater. Research areas include: fibre separation and pulping; development of pulpwood resources; cellulose-based composite materials; the use of biological systems for the production of chemicals and energy, particularly liquid and gaseous fuels; the development of agro-industrial systems; and technologies for purifying and recycling water.

**Division of Manufacturing Technology**

The Division studies processing techniques which improve both the durability of manufactured products and the economy of their production. It is concerned also with the properties of materials of importance in manufacturing.

**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 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**

This Division's research relates to all stages of the handling and utilization of wool, from the shearing shed to end use. In the raw wool area, major efforts are directed towards achieving economies in handling and marketing. Research on fabrics deals with those physical properties and processes, such as flame retardance and coloration, that affect the competitive position of wool as an apparel fibre, and with those properties important in the industrial use of both wool and other fibres.

## 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 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:

- 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 pollution;
- physics of interactions between soil, water, plants and atmosphere;
- radiophysics and its application to astronomy, navigation and communications;
- application of mathematics and statistics to problems in industry and science;
- 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. The Division conducts research on the properties of materials and on the physics of the sun and the earth's atmosphere. 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 aims to obtain a better understanding of weather, climate and atmospheric phenomena generally as a basis for better predictions of weather and climate and for more efficient control of pollution. To this end the Division's research is concerned with determining the characteristics of the atmosphere, the processes within it, and the interactions between the atmosphere and land and sea surfaces.

**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 Division's research is concerned primarily with clouds and their contribution to weather, and in particular with the atmospheric processes that govern cloud formation and the production of rain. It includes studies of the sub-microscopic particles upon which cloud droplets and ice crystals form. Man's activities often result in the production of large numbers of smoke and dust particles, and the Division is investigating whether these may affect weather and climate. The stimulation of rainfall by seeding clouds with small particles is another research activity.

**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 database 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 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 mathematical models and statistical methods to solve problems arising in research in agriculture, biology, the environment, the physical sciences and industry. It provides advisory and consultative services on mathematical and statistical problems to other Divisions of CSIRO and outside bodies. The Division also conducts basic research in probability, statistics, applied mathematics and computational mathematics.

**Division of Radiophysics**

The Division observes and interprets radio emissions from celestial objects and interstellar matter in order to contribute to knowledge of the physical processes involved. This work is carried out in major research programs on cosmic and solar radio astronomy. As progress in these fields requires use of the most advanced observing instruments and techniques available, substantial research and development effort is devoted to technical innovation. A third research program draws on the Division's radio and electronic expertise to study problems of importance to industrial and government organizations.

**Australian Numerical Meteorology Research Centre**

The Centre is a joint unit of CSIRO and the Department of Science and the Environment. It develops numerical models of the atmosphere and oceans and uses these to study the possible causes and nature of natural and man-induced climate changes and to improve the accuracy of Australian weather forecasts and extend the period for which they apply.

# 3. Marine science

CSIRO has been involved in marine science for more than 40 years and its Division of Fisheries and Oceanography is the largest research group working in this field in Australia. While the Executive has for some time been anxious to rationalize and expand CSIRO's research in the marine sciences, a major constraint has been the lack of a suitable vessel for oceanographic research. Although the Division of Fisheries and Oceanography has found it practicable to charter standard fishing vessels and modify them for fisheries research, this has not been so in the case of oceanographic research; the Executive believes that the only practical approach is the acquisition of a vessel built to an approved design. A further constraint has been the restricted nature of the site occupied by the headquarters laboratory of the Division at Cronulla, near Sydney, and the distance of the site from a suitable deep-water berth for the larger research vessels operated by the Division. Because of these constraints the Executive has had a series of proposals before the Government for a new laboratory for the Division and for an oceanographic vessel that could be operated as a national research facility.

In April 1980, the Prime Minister announced that the Government had agreed to the construction of a laboratory complex for CSIRO at Hobart at an estimated cost of $8.5 million. The complex will be known as the CSIRO Marine Laboratories and will house research and support staff from the Division of Fisheries and Oceanography at Cronulla. The Government also agreed to the construction of a 54-metre oceanographic research vessel for use by CSIRO and other research bodies. Some $90 000 will be provided in 1980/81 and a contract for its construction will be issued in June 1981. The new vessel will help meet the need of Australian oceanographers for adequately sized vessels designed to meet their specific research requirements. Satisfactory berthing facilities are expected to be available in Hobart. The Executive has welcomed these decisions as they will facilitate the implementation of CSIRO's policy on marine science, which is described below, and the expansion of the Organization's marine research.

Before examining CSIRO's future role in the marine sciences and developing its policy on this, the Executive asked Professor H. Charnock, formerly Director of the U.K. Institute of Oceanographic Studies, to examine physical oceanographic research in Australia with special reference to CSIRO. Professor Charnock's report, which was received by the Executive in February 1979, raised a number of broader issues relating to the whole field of marine science. The Executive decided therefore to establish an Ocean Sciences Review Committee under the chairmanship of Mr M. V. Tracey, Director of the CSIRO Institute of Biological Resources, to undertake a comprehensive review of all CSIRO's marine research.

Members of the Committee included Dr D. A. Hancock, Chief Research Officer, Western Australian Marine Research Laboratories, Western Australian Department of Fisheries and Wildlife; Dr W. F. Hunter, Superintendent, Royal Australian Navy Research Laboratory; Professor J. Imberger, Professor of Civil Engineering, University of Western Australia; and Professor H. A. Knox, Professor of Zoology, University of Canterbury (New Zealand).

The terms of reference of the Committee were:

- to advise the Executive on the future role appropriate to CSIRO in the ocean sciences, having due regard to the responsibilities of other organizations;
- to advise the Executive as to whether the Division of Fisheries and Oceanography should continue in its present organizational form;
- to review the overall objectives of the Division and advise the Executive on their appropriateness;
- to assess the present activities of the Division and their relevance to the industries or scientific disciplines served;
- to advise the Executive on the balance of resources devoted to the Division's various research programs;
- to make recommendations on the future role of the Division and its relationships with other CSIRO Divisions, both within and outside the Institute of Biological Resources, and with industry and other research organizations, particularly the Australian Institute of Marine Science; and
- to make general comments on the scientific standards of the research work and the management and organization of the Division.

The Committee made some 34 recommendations in its report and these provided the Executive with a basis for its policy statement on marine science. In developing this policy the Executive took into account a number of external factors, including the Government's decisions on the recommendations of the Independent Inquiry into CSIRO, the proclamation of the Australian Fishing Zone, the activities and interests of other research bodies, the recommendations of the Australian Science and Technology Council (ASTEC) and the inquiry by the Senate Standing Committee on Science and the Environment into Australian marine science.

The following policy statement was prepared by CSIRO before the release of ASTEC's report 'Marine Sciences and Technologies in Australia: Priorities for Additional Research and Development, 1980/81' and before the release of the 'Progress Report on Australian Marine Science' by the Senate Standing Committee on Science and the Environment. ASTEC was consulted in the course of preparation of the CSIRO policy statement. The completed statement was made available to the Senate Standing Committee to assist in the preparation of the Committee's report.

## CSIRO Marine Science Policy

*1. 'CSIRO will continue to undertake marine research as part of its responsibility as a national research organization and the Executive identifies marine science—particularly oceanography embracing physical, chemical and biological aspects—as an area of highest priority and commitment.'*

Australia has both a national and an international responsibility to study the biological resources and the oceanography of her surrounding waters. In keeping with the Organization's role of contributing to the performance of Australia's national and international obligations, CSIRO has an active involvement in the marine sciences. Nevertheless, the Executive believes that the present national effort, including that of CSIRO, is inadequate and needs strengthening, particularly in the field of oceanography. This view is shared by the scientific community generally and by ASTEC. CSIRO's commitment to strengthening its effort in marine science has led to the planned reorganization and expansion of existing activities described below.

Physical oceanography not only provides information of value to other disciplines, it is also important in its own right. Australia has a very long coastline fronting four major ocean systems. The dynamics of these systems influence Australia's weather patterns, fish population dynamics, commercial shipping, leisure boating, and waste-disposal systems as well as the cost of offshore oil, gas and mineral production.

The water movement and associated mixing within the oceans is responsible for convecting heat, salts, nutrients, pollutants and living biomass around the coastline, from the coasts to the deep oceans, and from one oceanic system to another. Further, the oceans provide the medium through which fish move, ships travel and sediments are transported. In this sense, the study of water motions in the oceans complements the research activities in many other areas (see point 5).

*2. 'Within any broad arrangements made by the Commonwealth Government, CSIRO will collaborate with the Australian Institute of Marine Science (AIMS) and other organizations in Australia and overseas and with international bodies in planning and carrying out its marine science commitments.'*

In establishing its marine science research priorities, CSIRO is taking account of the plans and activities of other agencies, both in Australia and overseas, in order to prevent unnecessary duplication of effort and to make the most effective use of relatively scarce research resources.

*3. 'In keeping with CSIRO's research responsibilities, the Organization's marine science will include a range of fundamental, strategic* *and applied work, with a major emphasis being given to strategic, mission-oriented studies.'*

As discussed in last year's Annual Report, CSIRO's primary role is seen as that of undertaking strategic, mission-oriented research. Thus, it is concerned essentially with fundamental work in areas of major importance to Australia and with the application of advanced scientific knowledge and techniques to the solution of national problems. In the case of CSIRO's marine research, the strategic studies that are being undertaken tend to be complementary to the activities of State and Commonwealth fisheries management authorities. However, there is also a need for CSIRO to be involved, at least in the short term, in the field of marine resources assessment (see point 6).

4. *'In view of CSIRO's national role and the continental scale of many ocean systems and processes, the Organization will not be constrained as to the areas in which it carries out marine research, except to the extent implied by territorial rights and any other government constraints, and by the need to avoid unnecessary duplication of effort.'*

To date, much of CSIRO's research in physical oceanography has been concerned with currents and eddies and has been conducted in the deep ocean beyond the continental shelf. There is now a need for more work to be done in the waters above the shelf. There is also scope for research in coastal waters on physical processes, such as tides and waves, which relate to a range of community and industry interests. While CSIRO needs to take into account the plans and activities of other research agencies in determining its research priorities (see point 2), and while it needs to negotiate with the appropriate authorities before conducting research in coastal waters which come under the jurisdiction of the States concerned, the Executive believes that it would be unnecessarily restrictive if too narrow a prescription were placed upon the areas in which the Organization could operate. Australia's coastal waters, and the waters above and beyond the continental shelf, are interconnected and share many physical processes. The arbitrary exclusion of CSIRO from a particular region could seriously interfere with research in neighbouring waters.

5. *'The existing Division of Fisheries and Oceanography will be restructured to form two Divisions. A new Division of Oceanography will undertake research which will concentrate on understanding ocean processes (including interactions between the ocean and atmosphere) and the mechanisms of oceanic phenomena. The study of water motions in the oceans complements the research activities in such diverse areas as fisheries, chemical and biological oceanography, weather forecasting, waste disposal, beach maintenance, offshore engineering, ship routing and marine sedimentology. The work of*

*the Division will not be directed toward the routine characterization of Australian waters.'*

Before deciding to split the Division of Fisheries and Oceanography into two new Divisions, the Executive gave careful consideration to a proposal to create an Oceanography Laboratory and a Fisheries Laboratory, physically separated yet part of the one Division. Reasons for discarding this proposal are discussed under point 7. Formation of a separate Division of Oceanography reflects the Executive's desire to strengthen and stimulate this area of research.

*6. 'The new Division of Fisheries Research will undertake research directed particularly to the study of the population dynamics of commercial and potentially commercial fish, especially in the Australian Fishing Zone (AFZ). In particular, the Division will continue to support the Commonwealth Government's fishery management agency, the Department of Primary Industry. The research will include both strategic work and resource-oriented studies. Associated with this, CSIRO will strengthen its liaison and communication with Commonwealth, State and other bodies responsible for fisheries research and management in order to optimize the research effort and the practical utilization of research findings. Notwithstanding the major commitment to work in the AFZ, work may be undertaken from time to time in international or foreign waters, in line with Australia's international interests and obligations. In the long term, it may be possible to phase down the applied research as knowledge accumulates and State bodies extend their fisheries research capability.'*

The Committee of the Independent Inquiry into CSIRO suggested that in view of CSIRO's broad capabilities in physical and biological sciences, the Organization might well adopt a short-term role with respect to marine resource assessment—the need for which has become even more urgent as a result of the proclamation in 1979 of the Australian Fishing Zone. The Committee suggested, however, that if this short-term role were adopted, CSIRO should distinguish it clearly from its long-term role of undertaking fundamental and strategic, mission-oriented studies.

*7. 'The Division of Oceanography will be part of the Institute of Physical Sciences, and the Division of Fisheries Research part of the Institute of Biological Resources. Inclusion of the new Division of Oceanography in the Institute of Physical Sciences will facilitate its interactions not only with the Division of Atmospheric Physics but also with other CSIRO Divisions involved in research in the fluid earth sciences (the Australian Numerical Meteorology Research Centre, the Division of Cloud Physics and the Division of Environmental Mechanics).'*

By placing the two Divisions in their respective Institutes, strong formal ties will be established between Divisions with some interests in common. For example, Divisions interested in geophysical fluid dynamics will now be associated in the one Institute. These formal ties between oceanographers were not present when the Division of Fisheries and Oceanography was part of the Institute of Biological Resources. The Executive firmly believes that this new organizational arrangement will enhance the quality of research, stimulate new collaboration between CSIRO scientists and enable CSIRO to contribute more effectively to Australian oceanography.

*8. 'The two Divisions, which will be known collectively as the CSIRO Marine Laboratories, will have headquarters on the same site to facilitate joint activities and collaboration and will share facilities and services at regional laboratories.'*

To ensure the continued cooperation between scientists committed to studying the marine environment, the Executive will locate the headquarters of both new Divisions at the CSIRO Marine Laboratories in Hobart. This arrangement will foster an informal continuation of collaborative links established over many years within the Division of Fisheries and Oceanography. The Executive believes that this new balance of formal and informal links will create a more productive research atmosphere than could otherwise be achieved.

*9. 'In order to carry out effective work on oceanography, the oceanographic vessel proposed by CSIRO to Government is essential. The vessel will be operated as a national facility, with CSIRO responsible for its management. A small, independent steering committee comprising representatives of major user groups will be established to advise on the allocation of vessel time, the scale of charges and general management policies.'*

As mentioned earlier, the Government has agreed to the construction of an oceanographic research vessel. Properly used, such a vessel is capable of gathering more data than even an expanded CSIRO oceanographic group would be able to handle, since substantial land time will be required for analysis, interpretation and writing up. Management of the vessel as a national facility will therefore provide non-CSIRO scientists with an opportunity to use the vessel. The steering committee will not only advise on priorities for the vessel's use but encourage joint activities between CSIRO and other research groups.

*10. 'CSIRO notes that the ASTEC Report 'Science and Technology in Australia 1977/78', Vol. 1A, Section 72, divides marine science empirically into marine biology and fisheries, marine geosciences, oceanography, coastal and ocean engineering, and environmental studies. In the light of the above, CSIRO sees its main, clearly defined and central role among these as being in oceanography, and* *marine biology and fisheries. The extent of CSIRO's involvement in the other fields will depend on availability of resources for CSIRO, the Organization's priorities, the programs and capabilities of other research bodies to cover these fields effectively, and the possible need for CSIRO to have certain skills to provide links with other bodies directly involved in them.'*

This is a matter which CSIRO will continue to keep under review. Should resources become available, efforts can be made to extend the Organization's interests into new marine science areas, providing there is no undue overlap with the established interests of other research bodies.

Following a recent review and advice provided by ASTEC, the Government has announced that the future role of the Bureau of Mineral Resources, Geology and Geophysics will include the development of an integrated, comprehensive understanding of the geology of the Australian continent, including offshore areas, as a basis for mineral exploration. This definition of the Bureau's role has helped CSIRO identify more clearly its own role in the offshore areas.

*11. 'In regard to other bodies within the Ministerial portfolio of Science and the Environment:*

*(a) CSIRO will cooperate and collaborate with AIMS, recognizing that the present main function of the latter is to carry out marine research in the general zone of the Great Barrier Reef, that its major skills are in the marine biological and ecological fields, and that its main orientation is towards the understanding of the systems involved.*

*(b) CSIRO's relations with the Great Barrier Reef Marine Park Authority (GBRMPA) will be based on the premise that this body has primarily a management role. Joint consultation between CSIRO, AIMS and GBRMPA will be encouraged.*

*(c) CSIRO will cooperate and collaborate with the Antarctic Division as the lead agency for marine science in Antarctica.*

*(d) CSIRO's relations with the Bureau of Meteorology will continue along existing lines, in particular including joint participation in the Australian Numerical Meteorology Research Centre and CSIRO's advice to and discussion with the Bureau in such fields as air-ocean interactions.'*

The establishment of the Marine Laboratories in Hobart will facilitate communication with members of the Antarctic Division, who will be based at Kingston, near Hobart.

*12. 'CSIRO seeks to encourage the further development of Australian-based commercial consultancies in marine science, and accordingly, CSIRO will not undertake major consultancies in competition with commercial consultants. CSIRO is, however, willing to* *undertake limited consultancies in fields where the Organization has special expertise, on the basis of appropriate payment for services provided, and subject to availability of staff.'*

*13. 'CSIRO will continue to contribute to, and to use, data bases for fisheries and oceanography. CSIRO should not itself be the agency responsible for operating such data bases. If CSIRONET computing facilities are used for these purposes on behalf of other agencies, normal charging practices will apply.'*

*14. 'While the major part of CSIRO's funds for marine research should be provided by direct Government Appropriation, CSIRO may, under the powers conferred upon it, seek grants from other sources, whether Government-funded or not, and undertake contract research related to its Appropriation-funded research programs.'*

# 4. Support for manufacturing industry

## Manufacturing Industry Committee

In February 1979, the Executive established a Manufacturing Industry Committee under the chairmanship of Dr W. J. McG. Tegart, Member of the Executive (see CSIRO Annual Report 1978/79) to advise on CSIRO's relationships with Australian manufacturing industry, and in particular to:

- assess the scope of current CSIRO programs and practices that are of assistance or potential assistance to manufacturing industry;
- encourage Institutes and Divisions to make new proposals in this field in time for consideration by the Committee before the 1980/81 budget;
- make recommendations to the Executive on an extended manufacturing industry program, with the aid of such proposals and any others proposed by the Committee; and
- consider whether any part of such a program is more appropriately undertaken by external contracts.

By arrangement with the CSIRO Advisory Council, two members of the Council with considerable experience in manufacturing industry, Mr A. Boden and Mr J. E. Kolm, were appointed to the Committee in March 1980.

The Manufacturing Industry Committee invited Institutes and Divisions to submit proposals for research in new fields of investigation which would assist Australian manufacturing industry. After considering these proposals the Committee recommended to the Executive that priority in 1980/81 should be given to expanding research aimed at:

- assisting the materials-processing industries and, in particular, the metal-manufacturing industry, both light and heavy; and
- developing new scientific instruments, particularly in the geophysical field.

The Committee also recommended that consideration be given to expanding work in the following fields of research in 1981/82:

- new ways of processing agricultural products;
- mineral processing, with continuing manufacturing industry involvement; and
- biotechnology.

The Manufacturing Industry Committee is considering in more detail the research needs of manufacturing industry in the following fields:

- electronic components and materials;
- electrical components;
- the utilization of microelectronics in industrial processing; and
- polymer utilization.

## Initiatives for Manufacturing Industry

A preliminary analysis by the Manufacturing Industry Committee indicated the need for CSIRO to increase its research on metal-products manufacturing, a sector that accounts for some 45 per cent of Australia's manufacturing industry. The Committee recommended that a CSIRO Division of Manufacturing Technology be established to work closely with firms engaged in the metal-processing industries. The Executive accepted this recommendation and the new Division, which has been developed from the existing production technology group of the Division of Materials Science, came into existence in April 1980.

The Division of Manufacturing Technology is part of the Institute of Industrial Technology and has its headquarters in Melbourne and a branch in Adelaide. A Sydney branch will be established as resources become available. The Division's research embraces metallurgical aspects of casting, forging, machining, surface finishing and welding, and will be expanded to incorporate areas such as production engineering, automation and robotics.

Professor R. H. Brown, Head of the Department of Mechanical Engineering at the University of Western Australia, has been appointed Chief of the Division and is expected to take up his position in August 1980. During the past two years, Professor Brown has been working with the Commonwealth Department of Productivity in the establishment of the Technology Transfer Council. He is Chairman of the Council's executive group and was a member of the task force on manufacturing of the Institution of Engineers Australia.

In a further move to strengthen the Organization's support for manufacturing industry, the Executive established a Melbourne branch of the Division of Applied Physics. The Division, which operates the National Measurement Laboratory in Sydney and has a branch laboratory in Adelaide, maintains the nation's standards of measurement and provides a calibration service to manufacturing industry through the National Association of Testing Authorities (NATA). The new laboratory will provide this service to manufacturing industry in the Melbourne region and will make staff available for consultation on problems involving physical measurement.

The Executive has recognized the desirability of Australia having the capability to design special purpose computers on single silicon chips using a technique known as very-large-scale integration (VLSI) and is establishing a research group within the Division of Computing Research to develop the necessary technology. Research by the group on design methodology is expected to assist Australian industry in the application of the next generation of computer technology to manufactured goods.

## Technology Transfer

In addition to establishing the Manufacturing Industry Committee, the Executive commissioned a report on CSIRO's present and future programs for transferring scientific and technical information to manufacturing industry.

The Report, prepared by the Director of the Bureau of Scientific Services, examined the idea of an extension service to manufacturing industry analogous to that operating in the rural sector but concluded that cost factors alone made this impractical. It recommended, therefore, that CSIRO should continue to make use of established technology transfer mechanisms rather than initiate an entirely new service. The Executive accepted this recommendation.

The Report also made recommendations regarding promotion criteria for research staff and interchange schemes with industry. The Executive accepted the need to encourage and reward the communication of research results through such mechanisms and these are now the subject of further detailed consideration.

The Bureau of Scientific Services has collaborated with the Metal Trades Industry Association of Australia in the establishment of a number of industry research committees and has provided secretarial and administrative assistance. The committees cover the foundry and forging industries and bring together industry managers and CSIRO research workers in these areas. The committees operate by surveying an industry and then establishing expert working parties or panels in particular problem areas.

The research committees, with their expert panels, are seen as the first step of a cooperative effort within industries to encourage technical improvement and innovation. The involvement of CSIRO staff on the committees and panels ensures that the Organization obtains first-hand information on the problems of particular industries. This feedback enables CSIRO to review the objectives of its own research programs in line with changing industry requirements.

CSIRO has provided support to two schemes initiated by the Department of Productivity—the Information Technology Council, formed to catalyse the transfer of information technology to Australian industry, and the Technology Transfer Council, formed to promote the flow of new technology to industry.

The Technology Transfer Council, which comprises representatives from professional bodies, industry, and government agencies such as CSIRO, has evolved the concept of a Technical Referral Network, wherein a number of Technical Referral Centres are located at host organizations in capital cities. Each Centre acts as a 'bridge' between sources of information and manufacturing firms. With the assistance of the Confederation of Australian Industry and the Metal Trades Industry Association, the Council intends to concentrate on the metals industry initially. It has set up six Technical Referral Centres, one being based at the CSIRO Division of Manufacturing Technology in Melbourne.

CSIRO also assisted in the formation of the Australian Scientific Instruments Association (ASIA) in 1980. ASIA is an association of Australian instrument manufacturers established to stimulate the Australian scientific instrument industry, to develop initiatives in export, and to encourage improved communication between the industry, research bodies, and users and inventors of scientific instruments. CSIRO is supplying some administrative services to ASIA during its formative phase. Dr C. K. Coogan, Assistant Chief of the Division of Chemical Physics, has been seconded to the Bureau of Scientific Services to devise methods for making CSIRO's developments in instrumentation more accessible to instrument manufacturers. In association with CSIRO, ASIA has produced a new current awareness journal for the industry, known as ASIASDI. ASIA has also collaborated with CSIRO and the Scientific Industry Council of Australia in the production of a microfiche directory of Australian scientific instruments, known as 'MAID'.

# 5. Research reviews

Regular reviews of CSIRO's research effort are conducted or initiated at Executive level. They comprise subject reviews, which are concerned with a subject area or discipline as a whole and often span research activities in a number of Divisions, and Divisional reviews, which involve an examination of the effectiveness and relevance of the research programs of an individual Division.

The results of reviews dealing with the ocean sciences and research for manufacturing industry are discussed in Chapters 3 and 4; other reviews that the Executive has considered or initiated during the year are discussed below.

## Subject Reviews

### Recombinant DNA Techniques in Research

In October 1977, the Executive commissioned a review of recombinant DNA techniques in research in order to guide decisions on the allocation of research resources. The review committee comprised Dr N. K. Boardman (Chairman), Member of the Executive; Dr J. N. Adams, Molecular Biology Laboratory, Walter and Eliza Hall Institute of Medical Research; Professor A. J. Pittard, Professor of Microbiology, University of Melbourne; Dr J. M. Rendel, CSIRO Division of Animal Production; and Dr P. R. Whitfeld, CSIRO Division of Plant Industry.

The committee's report was sent as a confidential document for comment to the Australian Science and Technology Council, the Australian Academy of Science, the Department of Science and the Environment, the Department of Health and to CSIRO Divisions.

The Executive then considered the content of the report in the light of comments received. Because of the particular issues of public interest and accountability that were involved, the Executive added a foreword before releasing the report for wider circulation.

The Executive adopted the following recommendations:

- that recombinant DNA technology be regarded as an important research tool for use in appropriate research programs by any Division having the necessary expertise;
- that CSIRO convene meetings to inform the biological research Divisions of the nature of recombinant DNA manipulations and their possible applications in research;
- that the Executive encourage the expansion of research into the molecular analysis of animal genes through the application of recombinant DNA techniques;
- that research on the transplantation of nuclei, the construction of hybrid embryos, and animal genetics at the cellular level be given encouragement by the Executive;
- that the Executive give consideration to initiating a review of

the research opportunities for the Organization in industrial microbiology, with particular reference to the potential afforded by the application of *in vitro* recombinant DNA technology;

- that CSIRO collaborate with the Australian Academy of Science and other bodies in sponsoring conferences on the techniques and applications of recombinant DNA research;
- that CSIRO continue to offer the Academy of Science Committee on Recombinant DNA its fullest cooperation, and ensure that 'biohazard committees' and their attendant safety officers exist in all relevant Divisions; and
- that the necessary physical facilities be provided to ensure that programs of work within CSIRO can be carried out in accordance with guidelines established by the Academy of Science Committee.

## Computing Facilities

In June 1979, the Executive established a committee under the chairmanship of Dr N. K. Boardman, Member of the Executive, to review the Organization's policy with respect to computing facilities required for service and research. Other members of the committee are Professor B. D. O. Anderson, Department of Electrical Engineering, University of New South Wales; Dr P. J. Claringbold, Chief of the CSIRO Division of Computing Research; Dr J. M. Gani, Chief of the CSIRO Division of Mathematics and Statistics; Professor J. D. Morrison, Department of Chemistry, La Trobe University; and Dr J. R. Philip, Director of the CSIRO Institute of Physical Sciences.

The committee's terms of reference are to advise the Executive on the following policy issues:

- the role that CSIRO and the Division of Computing Research should play in regard to computing research in Australia;
- the requirements for computing facilities for both research and information storage and processing, how appropriately these requirements are met at present, and how best they may be satisfied in the future by both CSIRONET and by dedicated facilities within Divisions (taking into account not only CSIRO's requirements, but also its obligations to provide scientific and technical computing facilities for government departments and instrumentalities and for universities);
- the range of customers to be serviced and the computing services to be provided by CSIRONET, taking into account both government decisions on the role of CSIRO and CSIRONET, and the funding of Divisional facilities, including staff, from Annual Appropriations;
- the appropriate balance between CSIRO and non- CSIRO users of CSIRONET;
- whether recent rapid developments in the computing area necessitate changes in the CSIRONET charter; and
- the future role, terms of reference, size and composition of the Advisory Committee on Computing, bearing in mind the Executive's continuing need for policy advice on the operation of CSIRONET.

## Energy

A statement on CSIRO's policy and priorities for energy research was published in last year's Annual Report. Much of CSIRO's energy program was also reviewed in the Organization's submission of August 1979 to the Inquiry by the Senate Standing Committee on National Resources into the Replacement of Petroleum-based Fuels by Alternative Energy Resources.

Because CSIRO's energy research has many facets and involves many scientific disciplines, such statements have tended to emphasize the aspect of diversity. This has led to criticisms that the energy research activities of CSIRO appear to be diffuse and do not show sufficient evidence of forming part of the Organization's overall research strategy and priorities.

In May 1980, therefore, the Executive established a Working Party on Energy, chaired by Dr W. J. McG. Tegart, Member of the Executive, to recast CSIRO's energy program to reflect more directly Executive perspectives and planning and, if necessary, to revise the energy research policy statement. The Working Party comprised Institute representatives nominated by Institute Directors and was supported by representatives from the Planning and Evaluation Advisory Unit, the Bureau of Scientific Services, and the Office of the Executive.

Its report was expected to be completed in July 1980.

## Forest and Forest-products Problems

Last year's Annual Report referred to the formation of an ad hoc committee to advise the Executive on the nature and relative importance of the problems of Australian forests and the forest-products industry. While the recommendations of the committee are now under consideration by the Executive, those recommendations relating specifically to the Division of Forest Research were taken into account, both by the committee which reviewed that Division (see under Divisional Reviews), and by the Executive when it considered the recommendations of the Divisional review committee.

## Water Research

CSIRO's research on water covers a wide range of topics, from water assessment and hydrology, through purification for human consumption and agricultural and industrial use, to repurification from effluents. The various research programs involved and the Divisions and Units in which they are carried out are described in the CSIRO Directory of Water Research, which was published in December 1979.

In July 1979, the Institute of Earth Resources established a water research program as a first step in coordinating the water research carried out by the Divisions of Land Resources Management, Land Use Research, and Soils. (These Divisions are now being reviewed—see under Divisional Reviews.) In addition, the Institute is undertaking a review of its water research program, having regard to Australia's current and projected water-resource problems. The Executive is awaiting the outcome of the Divisional reviews and the Institute's review before deciding what further action will be needed.

**Future Reviews**

Subject reviews of research on wood science, which is currently centred in the Division of Building Research, and biotechnology are planned for 1980/81.

## Divisional Reviews – completed

**Australian Numerical Meteorology Research Centre**

The Australian Numerical Meteorology Research Centre is operated and funded jointly by CSIRO and the Department of Science and the Environment. The research program for the Centre is recommended by an Advisory Committee on Policy and Programs and approved annually by the Chairman of CSIRO and the Secretary of the Department of Science and the Environment, acting jointly.

During the year the Executive considered a report from a committee of review comprising Mr J. P. Lonergan (Chairman), Deputy Secretary, Department of Science and the Environment; Dr N. K. Boardman, Member of the Executive; and Professor B. R. Morton, Department of Mathematics, Monash University. The committee's terms of reference required it, in accordance with the provisions of the current agreement, to:

- review in depth all arrangements for the operation of the Centre and make recommendations to the Chairman of CSIRO and the Secretary of the Department of Science and the Environment on the need for research on the development and application of numerical techniques in meteorology;
- consider whether the Centre should continue as a separate entity and, if so, to examine its role, taking into consideration the meteorological research being undertaken in CSIRO and the Bureau of Meteorology; and
- examine the interface between the Centre and the Bureau of Meteorology, particularly in relation to implementation of the Centre's research findings; the role of the Advisory Committee on Policy and Programs; arrangements for the provision of staff and financial resources; and organizational, management and other aspects of the Centre.

The Executive accepted the recommendations of the report, subject to further examination of some minor matters, and agreed that the present arrangements should be maintained for the next five years.

The major objective of the Centre will continue to be the development of numerical models that can be applied to:

- improving the accuracy and timeliness of weather predictions by the Bureau of Meteorology and extending their time-scale; and
- obtaining a better understanding of the variability of climate.

In its report, the committee drew attention to the need to develop improved numerical models for the tropics, and to the importance of developing numerical methods that would enable more accurate weather forecasts to be made for local areas.

To provide more adequate oversight of the Centre's activities, the Advisory Committee on Policy and Programs will be expanded and its terms of reference widened. In addition, a Coordinating Committee will be established to assist in coordinating the research programs of the Centre, the Division of Atmospheric Physics and the Bureau of Meteorology, to assist in the implementation of the various recommendations of the review committee's report, and to assist the Advisory Committee on Policy and Programs.

**Division of Forest Research**

In October 1979, the Executive established a committee to review the Division of Forest Research. The committee comprised Mr M.V. Tracey (Chairman), Director of the CSIRO Institute of Biological Resources; Professor E. P. Bachelard, Department of Forestry, Australian National University; Dr C. Bassett, Forest Research Institute of New Zealand; Dr E. F. Henzell, Chief of the CSIRO Division of Tropical Crops and Pastures; and Mr P. M. South, Woods and Forests Department, South Australia.

The committee's terms of reference were:

- to advise the Executive as to whether the Division should continue substantially in its present organizational form;
- to review the overall objectives of the Division and advise the Executive on their appropriateness;
- to advise the Executive on the appropriateness of the objectives of the Division's research programs and their relevance to the industries or scientific disciplines served;
- to make recommendations on the future role of the Division and its relationship with other Divisions and with industry, government departments and other research organizations; and
- to make general comments on the scientific standards of the research work and the management and organization of the Division.

The review committee's broad recommendations, which took into account the relevant recommendations of the ad hoc committee on forest and forest-products problems, were endorsed by the Executive in April 1980. They will be used as a guide in seeking a new Chief for the Division to replace the present Chief, who retires in December 1980. The Executive decided that:

- The Division of Forest Research should continue as an integral Division, and as the only one in CSIRO primarily concerned with forests. However, other Divisions should carry out some specialized work relating to forests, as necessary.
- The Division should study forests as total ecosystems, with a range of uses and values to the community. Thus, the work should not be limited to research on forest production for harvesting. The Division should continue to study both native and exotic species, and both natural and plantation forests.
- The research activities of the Division should be centred around four core areas, namely forest ecology, silviculture, tree breeding and genetic resources, and harvesting, to focus research effort

and avoid undue dispersion of effort. These activities should be supported in a variety of peripheral fields inside and outside the Division, as set out in the review committee's report.

- The Director of the Institute of Biological Resources should develop the concept of differentiating regional research activities into regional stations, which have a relatively strategic, long-term role, and regional groups, which undertake more tactical, limited-term assignments. It was agreed that, in these terms, the Mt Gambier and Atherton research stations should retain their classifications. The Director should examine regional activities and their appropriateness for Divisional purposes. He should also look at the possible need to rationalize and strengthen rainforest research.

The Executive approved the following statement of objectives for the Division:

'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 balanced management of Australia's forests in relation to wood production, water supply and ecosystem preservation.'

A number of other recommendations of the review committee which dealt with matters of internal management were endorsed by the Executive and referred to the Director of the Institute of Biological Resources for action.

### Division of Radiophysics

In May 1979, the Executive established a committee to review the Division of Radiophysics. The committee comprised Dr W. J. McG. Tegart (Chairman), Member of the Executive; Professor W. N. Christiansen, Emeritus Professor of Electrical Engineering, University of Sydney; Dr A. K. Head, CSIRO Division of Materials Science; Professor D. B. Melrose, Department of Theoretical Physics, University of Sydney; and Dr D. C. Morton, Director, Anglo-Australian Observatory.

The committee's terms of reference were:

- to advise the Executive as to whether the Division should continue as a separate entity;
- to review the objectives of the Division and advise the Executive on their appropriateness;
- to advise the Executive on the appropriateness of the objectives of each of the Division's research programs and their relevance to the industries or scientific disciplines served;
- to make recommendations on the future role of the Division and its relationships with Divisions within the Institute of Physical Sciences, with other CSIRO Divisions, and with industry, universities, research organizations and other bodies; and
- to make general comments on the scientific standards of the research work and the management and organization of the Division.

The Executive considered the committee's recommendations in April 1980 and decided that:

- the Division of Radiophysics should continue as a separate entity within CSIRO;
- the Division's objectives should be to conduct research into radiophysics, including radioastronomy, and into the application of radiophysics to community and industrial problems;
- the Division's capabilities in theoretical astrophysics should be strengthened by new appointments;
- the Executive should continue to seek funds for the Australian Synthesis Telescope;
- the Parkes Telescope Program Planning Committee should have continuing outside membership and, on completion of the Australian Synthesis Telescope, a single committee should be responsible for assigning time on both instruments; and
- procedures should be developed for informing the general public and the non-astronomical scientific community about the goals and results of the Division's researches.

## Divisional Reviews – in progress

**Division of Animal Production**

The Executive established a committee in December 1979 to review the Division of Animal Production. The Division, which was formed in 1975 from the Divisions of Animal Genetics and Animal Physiology, has not been reviewed previously. Dr K. A. Ferguson, Director of the CSIRO Institute of Animal and Food Sciences, is Chairman of the committee. Other members are Mr J. H. S. Heussler, Past President, United Graziers' Association of Queensland; Professor H. R. Lindner, the Weizmann Institute of Science, Israel; Professor R. J. Moir, Department of Animal Science and Production, University of Western Australia; and Dr A. Robertson, Unit of Animal Genetics, Agricultural Research Council, United Kingdom.

The committee's terms of reference are:

- to review the research of the Division and assess the progress made towards attaining the objectives of its research programs;
- to assess the appropriateness of the research objectives in relation to the problems of the livestock industries in Australia, to the research being carried out by other agencies such as State Departments of Agriculture and universities, and to the strategic role of CSIRO in livestock research;
- to make general comments on the standard of the research work and management of the Division; and
- to make recommendations on the future role and structure of the Division within the Institute of Animal and Food Sciences.

**Division of Cloud Physics**

A committee to review the Division of Cloud Physics was established in April 1980. Its members are Dr J. R. Philip (Chairman), Director of the CSIRO Institute of Physical Sciences; Professor J. H. Carver, Director, Research School of Physical Sciences, Australian National University; and Professor N. H. Fletcher, Professor of Physics, University of New England.

The committee's terms of reference are:

- to examine the present objectives of the Division and advise on the extent to which they are being achieved, taking account of the resources available;
- to report on the current status of the Division's rain-making program;
- to report on the cost-effectiveness of using the F27 aircraft for rain-making and other studies;
- to advise on the continuation or otherwise of the Division's use of the F27 aircraft, and of the Division's rain-making program;
- to advise on the effectiveness with which the Division's special techniques and skills have been imparted to potential users and on the extent of further effort in this direction;
- to advise on the appropriateness or otherwise of the continuation of the activities of the Division, having regard to overall Organizational priorities; and
- in the event of the committee recommending that the Division continue as an entity, to advise on the Division's future role, its organizational format, and the level of resources to be devoted to it.

**Dairy Research Laboratory, Division of Food Research**

In August 1979, the Executive established a committee to review the Dairy Research Laboratory of the Division of Food Research. Dr K. A. Ferguson, Director of the CSIRO Institute of Animal and Food Sciences, was Chairman of the committee. Other members included Dr J. H. B. Christian, Chief of the CSIRO Division of Food Research; Dr K. T. H. Farrer, Chief Scientist, Kraft Foods Ltd; Dr D. E. Hore, Assistant Director-General, Victorian Department of Agriculture; and Dr N. S. Snow, Technical Director, Australian Dairy Corporation.

The committee's terms of reference were:

- to examine the existing programs of the Dairy Research Laboratory and compare them with the research on dairy products being carried out in other laboratories in Australia;
- to consider economic and technological trends in the dairy industry and consequent priorities for research for the dairying manufacturing industry;
- to determine the appropriate role for CSIRO in dairy research, having regard for the research being undertaken in other laboratories, and to consider whether existing programs needed to be changed to fit in with that role; and
- to examine the funding and organizational arrangements for research at the Dairy Research Laboratory and advise whether changes were desirable.

The report of the review committee has been completed and is under consideration by the Executive.

**Division of Entomology**

In December 1979, the Executive established a committee under the chairmanship of Mr M. V. Tracey, Director of the CSIRO Institute of Biological Resources, to undertake a review of the Division of Entomology prior to the retirement of the Chief in 1981. The other members of the committee were Professor T. O. Browning, Waite Professor of Entomology, Waite Agricultural Research Institute, South Australia; Mr R. J. Hardy, Chief Entomologist, Tasmanian Department of Agriculture; Dr G. S. Hooper, Head, Department of Entomology, University of Queensland; Dr W. D. L. Ride, Director, Bureau of Flora and Fauna, Department of Science and the Environment; Mr R. M. Watts, Director-General, New South Wales Department of Agriculture; and Professor M. J. Way, Director, Imperial College of Science and Technology, United Kingdom.

The committee's terms of reference were:

- to review the overall objectives of the Division of Entomology and to advise the CSIRO Executive on their appropriateness;
- to advise the Executive on the relevance of the Division's current research programs to the industries and scientific disciplines served;
- to make general comments on the characteristics of the research staff as a group, the scientific standards of their work, and the management of the Division;
- to make recommendations on the future role of the Division and its relationships with other CSIRO Divisions, industry, government departments and other research organizations; and
- to advise the Executive as to whether the Division should continue substantially in its present organizational form.

The committee's report has been submitted to the Executive for consideration.

**Divisions of Land Use Research and Land Resources Management**

In May 1980, the Executive set up a committee to review the Divisions of Land Use Research and Land Resources Management. The committee comprises Dr N. K. Boardman (Chairman), Member of the Executive; Dr R. G. Downes, former Permanent Head of the Victorian Ministry for Conservation; Dr R. P. M. Dun, Deputy Director-General, New South Wales Department of Agriculture; Mr E. N. Fitzpatrick, Director of Agriculture, Western Australian Department of Agriculture; Dr K. G. McCracken, Chief of the CSIRO Division of Mineral Physics; Professor J. P. Quirk, Director, Waite Agricultural Research Institute, South Australia; and Professor G. Seddon, Director, Centre for Environmental Studies, University of Melbourne.

The committee's terms of reference are:

- to advise the Executive as to whether the Divisions should continue in their present organizational forms;
- to review the overall objectives of the Divisions and advise the Executive on their appropriateness;
- to assess the present activities of the Divisions and their rele-

vance to the scientific disciplines and the community and industry interests served;

- to advise the Executive on the balance of resources devoted to the Divisions' various research programs;
- to make recommendations on the future roles of the Divisions and their relationships with the Divisions within the CSIRO Institute of Earth Resources, with other CSIRO Divisions, and with industry, universities, other research organizations, and State Government agencies; and
- to make general comments on the quality of the research work and the management and organization of the Divisions.

**Division of Mathematics and Statistics**

A committee to review the Division of Mathematics and Statistics was established in April 1980. The committee comprises Dr J. R. Philip (Chairman), Director of the CSIRO Institute of Physical Sciences; Professor D. R. Cox, Imperial College of Science and Technology, United Kingdom; Professor L. N. Howard, Massachusetts Institute of Technology, U.S.A.; Professor J. J. Mahony, Department of Mathematics, University of Western Australia; and Professor E. J. Williams, Department of Statistics, University of Melbourne.

The committee's terms of reference are:

- to advise the Executive on the appropriateness of the Division's present objectives and the extent to which they are being achieved;
- to comment on the quality of the research and other activities of the Division;
- to comment, as appropriate, on the Division's relations with other Divisions of CSIRO;
- to advise on the objectives and activities of the Division;
- to comment on the management and internal organization of the Division;
- to advise on a proposal to bring about a close association between the Division and a group of mathematicians from the Australian National University in a Mathematical Sciences Research Centre; and
- to advise on means of improving the level of mathematical competence within CSIRO.

**Division of Soils**

The Executive established a committee in February 1980, under the chairmanship of Dr J. R. Philip, Director of the CSIRO Institute of Physical Sciences, to review the Division of Soils. The other members of the committee are Dr R. G. Downes, former Permanent Head of the Victorian Ministry for Conservation; Professor W. R. Gardner, University of Arizona, U.S.A.; Professor J. R. McWilliam, Head of the Department of Agronomy and Soil Science, University of New England; and Mr S. Pels, Senior Research Officer of the Water Resources Commission of New South Wales.

The committee's terms of reference, with due regard to the responsibilities of other organizations, are:

- to advise the Executive on the future research role appropriate to CSIRO in the soil sciences, including agricultural, hydrological, engineering and conservation aspects, and specifically:
- to advise the Executive as to whether the Division of Soils should continue in its present organizational form;
- to review the overall objectives of the Division and advise the Executive on their appropriateness;
- to assess the present activities of the Division and their relevance to the scientific disciplines and the community and industry interests served;
- to advise the Executive on the balance of resources devoted to the Division's various research programs;
- to make recommendations on the future role of the Division and its relationships with the Divisions within the CSIRO Institute of Earth Resources, with other CSIRO Divisions, and with industry, other research organizations, and State Government agencies; and
- to make general comments on the scientific standards of the research work and the management and organization of the Division.

## Future Divisional Reviews

Reviews of the Divisions of Chemical Technology, Mechanical Engineering, and Wildlife Research are planned for 1980/81.

# 6. Review of the Australian Journals of Scientific Research

## Background

As part of its function 'to publish scientific and technical reports, periodicals and papers' under sub-section 9(j) of the Science and Industry Research Act 1949, CSIRO publishes the Australian Journals of Agricultural Research, Biological Sciences, Botany, Chemistry, Marine and Freshwater Research, Physics, Plant Physiology, Soil Research, and Zoology. The Journals are known collectively as the Australian Journals of Scientific Research.

CSIRO meets all the production costs involved and provides editorial staff to process and edit the papers. Each Journal has an Advisory Committee, made up of eminent scientists in the appropriate field, which decides whether the papers submitted are suitable for inclusion in the Journal and which assists in the selection of referees and the consideration of referees' reports. CSIRO and the Australian Academy of Science jointly appoint the chairmen of the Advisory Committees, who also sit on a Board of Standards. This Board, which includes representatives of CSIRO and the Academy, establishes the standards for acceptance of papers for publication and considers practices and problems common to all of the Journals. It also advises on matters of policy and procedure and appoints the members of the Advisory Committees.

## Review

During 1977, the Executive of CSIRO and the Council of the Academy agreed to conduct a joint review of the Australian Journals of Scientific Research to assess the case for continued publication of each Journal. The review committee comprised Professor R. Hanbury Brown (Chairman), Department of Physics, University of Sydney; Dr L. T. Evans, President of the Australian Academy of Science; and Professor Emeritus H. W. Worner, Director of the CSIRO Institute of Industrial Technology. The work of the committee was postponed pending the outcome of the Independent Inquiry into CSIRO. Arising out of that Inquiry, the Government decided that publication by CSIRO of journals concerned with original science and of information related to scientific and technical matters should continue. The Government also decided that publication of the Australian Journals of Scientific Research should continue but that their scope and form should be examined.

Adopting these broad guidelines, the review committee sought opinions from universities, CSIRO Divisions, State and Federal Government departments, Australian scientific societies, and from all subscribers to the Journals on:

- the need for, and role of, the Journals in relation to Australian scientific publishing needs;
- their role in relation to world scientific publications; and
- the scientific quality and impact of the papers published in the Journals.

The review committee completed its report in November 1979.

## Role and Scope

The Executive and the Academy Council supported the review committee's conclusion that a series of national science journals of high quality served a useful purpose. Accordingly, they supported the committee's recommendations that publication of the Australian Journals of Scientific Research be continued, as should the policy of accepting contributions of sufficiently high a standard from workers in overseas research institutions as well as from Australian scientists. Furthermore, every effort should be made to increase the association between individual Journals and the relevant scientific societies, not only in Australia but also in New Zealand.

A recommendation that the Australian Journal of Soil Research be renamed the Australian Journal of Earth Sciences and that it include geological, hydrological and soils research in its coverage was not accepted, but CSIRO and the Academy agreed that the scope of the Australian Journal of Soil Research should be monitored. It was also agreed that the Australian Journal of Biological Sciences should concentrate increasingly on the publication of papers in animal science and that the Australian Journal of Botany should continue to cover the full range of botanical research, including in its content some purely taxonomic papers, in order to fulfil the function of a comprehensive national journal of botany.

## Administration and Editing

The main involvement of the Academy of Science with the Journals is through the participation of Academy representatives on the Board of Standards. The review committee recognized that the structure of the Board suited its functions as a deliberative body but considered that a smaller body would be more appropriate for advising on the day-to-day management of the Journals. CSIRO also considered that the Board as constituted was not suited to a policy-making role since the majority of members represented a particular Journal Advisory Committee and could be seen as having a vested interest in their particular Journal. Consequently, a three-member executive committee of the Board of Standards will now be established to consider certain policy aspects. It will report directly to the Executive of CSIRO and the Council of the Academy.

The practices followed for refereeing papers are not uniform across the Journal series. While the review committee saw no problem in this, CSIRO wished to ensure that each paper was refereed by at least two people and will discuss the matter further with the Academy. CSIRO and the Academy were in agreement that the present arrangement of having a separate editor and Advisory Committee for each Journal should be retained and not be replaced by an editorial board, but that every means should be sought to increase the use made of Advisory Committee members by the editors. Consideration is now being given to enlarging the membership of the Advisory Committees, especially by the addition of corresponding members.

## Funding

The review committee was concerned that unless adequate funds could be provided for publication, discontinuance of certain of the Journals would be necessary in order to ensure that the editorial and publication standards of the remaining Journals were maintained. The committee argued that the basis of funding the Journals should be changed so that the income derived from their sale could be used to offset costs. The Executive agreed to support the Journals with an annual allocation which took into account the revenue earned through sales. The Executive further agreed that subscription rates for the Journals be increased to bring them into line with those of comparable overseas journals, and that charges be made for supplementary issues. No charge is made for supplementary issues at present, although in the case of some Journals they constitute a substantial proportion of the total material published. However, in order to encourage greater use of the Journals, members of the relevant scientific societies in Australia and New Zealand will be offered reduced Journal subscription rates. The Executive and the Academy will re-examine the matter of increasing Journal income by imposing page charges after the Government has responded to the recommendations of the Industries Assistance Commission on the publishing industry.

CSIRO will also examine alternative methods of production and distribution of the Journals and the comparative costs of internal and commercial production.

# 7. Organization and staff

## Organization

CSIRO on 30 June 1980 had a total staff of 7387 people located in 109 laboratories and field stations throughout Australia. About one-third of the staff are professional scientists, with the others providing technical or administrative support. An organization chart appears overleaf.

### Executive

CSIRO is governed by an Executive comprising three full-time Members 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, the Directors and the heads 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 and buildings, 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 and Units

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, headed respectively by Chiefs and Officers-in-Charge. 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. Directors are responsible, in consultation with their constituent 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 are given in Chapter 2.

**Bureau of Scientific Services**

The Bureau of Scientific Services, headed by a Director, is responsible for facilitating and promoting transfer and utilization of technology and scientific and technical information for the benefit of Australian science, industry and the community at large. It also has a responsibility to foster technical development projects with other nations. The work of the Bureau stresses the importance of the interface between researcher and user, and is largely concerned with the transfer of information and research results. The Organization through the Bureau and its research scientists also has a role to play in the interpretation and dissemination of world scientific and technological research as well as those results generated within CSIRO.

The structure of the Bureau is still developing. At present it 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;
. encouraging the adoption of CSIRO technical know-how, inventions and technology in industry by the use of patents and licences, contracting out of 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.

**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;

## 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
Food Research
Dr J. H. B. Christian
Human Nutrition
Dr B. S. Hetzel

*Units and Officers-in-Charge*
Centre 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

CILES – *O-i-C* Mr P.J. Judge
CIRC – *O-i-C* Mr A.F. Gurnett-Smith

### 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 D. F. Waterhouse
**Fisheries and Oceanography**
Mr D. J. Rochford
**Forest Research**
Dr M. F. C. Day
**Horticultural Research**
Dr J. V. Possingham
**Irrigation Research**
Dr P. E. Kriedemann
**Plant Industry**
Dr W. J. Peacock
**Tropical Crops and Pastures**
Dr E. F. Henzell
**Wildlife Research**
Dr H. J. Frith

**INSTITUTE OF EARTH RESOURCES**

*Director*
Dr R. J. Millington *(Acting)*

*Divisions and Chiefs*

**Applied Geomechanics**
Dr D. F. Kelsall
**Land Resources Management**
Mr R. A. Perry
**Land Use Research**
Mr J. J. Basinski *(Acting)*
**Mineral Chemistry**
Dr D. F. A. Koch
**Mineral Engineering**
Dr D. F. Kelsall
**Mineral Physics**
Dr K. G. McCracken
**Mineralogy**
Mr A. J. Gaskin
**Process Technology**
Mr A. V. Bradshaw
**Soils**
Dr A. E. Martin

*Units and Officers-in-Charge*

**Fuel Geoscience**
Dr D. J. Swaine *(Acting)*
**Physical Technology**
Dr E. G. Bendit

**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**
Mr J. Warner
**Computing Research**
Dr P. J. Claringbold
**Environmental Mechanics**
Dr D. E. Smiles
**Materials Science**
Dr J. R. Anderson
**Mathematics and Statistics**
Dr J. M. Gani
**Radiophysics**
Mr H. C. Minnett

*Unit and Officer-in-Charge*

**Australian Numerical Meteorology Research Centre**
Dr D. J. Gauntlett



Organization Chart

The chart shows the structure of CSIRO as at 30 June 1980.

- 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.

## Divisional Changes

During the year the Executive strengthened the Organization's research and development activity in the manufacturing sector by creating a Division of Manufacturing Technology (see Chapter 4).

Following a review of the Microanalytical Laboratory of the Division of Applied Organic Chemistry, the Executive agreed that the Laboratory's functions should be taken over by the Australian Mineral Development Laboratories. The transfer was effected in February 1980.

## Administrative Arrangements

### Review of Administration

The re-organization of CSIRO's top management structure, following passage of the Science and Industry Research Amendment Act 1978, was reported in the 1978/79 Annual Report. Briefly, this reorganization involved the following moves: the Executive was reconstituted to comprise three full-time Members including the Chairman, and five part-time Members; the Chairman's position as Chief Executive was formalized; the research Divisions and Units were organized into five research Institutes; and a Bureau of Scientific Services and a Planning and Evaluation Advisory Unit were formed.

Following this reorganization, the Executive commissioned a review of CSIRO's administration. The purpose was to ensure that administrative arrangements were modified where necessary to meet the needs of the new management structure and also to identify areas where economies could be made.

A firm of management consultants, W. D. Scott and Co. Pty Ltd, which had assisted the Independent Committee of Inquiry into CSIRO in 1977, was engaged to conduct the review. It was agreed that the review should:

- focus on administrative support services to research management;
- concentrate on general principles and not become unnecessarily involved with procedural details; and
- direct its attention to the future needs of the Organization.

As a preliminary to its more detailed recommendations, the consultants advised the Executive on some aspects of top-level organizational arrangements relating particularly to support for the Chairman and the two other full-time Members of the Executive. They suggested that Head Office should be separated into three functional areas, each reporting independently to the Chairman. The areas suggested were Personnel, Finance and Administration, and a new grouping incorporating central policy coordination, corporate development and Executive services. The Executive adopted this suggestion and the new grouping is known as the Office of the Executive. The organization chart on pages 62 and 63 reflects the revised arrangement.

Two basic requirements underlay the more detailed recommendations made by the consultants. The first was the need to strengthen the line of accountability flowing from the Executive via the Chairman as Chief Executive and the Institute Directors to Chiefs and Officers-in-Charge. The second was to ensure that, as far as possible, Chiefs and Officers-in-Charge were fully accountable for scientific performance in their respective areas and for the way in which resources were used, developed and supplemented in those areas. Specific recommendations related to administrative support services within Institutes and Divisions and to changes in the role of Regional Administrative Offices.

The consultants concluded that CSIRO's total administrative costs were generally consistent with its role and geographical dispersal. They anticipated, however, that the implementation of revised administrative arrangements flowing from changes in the top management structure would provide opportunities for significant improvements in efficiency.

A working party comprising the three full-time Members of the Executive, assisted by the heads of the Office of the Executive, the Finance and Administration Branch, and the Personnel Branch, has been established to advise on these recommendations. The consultants' report has been made available to all staff through the CSIRO library system and opportunities will be provided for staff, particularly those likely to be significantly affected by changes, to contribute to discussion of issues.

## Decentralized Personnel Management

In recent years, the Executive has begun a program of decentralizing many of the Organization's personnel management functions to take advantage of shorter lines of communication and to involve in decision making those with knowledge and perspective gained closer to the workface. Accordingly, a number of decision-making powers have been delegated progressively to Chiefs and Officers-in-Charge and to Regional Administrative Officers as guidelines for exercising these delegations have been developed.

The development of the Institute structure and appointment of Institute Directors have enabled the Executive to decentralize further. The Executive has decided to delegate the responsibility for appointments and promotions, with the exception of the very senior levels, to Institute Directors in the case of the more senior staff categories and to Chiefs of Divisions for less senior categories. These decisions are consistent with the Executive's policy of delegating to Directors responsibility for the management, scientific performance and development of their respective areas.

To ensure that decentralization does not result in inconsistencies between Institutes and between Divisions, the Personnel Branch has developed guidelines for monitoring appointments and promotions. Also, classification guidelines for a number of staff categories have been completed. Procedures have been developed to ensure that specialists in staff evaluation are accessible to those with delegated authority for appointments and promotions.

As a result of these delegations, the Personnel Branch has become much more concerned with monitoring and interpretation of policy and with other activities which are more appropriately handled centrally, such as policy development, industrial relations and staff development.

**Vestibule Grade**

A recommendation arising out of the Independent Inquiry into CSIRO in 1977 was that consideration should be given to the introduction of a vestibule grade into which all new research staff would be appointed. Officers would spend about three years in this grade, obtaining varied research experience. Following an assessment of their potential, they would be allocated to either the Research Scientist or Experimental Officer streams.

At present, vacancies for Research Scientists and Experimental Officers are advertised as the need arises, and filled by appointing the most suitable applicant. Recruits are assessed on their qualifications and relevant research experience prior to joining the Organization, the primary consideration being their capacity to perform satisfactorily the duties of the position advertised. From time to time, this results in the appointment as an Experimental Officer of a person capable of performing the duties of a Research Scientist. Procedures exist for reclassifying such officers at an appropriate time. Procedures also exist for reclassifications in the reverse direction.

The introduction of a vestibule grade could reduce the need to utilize these reclassification procedures. However, its introduction could mean a loss in research effectiveness while officers were being given varied experience, and it could also lead to a decrease in morale. Morale could be affected if decisions about streaming, made at the end of the vestibule grade period, were seen as final. Moreover, the numbers of officers emerging from the vestibule grade into the two classification streams would be unlikely to match the Organization's requirements, and this could also lead to dissatisfaction.

The Executive has concluded that the benefits likely to flow from the introduction of such a scheme would be small and would not outweigh the potential disadvantages.

## Executive and Staff Changes

**Executive Changes**

Mr P. D. A. Wright and Professor D. P. Craig were appointed part-time Members of the Executive during the year.

Mr Wright is a cattle breeder and grazier, with interests in aviation. He was a member of the Australian Meat Board for twelve years and Deputy Chairman of the Board for seven. His current activities include membership of the Science and Industry Forum of the Australian Academy of Science, the Commonwealth Council for Rural Research and Extension, the Australian Meat Research Committee and the Australian Meat and Livestock Corporation's Producers Consultative Group.

Professor Craig is Professor of Physical and Theoretical Chemistry and Dean of the Research School of Chemistry at the Australian National University. Professor Craig is a Fellow of the Royal Society and a Fellow of the Australian Academy of Science. He was a member of the Council of the Australian Academy of Science and its Vice-President from 1974 to 1976. He is Chairman of the Queen Elizabeth II Fellowships Committee and has been a member of that Committee since 1977.

Mr Wright and Professor Craig replace Mr D. J. Asimus, who resigned from the Executive to take up an appointment as Chairman of the Australian Wool Corporation, and Mr V. E. Jennings, who completed his term of appointment in March 1980. Mr Jennings had served as a part-time Member of the Executive since 1974 and during this time had taken a particular interest in strategic planning and in safety.

## Senior Appointments and Retirements

Mr I.E. Newnham, Director of the Institute of Earth Resources, was invited to take up a new senior position in industry in February 1980. During his absence, Dr R. J. Millington, Chief of the Division of Land Use Research, was appointed Acting Director of the Institute. Mr Newnham will be returning to this position in October 1980.

In February 1980, Dr J. R. Philip, former Chief of the Division of Environmental Mechanics, took up the appointment of Director of the Institute of Physical Sciences for a period of three years.

Dr R. D. Brock of the Division of Plant Industry was appointed Counsellor (Scientific) in Washington for a period of three years from May 1980. He succeeded Mr J. H. Whittem.

Mr J. G. Downes, Counsellor (Scientific) in Moscow and formerly Chief of the Division of Textile Physics, retired in October 1979.

Dr A. E. Pierce, a former Member of the Executive, commenced his appointment as Minister (Scientific) in London in November 1979. Dr Pierce succeeds Dr R. M. Moore, who has retired from CSIRO.

Professor R. H. Brown, Head, Department of Mechanical Engineering, University of Western Australia, will take up the appointment of Chief of the new Division of Manufacturing Technology in August 1980.

Dr L. T. Chadderton was appointed Chief of the Division of Chemical Physics for a period of seven years from December 1979.

He succeeded Dr A. L. G. Rees on his retirement. Dr Chadderton was formerly Professor of Physics, H. C. Ørsted Institute, University of Copenhagen.

Dr J. H. B. Christian, Associate Chief of the Division of Food Research, was appointed Chief of the Division in succession to Mr M. V. Tracey, for a period of seven years from August 1979. Dr Christian had previously been Acting Chief following Mr Tracey's appointment as Director of the Institute of Biological Resources.

Dr W. G. Crewther, Chief of the Division of Protein Chemistry, was reappointed as Chief for a further term of three years from December 1980.

Dr J. J. Lowke, Reader, School of Electrical Engineering, University of Sydney, was appointed Chief of the Division of Applied Physics, for a period of seven years from June 1980. He succeeded Mr F. J. Lehany on his retirement.

Dr D. E. Smiles of the Division of Environmental Mechanics took up appointment as Chief of the Division for a period of three years from February 1980, in succession to Dr J. R. Philip.

Dr D. H. Solomon, Chief of the Division of Applied Organic Chemistry, was reappointed as Chief for a further term of seven years from February 1981.

Dr D. J. Swaine was appointed Acting Officer-in-Charge of the Fuel Geoscience Unit following the resignation of Dr G. H. Taylor, who was appointed Director of the Centre for Resource and Environmental Studies at the Australian National University.

Following the review of administration described earlier in this chapter, the following appointments were made:

| | |
|---|---|
| Mr L. G. Wilson | Executive Secretary |
| Mr J. Coombe | Deputy Executive Secretary |
| Mr H. C. Crozier | Secretary (Finance and Administration) |
| Mr I. C. Bogg | Deputy Secretary (Finance and Administration) |
| Mr K. J. Thrift | Secretary (Personnel). |

The date of effect of these appointments was 1 January 1980, except for the position of Deputy Secretary (Finance and Administration) which became effective on 27 March 1980.

# 8. 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'. On 2 October 1979, the Science and Industry Research (Consultative Council) Regulations came into effect, and the first meeting of the CSIRO Consultative Council as a formally constituted body was held in Canberra on 10 October 1979. The second meeting was held at the Division of Applied Physics in Sydney on 16 April 1980.

Arrangements had been made before the first meeting for the formal appointment to the Council of representatives of the Executive and of the relevant staff associations and unions. Dr N.K. Boardman was formally appointed as Chairman by the Executive, and Mr B.G. Cook (a representative of the CSIRO Officers' Association) was appointed as Deputy Chairman by the Council at its first meeting.

The Consultative Council comprises a Chairman, who represents 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.

## Sub-committees

Six sub-committees which had been formed at earlier interim meetings were formally established as sub-committees of the Council at its first meeting. A summary of the activities of these sub-committees follows.

### Flexible Working Hours

Since 1974, the Organization has been conducting trials on flexible working hours at most sites. These trials are being reviewed with the object of making recommendations to the Executive on the feasibility of adopting flexible working hours and on the ways in which such a scheme should be operated.

### Employment of Women

An Executive Committee on the Employment of Women was established prior to the formation of the Council. Its activities have been incorporated with those of the Council's sub-committee on the

Employment of Women in CSIRO which was established to examine the role of women in CSIRO; to investigate and evaluate attitudes towards the employment of women in CSIRO; and to report on and recommend solutions to any problems. The role of women in CSIRO is being examined at present and a survey to investigate the attitudes surrounding the employment of women in the Organization is expected to commence in November 1980.

**Technological Change**

The consultative procedures which should be followed when introducing new technology into CSIRO are being examined and recommendations on the establishment of guidelines for consultation are being developed.

**Staff Counselling**

A policy statement on staff counselling and personal counselling was developed and will be considered by the Council in October 1980.

**Terms and Conditions of Service**

In April 1980, the Council established a standing sub-committee to examine and to report on amendments to the CSIRO Terms and Conditions of Service. The removal of the employee category from the Terms and Conditions of Service is being examined.

**Remote Locality Conditions**

A survey of the attitudes of officers employed in remote areas is to be conducted by means of a questionnaire early in 1981. This will help to identify the problems caused to officers and their families by remote living.

## Other Matters

In addition to the activities of the various sub-committees, the following matters were among those discussed at the two meetings:

- the impact of financial constraints on staffing levels;
- identification of costs incurred by officers on transfers which are not reimbursable;
- the Organization's policies on advertising and staff promotions;
- the introduction of a formal procedure for resolving staff grievances;
- the provision of facilities for staff association representatives at CSIRO sites;
- the development of an amenities code for work places; and
- the provision of industrial nurses and occupational health centres.

# 9. Buildings

During 1979/80 the Department of Housing and Construction spent some \$37.6m on the construction of works and buildings for CSIRO and on maintenance of existing buildings. Of this amount, some \$20.7m was spent on the Australian National Animal Health Laboratory at Geelong, Victoria. The Department of Administrative Services spent \$417,000 on the acquisition of land and buildings for CSIRO.

Details of progress with major building projects are given below.

## Australian National Animal Health Laboratory

The Australian National Animal Health Laboratory (ANAHL) has been under construction since March 1978. During the year, the Government decided that the completion date of the project should be advanced from March 1984 to March 1983. To enable this new target to be achieved, manpower and plant resources have been increased and an additional \$7m has been made available. As a result of these extra costs and movements in the building cost index between November 1977 and May 1980, the current authorized cost is \$105.8m.

The project is on schedule. Most of the below-ground structural work is now complete and erection of the pre-cast concrete components on the work level is advanced. In addition, a large area of the engineering service's complex is roofed and the structural framework, main floor and basement levels of the engineering service's machinery hall have been completed. The 64-metre water tower chimney stack is expected to be completed in August 1980. Site works are well advanced and landscaping of those areas not required for construction has begun. The projected cash expenditure on the project during 1980/81 is \$35m.

## Chemical Technology

In May 1979 Parliament approved the recommendation of the Parliamentary Standing Committee on Public Works that the construction of a new laboratory complex for the Division of Chemical Technology should proceed. A contract for \$10.24m for the construction of the laboratory was let in June 1980, and it is estimated that the laboratory will take two and a half years to complete. The laboratory will be constructed on a 15.4-hectare site at Clayton, adjacent to Monash University. The site, which was acquired for CSIRO in 1961, already houses the Divisions of Chemical Physics and Mineral Engineering. The research undertaken by the Division of

Chemical Technology is concerned with extending Australia's water resources through purification and recycling, and with the fractionation and processing of plants to produce cellulosic fibres, animal feeds, chemicals and fuels.

## 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 total cost of $19m. Construction of the Materials Science laboratory is expected to commence towards the end of 1980/81 and of the Applied Organic Chemistry laboratory during 1981/82.

Both Divisions carry out research directed towards improving the performance and efficiency of Australian industry. The Division of Materials Science is concerned with catalytic processes in the production of liquid fuel and with materials research and development. The Division of Applied Organic Chemistry is concerned with conversion of coal tars to crude oil, production of hydrogen by solar energy, synthesis of chemicals for use in agriculture and medicine, and development of special plastics and resins.

The proposed laboratories, which are designed to accommodate 225 staff, will permit the transfer of 190 staff from accommodation at the University of Melbourne and at Fishermen's Bend and will enable badly needed land to be returned to the University. Because the existing buildings at Fishermen's Bend were not designed for modern industrial research, and are located in environments that are unsuited to research involving highly sensitive instruments, the Divisions have had to place severe restrictions on the type of work they undertake.

The establishment of the Chemical Technology, Materials Science and Applied Organic Chemistry laboratories at Clayton is part of a long-term plan initiated by the Executive in the late 1950s to overcome the inadequate and unsuitable conditions in which much of the Organization's chemical research was then carried out.

## Crop Adaptation Laboratory

In October 1979 Parliament approved the recommendation of the Parliamentary Standing Committee on Public Works to construct a Crop Adaptation Laboratory for the Division of Plant Industry at Black Mountain, Canberra. It is anticipated that construction of the laboratory will commence during the latter part of 1980 at an estimated cost of $2.9m and will take 18 months to complete. The laboratory will provide permanent accommodation for 73 staff who are currently housed at a number of separate locations on the Black Mountain site. Much of their present accommodation is make-shift and inadequate and because facilities and essential research equipment are widely dispersed, it has been difficult to achieve an integrated and cohesive approach to research problems.

The research to be undertaken in the Crop Adaptation Laboratory is directed at increasing the yield of existing non-irrigated and dryland crops, and at developing alternative crops, such as grain legumes and oilseeds, for Australian conditions. Long-term seed storage facilities in the new laboratory will be used to conserve valuable genetic material needed for developing and improving new and existing crops.

## CSIRO Marine Laboratories

In April 1980 the Prime Minister announced that the Government would establish a laboratory complex for CSIRO at Hobart at an estimated cost of \$25m including transfer costs and \$9m for an oceanographic research vessel. The new complex, which will be known as the CSIRO Marine Laboratories, will house scientific and support staff from the Divisions of Fisheries Research and Oceanography, including staff currently located at Cronulla, near Sydney. The transfer from Cronulla to Hobart will overcome problems posed by the lack of suitable deepwater wharfage facilities for berthing research vessels near Cronulla and by the inadequate and crowded accommodation at the Cronulla site. The new laboratories will also provide a base for the enhancement of CSIRO research in marine science (see Chapter 3).

Projects costing more than \$40,000 which were completed during 1979/80 are listed below, with their authorized cost.

## Institute of Animal and Food Sciences

**Animal Health**—Armidale, NSW—erection of immunological laboratory—\$242,809

**Animal Health**—Glebe, NSW—improvements to fire-fighting facilities —\$49,956

**Animal Production**—Badgery's Creek, NSW—upgrading of field station facilities, including irrigation and cattle pens—\$131,445

**Animal Production**—Prospect, NSW—modifications to animal house and canteen—\$371,651

**Animal Production**—Prospect, NSW—upgrading of electricity supply —\$149,334

**Human Nutrition**—O'Halloran Hill, SA—erection of laboratories and animal house, including primate facilities—\$838,543

## Institute of Biological Resources

**Entomology**—Gundaroo, NSW—construction of access road—$58,551
**Fisheries and Oceanography**—Cleveland, Qld—construction of marine facilities—$308,370
**Plant Industry**—Black Mountain, ACT—erection of glasshouse services building and potting shed (stage I)—$165,636
**Plant Industry**—Burren Junction, NSW—erection of one house and a small ablutions block and upgrading of existing quarters—$77,485
**Plant Industry**—Black Mountain, ACT—erection of glasshouse for aphid research—$99,774
**Tropical Crops and Pastures**—Samford, Qld—conditioned seed store—$73,501
**Tropical Crops and Pastures**—Katherine, NT—erection of house at 4-mile farm—$59,460
**Wildlife Research**—Kapalga, NT—construction of access roads—$67,405
**Wildlife Research**—Helena Valley, WA—erection of workshop and store—$79,837

## Institute of Earth Resources

**Land Resources Management**—Alice Springs, NT—erection of laboratory—$684,566
**Minerals Research Laboratories**—North Ryde, NSW—redevelopment of building 8—$790,321
**Soils**—Glen Osmond, SA—extension of plant and soil preparation building—$64,622
**Soils**—Townsville, Qld—erection of soil services building—$83,081

## Institute of Industrial Technology

**Building Research**—Highett, Vic—erection of laboratory—$867,542
**Chemical Technology**—Lower Plenty, Vic—erection of laboratory—$563,500
**Protein Chemistry**—Parkville, Vic—provision of air injection unit in fume cupboards—$144,792
**Protein Chemistry**—Parkville, Vic—upgrading of air-conditioning, west wing laboratory—$58,165

## Institute of Physical Sciences

**Environmental Mechanics**—Black Mountain, ACT—provision of fire protection and reglazing of roof—$50,241
**Radiophysics**—Parkes, NSW—provision of fire alarms to laboratory/workshop/office building—$65,827
**Radiophysics**—Culgoora, NSW—extension of radio observatory building—$438,185

## Bureau of Scientific Services

**CILES**—Melbourne, Vic—modifications to buildings—$315,511

Works costing more than $40,000 which were committed during 1979/80 are listed below with their program authorization.

## Institute of Animal and Food Sciences

**Animal Production**—Prospect, NSW—erection of animal genetics research laboratories and offices—$1,093,544
**Human Nutrition**—O'Halloran Hill, SA—provision of engineering services and construction of carpark and access road—$175,000

## Institute of Biological Resources

**Tropical Crops and Pastures**—Kimberley, WA—erection of grain handling building—$254,991
**Tropical Crops and Pastures**—Kimberley, WA—erection of six 1-bedroom flats—$266,030
**Wildlife Research**—Kapalga, NT—erection of buffalo-proof fence—$79,380

## Institute of Earth Resources

**Land Use Research**—Black Mountain, ACT—erection of workshop and garage—$534,980
**Minerals Research Laboratories**—North Ryde, NSW—reconstruction of entrance roads—$216,683
**Minerals Research Laboratories**—North Ryde, NSW—erection of general purpose energy laboratory—$907,639
**Minerals Research Laboratories**—North Ryde, NSW—upgrading of fume extraction facilities, building 12—$367,089
**Minerals Research Laboratories**—North Ryde, NSW—upgrading of water supply services—$559,771

## Institute of Industrial Technology

**Chemical Technology**—Clayton, Vic—erection of laboratory complex —$10,238,400

## Institute of Physical Sciences

**Materials Science**—Woodville, SA—alterations to building 3—$400,000

## Other

**Site Services**—Black Mountain, ACT—relocation of site services (stage 1) and access road—$229,186

# 10. Finance

One of the Terms of Reference of the Independent Committee of Inquiry into CSIRO was to examine 'the extent to which, and the means by which, programs of the Organization could attract revenue both to support the conduct of ongoing or intended research, and also in return for the results achieved in research'.

Following the Committee's recommendations on this matter, the Government decided in 1978 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 Government further decided that, given the research role it perceived for CSIRO, the Organization should not have as its principal aim the generation of revenue, either to support its research or as a direct return for results achieved in research. CSIRO should continue to compete for Rural Industry Research Funds, provided they did not become a major component of support for research relating to the particular rural industries concerned. The Organization could also, in appropriate cases, undertake work on behalf of industry. This last decision recognized that there were often cases where CSIRO was the only body in the country with the expertise and resources appropriate to undertaking particular tasks. In such cases, CSIRO should give sympathetic consideration to meeting industry's needs, and the full commercial cost of assisting industry should be charged for, unless the assistance given contributed to existing research programs.

These decisions form the basis of the Executive's approach to the financing of CSIRO's work. Income will continue to be generated through the performance of work carried out under contracts and grants, but such work will not be undertaken simply for the purpose of generating revenue.

The financial year 1979/80 saw a continuation of the pressure on the Organization's resources which has been a characteristic of the past five years.

The total Appropriation funding and staffing available to the Organization continued to expand as a result of such factors as the transfer of 60% of the wool research program's funding from the Wool Research Trust Account to Appropriation, the transfer of a portion of the Department of Defence's Materials Research Laboratories to CSIRO, and a significant increase in funding for fisheries research.

However, ceilings on staff numbers for the conduct of ongoing research were reduced again and, in real terms, the funds available to support day-to-day operations were reduced even more sharply. This created a potential imbalance and the Executive therefore decided to transfer an amount equal to 2% of the Organization's total Appropriation funds from salaries to operating funds. The latter funds cover such items as laboratory equipment and consumables, scientific journals, travel, telephones and printing.

While this transfer was necessary to maintain an efficient level of operation in ongoing programs, it had the effect of inhibiting the transfer of resources into new high-priority areas. A primary vehicle for initiating work in these areas is the reallocation of vacancies as they occur in other programs. The need to transfer funds from salaries to operations therefore significantly reduced the number of vacancies available for redeployment.

Expenditure from direct Appropriation and Revenue amounted to $162 823 275 in 1979/80, which represented an increase of $13 320 478 or 8.9% over the 1978/79 period. Of this sum, $1 005 000 was provided to meet the cost for the 1979/80 financial year of the expanded fisheries research program which CSIRO had embarked upon in 1978/79, following a request from the Government to support the Department of Primary Industry in its role of managing and monitoring resources in the Australian Fishing Zone. A further $576 000 of this sum was provided to meet the operating costs of that portion of the Materials Research Laboratories at Maribyrnong which was transferred from the Department of Defence to CSIRO on 1 July 1979.

During 1979/80 CSIRO continued to receive significant support for its energy research programs through grants from the National Energy Research, Development and Demonstration Council (NERDDC) funded from Appropriation to the Department of National Development and from levies collected from the coal industry under the Coal Levy Research Act. Expenditure from these sources amounted to $1 524 082 from the Coal Research Trust Account and $633 444 from Appropriation funded grants, compared with $300 789 and $33 722 respectively in 1978/79. Largely as a result of this increased funding from NERDDC, the total funds spent by CSIRO from sources other than direct Appropriation increased by 11.9% over the 1978/79 level to $20 555 902.

Table 3 summarizes CSIRO expenditure against sources of funds for 1979/80 and categories of expenditure. The total expenditure of $183 379 177 from all sources of funds directly available to CSIRO represents an increase of 9.2% over the 1978/79 level. As can be seen from the table, some 88.8% of CSIRO's income was provided directly by the Commonwealth Government and by Revenue. Of the remaining 11.2%, approximately half was contributed from Rural Industry Research Funds derived from statutory levies on produce, with supporting contributions from the Commonwealth Government.

While the Organization's medium- to longer-term strategic mission-oriented research was funded mainly from direct Appropriation, funds from rural industry and other contributory sources provided an important complement to this ongoing research effort.

These contributory funds are primarily directed towards solving particular problems confronting industry or to providing further information on specific facets relating to an industry.

**TABLE 3**

| 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 | 157 693 338 | 1 383 284 | 3 746 653 | 162 823 275 |
| Wool Research Trust Fund | 5 925 092 | – | 547 007 | 6 472 099 |
| Meat Research Trust Account | 2 942 326 | – | 322 478 | 3 264 804 |
| Wheat Research Trust Account | 399 623 | – | 1 000 | 400 623 |
| Dairying Research Trust Account | 295 778 | – | – | 295 778 |
| Fishing Industry Research Trust Account | 143 259 | – | – | 143 259 |
| Oilseeds Research Trust Account | 55 700 | – | – | 55 700 |
| Dried Fruits Research Trust Account | 47 659· | – | – | 47 659 |
| Poultry Industry Trust Fund | 10 049 | – | 9 500 | 19 549 |
| Chicken Meat Research Trust Account | 31 842 | – | 10 686 | 42 528 |
| Pig Industry Research Trust Account | 23 696 | – | 3 529 | 27 225 |
| NERDDC – Coal Research Trust Account | 1 524 082 | – | – | 1 524 082 |
| NERDDC – Appropriation Fund | 633 444 | – | – | 633 444 |
| Rural Credits Development Fund | 188 084 | – | – | 188 084 |
| Other contributors | 7 205 736 | – | 235 332 | 7 441 068 |
| Total | 177 119 708 | 1 383 284 | 4 876 185 | 183 379 177 |

AUDITOR-GENERAL'S OFFICE

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

Please Quote: F80/331

16 September 1980

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

Dear Sir

COMMONWEALTH SCIENTIFIC AND
INDUSTRIAL RESEARCH ORGANIZATION

In compliance with 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 1980 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 section 57(1)(a) of the Act, is attached.

I now report in accordance with 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.

Yours faithfully

(SGD) D.R. STEELE CRAIK

D.R. STEELE CRAIK
AUDITOR-GENERAL

## Summary of Receipts and Payments

(Figures in brackets refer to 1978/79 financial year)

| | **Funds held 1 July 1979 ($)** | **Receipts ($)** | **Total funds available ($)** | **Payments ($)** | **Funds held 30 June 1980 ($)** |
|---|---|---|---|---|---|
| General Research Account | 1 551 342<br>(479 293) | 162 474 825*<br>(150 574 846) | 164 026 167<br>(151 054 139) | 162 823 275<br>(149 502 797) | 1 202 892<br>(1 551 342) |
| Specific Research Account | 4 421 447<br>(3 362 615) | 20 995 864<br>(19 431 533) | 25 417 311<br>(22 794 148) | 20 555 902<br>(18 372 701) | 4 861 409<br>(4 421 447) |
| Other Trust Moneys ** | 250 244<br>(317 517) | 2 030 218<br>(1 455 702) | 2 280 462<br>(1 773 219) | 2 192 416<br>(1 522 975) | 88 046<br>(250 244) |
| **Total** | **6 223 033**<br>(4 159 425) | **185 500 907**<br>(171 462 081) | **191 723 940**<br>(175 621 506) | **185 571 593 †**<br>(169 398 473) | **6 152 347 ‡**<br>(6 223 033) |

* See Note 2
** See Note 3
† See Note 4
‡ See Note 5

J. P. Wild *(Chairman)*

F. J. Whitty *(Assistant Secretary, Management Services)*

## Consolidated Statement of Payments

| 1978/79 ($) | | 1979/80 ($) |
|---|---|---|
| | **Headquarters** (including Regional Administrative Offices) | |
| 6 759 031 | Salaries and allowances | 6 974 242 |
| 373 938 | Travelling and subsistence | 359 791 |
| 613 838 | Postage, telegrams and telephone | 585 080 |
| 1 920 945 | Incidental and other expenditure | 2 259 702 |
| - * | Advisory Council | 135 803 |
| - * | State Committees | 20 589 |
| 9 667 752 | | 10 335 207 |
| | **Research Programs** | |
| | Institute of Animal and Food Sciences | |
| - * | Institute Headquarters | 137 735 |
| 6 520 205 | Animal Health | 6 942 190 |
| 7 693 772 | Animal Production | 8 684 504 |
| 2 486 072 | Centre for Animal Research and Development, Indonesia | 2 438 952 |
| 6 971 079 | Food Research | 7 495 653 |
| 1 710 429 | Human Nutrition | 2 058 685 |
| 1 249 058 | Molecular and Cellular Biology | 1 347 578 |
| 353 723 | Wheat Research | 402 661 |
| 26 984 338 | | 29 507 958 |
| | Institute of Biological Resources | |
| - * | Institute Headquarters | 158 509 |
| 7 560 838 | Entomology | 8 137 328 |
| 6 623 591 | Fisheries and Oceanography | 7 743 792 |
| 4 341 417 | Forest Research | 4 830 940 |
| 1 574 183 | Horticultural Research | 1 692 615 |
| 1 357 035 | Irrigation Research | 1 600 876 |
| 7 946 994 | Plant Industry | 8 524 964 |
| 5 987 653 | Tropical Crops and Pastures | 6 492 755 |
| 2 817 521 | Wildlife Research | 3 036 021 |
| 38 209 232 | | 42 217 800 |
| | Institute of Earth Resources | |
| - * | Institute Headquarters | 145 814 |
| 2 137 939 | Applied Geomechanics | 2 751 131 |
| 4 016 992 | Land Resources Management | 3 960 815 |
| 3 285 329 | Land Use Research | 3 493 588 |
| 11 856 519 | Mining, Minerals and Energy | 13 865 548 |
| 350 260 | Physical Technology ** | 525 471 |
| 4 195 818 | Soils | 4 648 326 |
| 25 842 857 | | 29 390 693 |

* In 1978/79 expenditure for these units was recorded under Headquarters general dissections.

** The research activities of the Physical Technology Unit were previously integrated with the Division of Textile Physics (Institute of Industrial Technology).

| 1978/79 ($) | | 1979/80 ($) |
|---|---|---|
| | Institute of Industrial Technology | |
| - * | Institute Headquarters | 150 569 |
| 2 725 030 | Applied Organic Chemistry | 3 155 284 |
| 5 171 565 | Building Research | 5 552 778 |
| 2 718 283 | Chemical Technology | 3 014 220 |
| 2 186 195 | Mechanical Engineering | 2 480 056 |
| 2 875 128 | Protein Chemistry | 3 181 096 |
| 4 082 294 | Textile Industry | 4 381 085 |
| 2 460 511 | Textile Physics | 2 570 328 |
| 22 219 006 | | 24 485 416 |
| | Institute of Physical Sciences | |
| - * | Institute Headquarters | 127 432 |
| 8 413 295 | Applied Physics | 8 987 079 |
| 2 217 132 | Atmospheric Physics | 2 325 681 |
| 433 345 | Australian Numerical Meteorology Research Centre | 450 354 |
| 2 478 587 | Chemical Physics | 2 750 926 |
| 1 515 580 | Cloud Physics | 1 735 625 |
| 2 901 784 | Computing Research | 3 529 350 |
| 648 569 | Environmental Mechanics | 671 040 |
| 3 204 968 | Materials Science | 3 953 333 |
| 2 477 581 | Mathematics and Statistics | 2 681 979 |
| 4 421 310 | Radiophysics | 4 700 353 |
| 28 712 151 | | 31 913 152 |
| | Bureau of Scientific Services | |
| - * | Bureau Headquarters | 142 309 |
| 3 595 090 | Central Information, Library and Editorial Section | 3 811 796 |
| 186 307 | Centre for International Research Cooperation | 230 557 |
| 1 302 109 | Commercial Group | 1 291 170 |
| 1 093 512 | Science Communication Unit ** | 1 031 413 |
| 6 177 018 | | 6 507 245 |
| 3 068 961 | Miscellaneous | 2 762 237 |
| 151 213 563 | Total Research Programs | 166 784 501 |
| | **Contributions** | |
| 871 050 | Research Associations | 778 428 |
| 538 508 | Other Contributions | 604 856 |
| 1 409 558 | | 1 383 284 |

* In 1978/79 expenditure for these units was recorded under Headquarters general dissections.
** Formerly known as Central Communication Unit.

| 1978/79 ($) | | 1979/80 ($) |
|---|---|---|
| | **Capital Works and Services** | |
| | Buildings, works, plant and developmental | |
| 2 984 293 | expenditure | 1 589 485 |
| 2 600 332 | Major items of laboratory equipment | 3 286 700 |
| 5 584 625 | | 4 876 185 |
| | **Other Trust Moneys** | |
| | Remittance of revenue from investigations | |
| 407 004 | financed from Industry Trust Accounts | 474 524 |
| 1 115 971 | Other miscellaneous remittances | 1 717 892 |
| 1 522 975 | | 2 192 416 |
| **169 398 473** * | **Total Expenditure** | **185 571 593** |

* Dissection details of 1978/79 expenditure have been adjusted, where necessary, to allow comparison with 1979/80 figures.

J. P. Wild *(Chairman)*

F. J. Whitty *(Assistant Secretary, Management Services)*

## Statement of Payments—General Research Account

| 1978/79 ($) | | 1979/80 ($) |
|---|---|---|
| | **Headquarters** (including Regional Administrative Offices) | |
| 6 759 031 | Salaries and allowances | 6 973 911 |
| 373 595 | Travelling and subsistence | 355 457 |
| 613 838 | Postage, telegrams and telephone | 585 080 |
| 1 920 945 | Incidental and other expenditure | 2 259 626 |
| - * | Advisory Council | 135 803 |
| - * | State Committees | 20 589 |
| 9 667 409 | | 10 330 466 |
| | **Research Programs** | |
| | Institute of Animal and Food Sciences | |
| - * | Institute Headquarters | 137 735 |
| 5 814 820 | Animal Health | 6 280 037 |
| 5 581 483 | Animal Production | 6 170 840 |
| 5 739 285 | Food Research | 6 139 023 |
| 1 698 290 | Human Nutrition | 2 040 822 |
| 1 249 058 | Molecular and Cellular Biology | 1 346 019 |
| 198 455 | Wheat Research | 229 473 |
| 20 281 391 | | 22 343 949 |
| | Institute of Biological Resources | |
| - * | Institute Headquarters | 158 509 |
| 5 940 251 | Entomology | 6 414 624 |
| 6 486 223 | Fisheries and Oceanography | 7 540 418 |
| 4 327 140 | Forest Research | 4 743 988 |
| 1 518 074 | Horticultural Research | 1 640 313 |
| 1 307 215 | Irrigation Research | 1 515 572 |
| 7 630 123 | Plant Industry | 8 161 706 |
| 5 542 251 | Tropical Crops and Pastures | 5 878 253 |
| 2 610 712 | Wildlife Research | 2 810 254 |
| 35 361 989 | | 38 863 637 |
| | Institute of Earth Resources | |
| - * | Institute Headquarters | 140 777 |
| 1 761 216 | Applied Geomechanics | 1 709 390 |
| 3 783 594 | Land Resources Management | 3 848 839 |
| 2 829 751 | Land Use Research | 3 015 248 |
| 11 047 238 | Mining, Minerals and Energy | 11 923 632 |
| 350 260 | Physical Technology ** | 522 471 |
| 4 112 726 | Soils | 4 477 596 |
| 23 884 785 | | 25 637 953 |

* In 1978/79 expenditure for these units was recorded under Headquarters general dissections.

** The research activities of the Physical Technology Unit were previously integrated with the Division of Textile Physics (Institute of Industrial Technology).

| 1978/79 ($) | | 1979/80 ($) |
|---|---|---|
| | Institute of Industrial Technology | |
| - * | Institute Headquarters | 150 569 |
| 2 554 004 | Applied Organic Chemistry | 2 866 060 |
| 5 042 249 | Building Research | 5 417 006 |
| 2 499 931 | Chemical Technology | 2 722 276 |
| 1 992 050 | Mechanical Engineering | 2 127 413 |
| 2 784 430 | Protein Chemistry | 3 175 922 |
| 1 719 448 | Textile Industry | 1 982 553 |
| 1 570 700 | Textile Physics | 1 653 284 |
| 18 162 812 | | 20 095 083 |
| | Institute of Physical Sciences | |
| - * | Institute Headquarters | 127 432 |
| 8 413 295 | Applied Physics | 8 987 079 |
| 2 181 147 | Atmospheric Physics | 2 267 360 |
| 422 861 | Australian Numerical Meteorology Research Centre | 434 806 |
| 2 476 387 | Chemical Physics | 2 750 926 |
| 1 515 580 | Cloud Physics | 1 688 663 |
| 2 900 384 | Computing Research | 3 478 645 |
| 641 811 | Environmental Mechanics | 668 761 |
| 3 145 985 | Materials Science | 3 751 431 |
| 2 477 581 | Mathematics and Statistics | 2 673 822 |
| 4 203 067 | Radiophysics | 4 439 772 |
| 28 378 098 | | 31 268 697 |
| | Bureau of Scientific Services | |
| - * | Bureau Headquarters | 142 309 |
| 3 594 850 | Central Information, Library and Editorial Section | 3 765 242 |
| 163 645 | Centre for International Research Cooperation | 219 424 |
| 1 302 109 | Commercial Group | 1 290 544 |
| 1 007 969 | Science Communication Unit ** | 985 400 |
| 6 068 573 | | 6 402 919 |
| 3 031 554 | Miscellaneous | 2 750 634 |
| 135 169 202 | Total Research Programs | 147 362 872 |
| | **Contributions** | |
| 871 050 | Research Associations | 778 428 |
| 538 508 | Other Contributions | 604 856 |
| 1 409 558 | | 1 383 284 |

* In 1978/79 expenditure for these units was recorded under Headquarters general dissections.
** Formerly known as Central Communication Unit.

| 1978/79 ($) | | 1979/80 ($) |
|---|---|---|
| | **Capital Works and Services** | |
| 999 875 | Buildings, works, plant and developmental expenditure | 922 654 |
| 2 256 753 | Major items of laboratory equipment | 2 823 999 |
| 3 256 628 | | 3 746 653 |
| **149 502 797 *** | **Total Expenditure** | **162 823 275** |

* Dissection details of 1978/79 expenditure have been adjusted, where necessary, to allow comparison with 1979/80 figures.

J. P. Wild *(Chairman)* F. J. Whitty *(Assistant Secretary, Management Services)*

# Statement of Payments—Specific Research Account

| 1978/79 ($) | | 1979/80 ($) |
|---|---|---|
| | **Headquarters** (including Regional Administrative Offices) | |
| - | Salaries and allowances | 331 |
| 343 | Travelling and subsistence | 4 334 |
| - | Incidental and other expenditure | 76 |
| 343 | | 4 741 |
| | **Research Programs** | |
| | Institute of Animal and Food Sciences | |
| 705 385 | Animal Health | 662 153 |
| 2 112 289 | Animal Production | 2 513 664 |
| 2 486 072 | Centre for Animal Research and Development, Indonesia | 2 438 952 |
| 1 231 794 | Food Research | 1 356 630 |
| 12 139 | Human Nutrition | 17 863 |
| - | Molecular and Cellular Biology | 1 559 |
| 155 268 | Wheat Research | 173 188 |
| 6 702 947 | | 7 164 009 |
| | Institute of Biological Resources | |
| 1 620 587 | Entomology | 1 722 704 |
| 137 368 | Fisheries and Oceanography | 203 374 |
| 14 277 | Forest Research | 86 952 |
| 56 109 | Horticultural Research | 52 302 |
| 49 820 | Irrigation Research | 85 304 |
| 316 871 | Plant Industry | 363 258 |
| 445 402 | Tropical Crops and Pastures | 614 502 |
| 206 809 | Wildlife Research | 225 767 |
| 2 847 243 | | 3 354 163 |
| | Institute of Earth Resources | |
| - | Institute Headquarters | 5 037 |
| 376 723 | Applied Geomechanics | 1 041 741 |
| 233 398 | Land Resources Management | 111 976 |
| 455 578 | Land Use Research | 478 340 |
| 809 281 | Mining, Minerals and Energy | 1 941 916 |
| - | Physical Technology * | 3 000 |
| 83 092 | Soils | 170 730 |
| 1 958 072 | | 3 752 740 |

* The research activities of the Physical Technology Unit were previously integrated with the Division of Textile Physics (Institute of Industrial Technology).

| 1978/79 ($) | | 1979/80 ($) |
|---|---|---|
| | Institute of Industrial Technology | |
| 171 026 | Applied Organic Chemistry | 289 224 |
| 129 316 | Building Research | 135 772 |
| 218 352 | Chemical Technology | 291 944 |
| 194 145 | Mechanical Engineering | 352 643 |
| 90 698 | Protein Chemistry | 5 174 |
| 2 362 846 | Textile Industry | 2 398 532 |
| 889 811 | Textile Physics | 917 044 |
| 4 056 194 | | 4 390 333 |
| | Institute of Physical Sciences | |
| 35 985 | Atmospheric Physics | 58 321 |
| 10 484 | Australian Numerical Meteorology Research Centre | 15 548 |
| 2 200 | Chemical Physics | - |
| - | Cloud Physics | 46 962 |
| 1 400 | Computing Research | 50 705 |
| 6 758 | Environmental Mechanics | 2 279 |
| 58 983 | Materials Science | 201 902 |
| - | Mathematics and Statistics | 8 157 |
| 218 243 | Radiophysics | 260 581 |
| 334 053 | | 644 455 |
| | Bureau of Scientific Services | |
| 240 | Central Information, Library and Editorial Section | 46 554 |
| 22 662 | Centre for International Research Cooperation | 11 133 |
| - | Commercial Group | 626 |
| 85 543 | Science Communication Unit * | 46 013 |
| 108 445 | | 104 326 |
| 37 407 | Miscellaneous | 11 603 |
| 16 044 361 | Total Research Programs | 19 421 629 |
| | **Capital Works and Services** | |
| 1 984 418 | Buildings, works, plant and developmental expenditure | 666 831 |
| 343 579 | Major items of laboratory equipment | 462 701 |
| 2 327 997 | | 1 129 532 |
| **18 372 701** | **Total Expenditure** | **20 555 902** |

* Formerly known as Central Communication Unit.

J. P. Wild *(Chairman)*

F. J. Whitty *(Assistant Secretary, Management Services)*

## Notes to and forming part of the Accounts for the Year ended 30 June 1980

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:

| | 1978/79 ($) | 1979/80 ($) |
|---|---|---|
| Appropriations—Consolidated Revenue Fund | | |
| Operational | 142 929 000 | 154 000 000 |
| Capital | 3 100 000 | 3 100 000 |
| | 146 029 000 | 157 100 000 |
| Revenue and Other Receipts | | |
| Sale of publications | 295 762 | 414 756 |
| Receipts in respect of expenditure in former years | 308 229 | 365 531 |
| Sale of produce, including livestock | 459 369 | 485 257 |
| Royalties from patents | 28 467 | 90 902 |
| Fees for tests and other services | 251 666 | 287 918 |
| Computing service charges | 2 765 732 | 3 219 687 |
| Interest on investments | 267 710 | 264 123 |
| Miscellaneous receipts | 168 911 | 246 651 |
| | 4 545 846 | 5 374 825 |
| | 150 574 846 | 162 474 825 |

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

4. Total expenditure comprises:

| | 1978/79 ($) | 1979/80 ($) |
|---|---|---|
| Salaries and allowances | 112 193 056 | 121 272 104 |
| Travelling and subsistence | 5 235 348 | 6 149 328 |
| Equipment | 10 031 834 | 12 575 421 |
| Maintenance | 36 297 967 | 40 670 456 |
| Capital works and services | 5 640 268 | 4 904 284 |
| | 169 398 473 | 185 571 593 |

5. Funds held at 30 June 1980 included investments totalling $5,162,200. The comparative figure at 30 June 1979 was $2,160,200.

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

| | 1978/79 ($) | 1979/80 ($) |
|---|---|---|
| Receipts | | |
| CSIRO users | 2 908 160 | 2 721 324 |
| Other users | 2 765 732 | 3 219 687 |
| | 5 673 892 | 5 941 011 |

| | 1978/79 ($) | 1979/80 ($) |
|---|---|---|
| Payments | | |
| Operational expenditure | 5 808 544 | 6 199 968 |
| Capital expenditure | 85 151 | 721 860 |
| | 5 893 695 | 6 921 828 |

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

| | 1978/79 ($) | 1979/80 ($) |
|---|---|---|
| Department of Housing and Construction | | |
| Repairs and maintenance | 3 238 503 | 4 220 889 |
| Buildings and works | 19 669 332 | 33 386 849 |
| | 22 907 835 | 37 607 738 |
| Department of Administrative Services | | |
| Acquisition of sites and buildings | 261 479 | 417 300 |

J. P. Wild *(Chairman)*

F. J. Whitty *(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 Act 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. Advice provided by the Council and comments on that advice appear for the first time in this Report.

# 11. Advisory Council and State Committees-functions and advice

In 1978, the functions and composition of the CSIRO Advisory Council and the six State Committees were reshaped by amendments to the Science and Industry Research Act 1949. The first meeting of the new Advisory Council took place in July 1979, and it met a further three times during the year under review. Each State Committee has met at least twice during the same period. The names of members of these bodies, and their affiliations, are set out in Appendix II.

## 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 those interests of the Australian community that may be furthered by the Organization; and
- any other matter 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. Three items of advice from the Council, and comments on these by the Executive, appear later in this chapter.

The Council and the Executive have discussed the way they should interact in carrying out their respective roles. The legislation establishing both bodies lays down no guidelines for this. It has been agreed that the primary role of the Council is to provide independent advice to the Executive on the perceived research needs of industry and the Australian community. It has also been agreed that effective interaction can best be achieved through the close involvement of the Council in strategic planning procedures now being developed (see Chapter 1). However, until these procedures are in operation, the Council's main input will be in the more traditional processes of research policy formulation. Research reviews and annual budget formulation are primary elements of these.

The Council is concentrating on the more significant levels of planning in the four sectors that form the main segments of the classification system described in Chapter 1—rural industries; mineral, energy and water resources; manufacturing industries; and community interests. A Rural Industries Standing Committee has been established with Mr J. H. Heussler as Chairman, and the establishment of standing committees in the other three sectors is being considered.

The Council has given particular attention to research by CSIRO for manufacturing industry, and Mr A. Boden, Chairman of the NSW State Committee, and Mr J. E. Kolm, Chairman of the Victorian State Committee, have been appointed to the Organization's Manufacturing Industry Committee (see Chapter 4). The Council has also been involved in several of the Divisional and subject reviews described in Chapter 5 and is giving consideration to a number of areas of particular interest to the Executive, including the transfer of information and know-how to industry, and research and development for service industries. In addition, the Council has offered advice to the Executive under Section 34(d) of the Science and Industry Research Act in relation to arboviruses, physical oceanography and energy research.

The three items of advice given to the Executive by the Council during the reporting year and the Executive's comments on them follow.

### Arboviruses

At its meeting in March 1980, the Advisory Council considered a report on a proposal made by the Western Australian State Committee that work be undertaken on arboviruses and their host reservoirs in the Kimberley and Pilbara regions of Western Australia. The Council resolved that the proposed project was medically oriented research to a degree which placed it beyond the ambit of CSIRO's program, in terms of direct support. It advised the Executive as follows:

*'However, Council accepts that the work is of considerable merit, with important national implications for human health and primary industry, and in the event of support being forthcoming from other sources, the CSIRO Executive should favourably consider the Organization helping in a consultative and coordinating capacity.'*

The Executive responded as follows:

*'CSIRO recognizes the important national implications of arbovirus research for human health and primary industry. It has a significant arbovirus research effort in the field of livestock health and is providing collaborative support through entomological and wildlife research to work aimed at human health being conducted by other institutions.*

*The Executive notes the Council's view that the particular project proposal put forward through the Western Australian State Committee is medically oriented and agrees that it would not be appropriate for CSIRO to assume primary responsibility for it. It also notes that the project has been receiving support through the National Health and Medical Research Council and the Commonwealth Department of Health and believes that these would remain the most appropriate avenues for direct federal funding of the project.*

*CSIRO has communicated to the Department of Health its willingness to examine jointly the possibility of collaboration and* *has also referred the project proposal to the Medical Research Liaison Committee which provides a consultative link between CSIRO and the Department of Health for advice.'*

Physical Oceanography

At its meeting in March 1980, the Advisory Council considered a report by the Western Australian State Committee entitled 'Applied Physical Oceanography—A Preliminary Study into Western Australia's Needs and Future Research Programs'. It advised the Executive as follows:

'1. *The proposal contained in the Report of the Western Australian State Committee for a program of studies of Physical Oceanography in the area of the North-West Shelf of Western Australia, including the Exmouth Plateau, should be considered to be of high priority in the national interest.*
2. *The responsibility for organizing, supervising and coordinating these studies should be taken up by the CSIRO as an industrial and economic matter of importance to the Australian community.*
3. *In view of budgetary considerations, the Minister should be informed of these views, and requested to refer the proposals to ASTEC for the purpose of establishing the project as one of high national priority.*
4. *The various indications of funds and other resources likely to be available for these studies should be followed up by the Executive as a matter of urgency and with an indication of CSIRO's interest and support for the studies.'*

The Executive responded as follows:

*'The program of studies forming the subject of the advice includes data collection on a wide range of oceanographic parameters including current, wave, tide, temperature, nutrient flow and meteorological measurements. Knowledge gained would facilitate the optimal design of drilling rigs, production platforms and the laying of subsea pipelines and would contribute to the exploitation of valuable fisheries. The area is also important to national defence.*

*The Executive agrees that the proposed program is of high national importance.*

*The declaration of the Australian 200-mile Fishing Zone, the proposal for an Economic Zone and Australia's interest in economic resources beyond these zones create a need to define the characteristics of our marine environment as a whole. Scientific research will play a very important part in fulfilling this need. In terms of the resources required, however, a major task is expected to comprise survey work inappropriate to CSIRO as a long term responsibility and on a scale far greater than could be met from resources likely to be available to CSIRO.'*

The role of the Organization in marine science is discussed more fully in Chapter 3.

Energy Research

The Advisory Council met in May 1980 following a direction by the Minister for Science and the Environment to the Chairman of the

Council under sub-section 36(2) of the Science and Industry Research Act 1949. The Council had before it a request for advice from the Executive of CSIRO. This request arose from a report by a committee of review on the Lucas Heights Research Establishment of the Australian Atomic Energy Commission (AAEC). The review committee had been drawn from the National Energy Research, Development and Demonstration Council (NERDDC), and its report had been tabled in Parliament in November 1979 by the then Minister for National Development, Mr Newman.

An option canvassed during consideration of the report was that energy research, development and demonstration activities in CSIRO should be transferred to a new energy research body based on the AAEC Research Establishment. This option was not proceeded with and it was reaffirmed that the integrity of CSIRO as the Commonwealth's major research body should be preserved. However, to facilitate meeting the requirements of the National Development and Energy portfolio for energy research, it was agreed that the Ministers for Science and the Environment and National Development and Energy would consult periodically. Also, a standing policy committee comprising the Chairman of CSIRO and the Secretary of the Department of National Development and Energy has been formed to support them. This policy committee will in turn be supported by technical committees.

The Advisory Council's advice on this matter was as follows:

*'Council advises the Executive of CSIRO that it:*

- *welcomes the report that the proposal for the transfer of CSIRO energy research, development and demonstration activities to another body was not accepted at Ministerial level;*
- *commends the formation, by Ministerial request, of a policy committee comprising the Chairman of CSIRO and the Secretary of the Department of National Development and Energy;*
- *notes that the committee will be supported by such staff and technical sub-committees as are appropriate;*
- *expresses the expectation that advice which the Council may give to the CSIRO Executive on energy research, development and demonstration will be passed to the new policy committee, and similarly that the advice of the National Energy Research, Development and Demonstration Council will be considered by the committee; and*
- *requests that it receive progress reports from the Executive on the work of the policy committee on a regular basis.'*

The Executive responded as follows:

*'The Executive has agreed that advice furnished to it by the Advisory Council on energy research, development and demonstration will be transmitted to the policy committee. It also expects that advice from NERDDC will be transmitted to the committee and that all such advice will be given full consideration.*

*The Executive has also agreed that it will provide the Council with regular reports on the work of the policy committee.'*

**Support for Major Initiatives**

In addition to providing the Executive with formal advice, Council expressed its support for three major initiatives proposed by CSIRO for the financial year 1980/81—the construction of an oceanographic research vessel, the construction of a synthesis telescope, and the establishment of a Division of Manufacturing Technology.

The Advisory Council did not allocate priorities amongst these three proposals, but it did agree to the following motion with respect to the proposed Division of Manufacturing Technology:

> 'The Advisory Council unanimously supports the proposal on manufacturing technology in view of the present emphasis on internationally competitive industry. The Council recommends urgent implementation of the proposal in 1980 including the allocation of the additional funds sought.'

## State Committees

Following the reconstitution of the Advisory Council, the membership and functions of the six State Committees were also revised. Members were selected by reason of their association with industry, tertiary education and community interests in the State concerned, or their position with State Government Departments or Authorities.

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 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 State Committees to the Advisory Council will provide an important input into the development of CSIRO's research policies, and guidelines are being prepared to enable State Committees to participate in the process of strategic planning. In addition, the Council is providing the Committees with advice on their statutory functions.

The possibility of forming a committee similar to State Committees in the Northern Territory had been raised by the Chief Minister for the Northern Territory in a letter to the Chairman of CSIRO. The Council advised the Executive that it had no objection in principle to the establishment of a Northern Territory Committee and that it saw advantages in such a move. The Executive is now examining the legislative and administrative issues that would be involved.

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

The New South Wales State Committee visited Divisions, taking the opportunity for discussions with staff about research and industry matters. The Committee prepared papers on coal liquefaction and career prospects for research staff engaged on problem-solving for industry. These have been forwarded through the Advisory Council to the Executive. Also, the Committee initiated discussions with the Metropolitan Water Sewerage and Drainage Board on problems associated with the treatment and disposal of waste water and sewage.

In order to improve the coverage of the wide range of subjects requiring study in New South Wales, the Committee's Chairman has coopted additional persons to work with sub-committees.

The Victorian State Committee met on five occasions during the year and visited four Melbourne Divisions. The Committee's Chairman presented a comprehensive paper on CSIRO initiatives in manufacturing industry and on questions put to Council by the Executive during 1979. The Committee considered questions of CSIRO staff mobility, and of staff promotion on the basis of practical achievement as opposed to academic publication record. Arrangements were made for the appropriate authorities in Victoria to collaborate with the Water Review Committee of the Institute of Earth Resources. Three sub-committees have been established for the following purposes:

- to prepare a final draft report to the Advisory Council on CSIRO's interface with manufacturing industry;
- to provide an input to the CSIRO committee reviewing the Divisions of Land Use Research and Land Resources Management; and
- to review problems in the rural area which can be solved by research and development.

The Queensland State Committee has been identifying State research needs in the manufacturing, mining and rural industries. The Chairman noted the Committee's particular interest in the activities of the Long Pocket Laboratories.

The South Australian State Committee met Chiefs of Divisions and CSIRO staff. During these talks arrangements concerning the new Division of Manufacturing Technology were discussed. The Committee was interested in greater publicity for CSIRO activities, and in the distribution of research effort between States. The Committee felt that advice from CSIRO on these matters would assist it in determining priorities for its work. Accordingly, the Chairman of CSIRO had offered to make the services of senior CSIRO staff available at State Committee meetings where appropriate.

The Western Australian State Committee visited the Headquarters of the Divisions of Land Resources Management and Mineralogy in Perth and completed the following reports:

- Studies in Tropical Ecology—a multidisciplinary approach to arbovirus in Western Australia. Submitted to Advisory Council, July 1979;

- Applied Physical Oceanography—a preliminary study into Western Australia's needs and future research programs. Submitted to Advisory Council, November 1979;
- Calibration Services in Western Australia; and
- Water Problems in Western Australia Requiring Research.

The first two reports were reviewed by the Advisory Council and submitted to the CSIRO Executive. Sub-committees have been established to examine the need for research in the areas of resource-processing and manufacturing, new land-use options in Western Australia, and agronomy and sheep breeding, and to review an earlier report on fresh fruit and vegetable research in north-west Australia. The Committee also met with the Water Research Committee of the Institute of Earth Resources and filed a report on salinity problems in Western Australia.

The Tasmanian State Committee met twice and considered areas on which it might concentrate. The Chairman of the Committee has advised that the Committee will be concentrating on energy, wood fibre use, forestry and marine sciences because these are areas of particular importance to Tasmania. A preliminary inquiry into water research raised 19 problem areas for study. A statement prepared by the Committee on the advantages of CSIRO's research on fisheries and oceanography being transferred to Hobart was forwarded to the Executive by the Advisory Council.

# Research

The items in this section, selected from Institute annual reports for 1979/80, illustrate something of the wide range of CSIRO's research. These annual reports provide more detailed expositions of the research work of constituent Divisions and Units than would be practical in the Organization's annual report. More comprehensive information can be obtained from the Institute annual reports themselves, 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. Institute of Animal and Food Sciences

## Remote Sensing and Pasture Fertilizers

In Australia, the phosphorus, nitrogen and sulphur status of soils in the improved pasture zone is generally low. Pasture improvement thus depends on the application of large quantities of superphosphate to promote vigorous legume growth which, in turn, provides nitrogen for the grass component.

Superphosphate is traditionally used both as an aid to the establishment of pasture and as a regular annual maintenance fertilizer. Recent increases in its cost have led agronomists and farmers to question the need for repeated maintenance applications, but at present there is no practical way of assessing this. Soil tests are costly and unsuited to surveying the fertilizer needs of large areas.

The Division of Animal Production has shown that improved pastures which have been given different superphosphate treatments have differing visible and infra-red reflectance characteristics. This effect can be recorded in false-colour infra-red photographs—heavily-fertilized areas appear as bright red; less fertile areas, shades of pink; and unimproved pastures, shades of blue-grey.

Visible and infra-red data from the earth resources satellite LANDSAT also show the same trend and are being examined for their potential to provide a practical and cost-effective means of estimating the need to apply maintenance fertilizer to pastures. Energy from the sun is reflected by the pasture and recorded by LANDSAT. The data are then relayed by radio to a computer which is programmed to produce a map delineating areas with different fertilizer needs on the basis of the pasture's reflectance characteristics. This map could be used as a basis for planning a farm's annual fertilizer program.

## Footrot in Sheep

The relatively short duration of protection against footrot induced by immunization with *Bacteroides nodosus* in oil adjuvant (a substance producing an auxilliary effect) is one of the limitations of footrot vaccination in sheep.

The possibility of improving the performance of the vaccine by increasing the content of *B. nodosus* organisms has been examined by the Division of Animal Health. Four vaccines were used, containing one of two concentrations of *B. nodosus* cells in either of two adjuvants. There was no significant difference in the incidence of infection between the treatments, although there was a significant level of resistance to footrot in all vaccinated groups when compared with controls. Thus, increasing the concentration of organisms in the vaccine above the recommended level does not appear to improve its performance.

Further studies are in progress to determine the possibility of improving the potency of the vaccine in other ways.

The lack of any easy means of distinguishing between benign and virulent forms of footrot in sheep has seriously affected progress in control programs conducted by State veterinary authorities, especially in areas where compulsory quarantine and treatment measures have been introduced.

A large number of *B. nodosus* isolates were screened in the Division using a battery of *in vitro* tests. A remarkable correlation was found between the results obtained with the diagnostic differentiating test and strain virulence. The differentiating test showed considerable promise in field diagnosis during the past year by discriminating between the two clinical forms of the disease on every occasion. Further research is aimed at refining the test and determining the possible presence of other virulence indicators.

## Heat Tolerance and Fertility in Cattle

What is the scope for improving the fertility of cattle in northern Australia by selecting for heat tolerance?

The productivity of cattle in much of northern Australia has been improved by introducing tropically-evolved zebu breeds, mainly Brahman, Afrikander and Sahiwal. The zebu breeds have been exploited most usefully in breeds or lines derived from crossbreds in which their tolerance of heat, parasites, drought, etc. is combined with the productive potential of British breeds. While the zebu cross is more heat tolerant than the Hereford or Shorthorn, and has been regarded as being sufficiently heat tolerant for most conditions, the scope for improving heat tolerance had not been examined.

At the Tropical Cattle Research Centre, Rockhampton, which is on the southern limit of the tropics, rectal temperatures during summer of more than 1000 cows in the breeding herd were found to be very significantly related to fertility. A difference of $1^{\circ}$C in rectal temperature was associated with differences of 19% in calving rate and about two kg in birth weight of calves produced. Those cows which failed to control body temperature had high embryonic mortality and retarded foetal growth.

The relationship was highly significant in zebu-cross cows as well as in those of British breed. In the zebu cross, with a heritability of rectal temperature of $0.36 \pm 0.17$ and a strong genetic correlation between rectal temperature and the number of calves born ($0.7 \pm 0.2$), there is considerable genetic variation in heat tolerance. This has an important impact on reproduction.

Even in the subtropics therefore, and even in relatively adapted zebu crossbreds, there is opportunity to improve productivity and fertility by selecting for heat tolerance.

## Abattoir By-products

One of the objectives of the Meat Research Laboratory of the Division of Food Research is to increase the value of products derived from meat processing. This can be done by improving the quality of products, by reducing processing costs, or by developing new products from by-products which are currently of low value.

Over the past three years, the Laboratory has been developing a process for the economic recovery of the meat left on carcass frames or removed with fat trimmings during boning, which accounts for approximately 10% of the beef carcass. Manual recovery is not economically feasible. Attempts by meatworks to salvage this meat have not been completely successful because of low yields, recovery of too much fat, bone and connective tissue, or because it was denatured in the process. At present, most of the meat is rendered to meat-and-bone meal for stock feed and fertilizer.

A number of ways to dissolve meat adhering to fat and bones have been studied. Several were unsuited to commercial development because of high cost, reagent toxicity, poor yield, or damage to the meat proteins. However, one new process for the recovery of meat proteins is now being evaluated in pilot-plant studies. The process involves:

- reducing the size of the raw material;
- mixing the raw material in water with a solubilizing agent which dissolves only the raw meat;
- filtering the meat solution to remove bones, fat and connective tissues;
- deactivating the solubilizing agent; and
- concentrating the extract back to the solids content of meat.

The protein concentrate which results retains many of the desirable characteristics of meat and should find application in a wide variety of meat products. Being fat-free, it can be used in special dietary foods.

Preliminary costing indicates that the product will be less expensive than meat and competitive in price with non-meat alternatives used in the food industry.

As further improvements are made to non-meat alternatives, recovery of functional meat proteins will provide a range of secondary products needed by the industry to retain established markets.

The New Products Section of the Meat Research Laboratory was formed in 1976 to investigate the use of abattoir by-products for the production of biochemicals of value for pharmaceutical or veterinary purposes.

To determine which by-products and recoverable chemicals were worth examining, the team used the criteria that they should be easy to obtain and in plentiful supply, and that a ready market should be available or likely to become available.

One of the most promising areas for the upgrading of abattoir by-products is animal steroids. There are two main sources of these steroids in abattoir animals: bile (or gall), and spinal cords. Both of these by-products are plentiful and the technology for recovering the crude steroid chemicals is already available. The recovery costs are not great, particularly in relation to similar substances already recovered in Australia or overseas. There is also an ever-increasing demand for certain steroid drugs. These are:

1. Ovulatory control drugs called oestrogens and progestagens which are used in oral contraceptives. These steroids are derived mainly from animal or plant sources by complex and costly chemical procedures and have a price of over $1000/kg.
2. Corticosteroids related to corticosterone or cortisone. These are used in the control of rheumatoid arthritis and various inflammatory conditions including bronchitis, rhinitis and asthma.
3. Antidiuretic drugs used to control urine volume in the elderly and sick.

Most Australian abattoirs collect cattle bile and concentrate it to about 75% solids. Most of this concentrate is then sold overseas. Spinal cords are normally rendered and not sold separately. Thus, both bile and spinal cords would be readily available if a market were developed for them.

The main steroids in cattle bile are cholic and deoxycholic acid, present in a ratio of about four to one. Together they make up about 75% of the dry weight of bile.

The extraction of pharmaceutically useful compounds from spinal cord cholesterol and gall-bladder bile acids is being studied. Cholesterol can be transformed by fermentation with microbes to substances useful for the production of steroid chemicals, but yields are uneconomic. Studies with gall-bladder bile are more promising, and the fermentation products are being separated and identified.

## New Antitumour Drug Regimes

Bleomycins and phleomycins are mixtures of related antitumour drugs and antibiotics produced by the soil micro-organism *Streptomyces verticillus.* The bleomycins are clinically important in the treatment of particular kinds of cancers known as epithelial carcinomas, including cervical and testicular carcinoma, as well as certain lymphomas.

Some years ago the Molecular and Cellular Biology Unit showed that the antibacterial effects of a commercial phleomycin mixture (batch 9331-648) were improved substantially by the addition of caffeine. Subsequently, about 350 other compounds were found to have a similar or greater effect. A number of them, innocuous alone, had a 'dose-sparing' effect equivalent to increasing the phleomycin concentration by as much as 200 times.

More recently the compounds capable of amplifying the effects of the phleomycins have been shown to have the same effects on the bleomycins. This phenomenon, discovered with bacteria, applies also to mammalian tumour cells. A number of compounds have been found to amplify antitumour activity in experiments with transplantable malignant tumours in rats and mice.

The Unit has been working in collaboration with the Divisions of Applied Organic Chemistry and Food Research and the Medical Chemistry Group of the Australian National University. They have produced a number of pure phleomycins, including those making up the mixture 9331-648, together with several bleomycins already characterized by other laboratories. Some of these have been used in antitumour tests and have been found to be active. The effective regimes are now ready for toxicological evaluation prior to clinical testing.

Different phleomycins and bleomycins often show different patterns of response to enhancement by particular amplifying compounds. Thus, the antibacterial activity of phleomycin G was amplified by virtually all the compounds used; but phleomycin CHP was amplified significantly only by caffeine and the related purine, theophylline. The amplifying compounds varied greatly in the effects they produced. Thus, the triphenylmethane dye, crystal violet, produced three times the effect of caffeine (both substances used at optimal concentration) and six times the effect of theophylline. Since the different phleomycins differ only in the nature of their basic side chains, it can be concluded that the side chains determine their response to amplifying agents.

The essential difference between the bleomycins and phleomycins lies in the nature of the core structure. Pairs of phleomycins and bleomycins having identical basic side chains can be produced. Nine such pairs of corresponding phleomycins and bleomycins showed patterns of amplification by the test compounds that were identical qualitatively and quantitatively.

Early studies at the Molecular and Cellular Biology Unit used the phleomycin mixture 9331-648 donated by Bristol Laboratories of Syracuse, N.Y.; various pure bleomycins donated by their discoverers, the Microbial Chemistry Foundation of Tokyo; and Blenoxane, a commercial mixture of bleomycins A, B1, and B2 used clinically. Subsequently, the Unit has produced its own phleomycins and bleomycins. The significant improvements made to the technology of production, isolation and fractionation could have commercial significance.

Although bleomycins such as the Blenoxane mixture are important antitumour drugs and in mixed therapy produce some remarkable results, the phleomycins remain clinically untested. The reasons for this are largely historical. By chance the mixture of phleomycins (similar to phleomycin 9331-648) first isolated from *S. verticillus* consisted mainly of phleomycins E and G, having the strongly basic di- and tri-guanidine-containing side chains, whereas the bleomycin mixture first isolated from the culture liquor of the same *Streptomyces* species contained bleomycins A, B1 and B2 as the principal constituents, with no di- or tri-guanidines in their side chains. Studies at the Tokyo Microbial Chemistry Foundation showed that the higher general toxicity of the former (which caused their rejection from clinical testing) was probably due to the di- and tri-guanidine groups in the side chains.

Less toxic phleomycins were never evaluated alone as antitumour drugs. As a first step to rectifying this omission, testing has started on the antitumour activity of a series of phleomycins prepared in the collaborative program.

The availability for the first time of a comprehensive range of phleomycins with a range of side chains similar to those of clinically promising bleomycins (including the new Pepleomycin) makes their clinical evaluation both possible and worth while.

## Blood Vessel Growth

Salivary glands have proved a rich source of substances with growth-regulating properties, such as 'Nerve Growth Factor', 'Epidermal Growth Factor' and the immuno-suppressive factor (IT). Some time ago the Molecular and Cellular Biology Unit found that injecting young mice with crude extracts of mouse submaxillary gland, and later with bovine parotid gland, caused a massive, abnormal capillary outgrowth in the vascular bed of various tissues.

Folkmann and co-workers in Boston had earlier demonstrated that the powerful stimulus exerted by developing tumours on surrounding blood vessels, leading to ingrowth and vascularization of the tumours, was caused by a diffusible substance. They found that the substance could cross a dialysing membrane if placed between tumour and tissue bed, and could be extracted and demonstrated to cause vascular growth when injected. This substance was called 'tumour angiogenic factor' and it was said to be a protein of molecular weight about 100 000 daltons. Their work initially indicated that it induced cell division, but they have since concluded that its primary action is to induce migration and advance of the endothelial cells which make up capillaries.

When salivary gland extracts were fractionated at the Molecular and Cellular Biology Unit, angiogenically-active components of lower molecular weight were isolated. Initially, a molecule of molecular weight 3000 was isolated, but this was readily separated into a carrier molecule with a molecular weight of approximately 3000 and a highly active angiogenic component with a molecular weight of 210. Similar extracts prepared from tumours and certain cell cultures which had some angiogenic activity yielded an active preparation of the same molecular weight and character.

The angiogenic factor prepared from these various sources induces random capillary growth when injected subcutaneously into mice or rats. When prepared as a pellet of plastic polymer and introduced into the anterior chamber of the rat eye, it induces vascular outgrowth from the edge of the iris; the induced vessels wander toward and over the pellet, and can be observed and photographed using an ophthalmic slit lamp. Despite vascular growth activity, little or no stimulation of cell division occurs. Crude extracts of salivary glands or tumours also contain mitotic stimulator substances. These are, however, not specific stimulators of capillary endothelial cells, and following further fractionation they separate from the fraction with angiogenic activity.

Final fractionation of the fraction with a 210 molecular weight from either salivary glands or tumours showed that the active moiety was cupric ions. Testing of simple cupric salts—by both kidney vascular bed assay and pellet implantation assay in the eye—showed that low concentrations of these salts behaved identically to the preparations of angiogenic factor from tissues. Of a large number of other metallic compounds tried, only stannous tin salts were active like copper. Thus it is believed that the endothelial growth factor, as prepared by the Molecular and Cellular Biology Unit, and Folkmann's tumour angiogenic factor are effectively the same cupric compound.

There are obvious applications to be derived from these discoveries. Further development should enable control of vascular growth—either stimulation of better growth where the spontaneous growth is inadequate, or inhibition of growth where this is required. Since tumours will not develop further than about 1 mm in diameter without vascularization, there is the possibility of controlling tumour growth by blocking the release of cupric ions from developing tumours, or interfering with their action on nearby endothelium.

# 13. Institute of Biological Resources

## SIRATAC

SIRATAC is an on-farm computer-based management system for growing cotton developed jointly by the Division of Plant Industry and the New South Wales Department of Agriculture working in close cooperation with cotton growers. Its aim is to draw together results of entomological, agronomic and plant breeding work carried out at the Myall Vale and Burrenda Research Stations in northern New South Wales. Ultimately it will help farmers to make day-to-day management decisions such as when to spray, what to spray with, and when to irrigate or fertilize. Besides increasing net farm income, the system should help prevent the build-up of insecticide-resistant pest populations and minimize environmental pollution.

The system concentrates in the first instance on pest management. Results of trials on a commercial farm in 1978-79 were extremely promising, with both costs of insecticide sprays and associated pollution reduced by 50% without significant loss in yield of cotton. A number of growers assisted with further trials during the 1979-80 season.

An important feature of the program is the emphasis placed on the use of 'soft' sprays—those containing pest-specific viral agents—during non-critical periods of growth, when only moderate levels of control are required. These sprays reduce the strong selective pressures which broad-spectrum chemicals apply to pest populations, thus inducing pesticide resistance. Also, predators are left unharmed and supplement the spray control.

It is expected that the principles being developed in SIRATAC for the management of cotton will be equally applicable to other intensively managed field and horticultural crops.

## Molecular Genetics and Plant Breeding

Recent advances in recombinant DNA techniques, often termed 'genetic engineering', and cell and tissue culture research have given plant geneticists new insights into gene structure and function and increased the feasibility of using new methods of plant breeding. The ultimate aim of this research is to isolate genes for certain characters from one plant and transfer them to another, thus overcoming the constraints that until now have only permitted crosses to be made within species or between closely related species.

Techniques for isolating and sequencing specific fragments of DNA have developed rapidly over the past five years, based partly on the discovery that certain enzymes found in bacteria cut DNA at defined points. About 150 of these enzymes, known as restriction endonucleases, are now available for isolating particular regions of DNA. These regions, which may contain one or several genes, can be recombined with the DNA of another organism using similar techniques.

The successful transfer of genes to a new host organism has already been achieved with certain bacteria, blue-green algae, some fungi and animals. However, there has been less progress in research on the new technology with plants. The Division of Plant Industry has responded by mounting an intensive program to isolate and multiply, or clone, a number of useful plant genes, including those for alcohol dehydrogenase (associated with waterlogging resistance), nitrate reductase (important in nitrogen metabolism) and pea storage proteins.

One difficulty with the plant system has been the construction of the medium of transfer, called a vector. Some research has been directed towards the possibility of using the crown-gall bacterium, *Agrobacterium tumefasciens*, and certain plant viruses because of their ability to enter and infect plant cells. Combinations of the DNA of cauliflower mosaic virus with that of plants have been made, but the DNA is so modified in the bacterial cells where the constructions are made that it becomes non-functional. Besides trying to overcome this difficulty, the Division of Plant Industry plans to turn its attention to yeasts, as they are closer to plants in the evolutionary scale than bacteria or viruses. If recombinant DNA can be made to express itself in yeasts, it is considered more likely that it could then be transferred successfully to plants.

Initially the new technology may best be applied to such traditional plant breeding objectives as incorporation of disease-resistant genes into crop plants. Other more ambitious projects under review in the Division include the improvement of the quality of seed protein, incorporation of drought tolerance, the transfer to non-legume crop plants of the ability to fix atmospheric nitrogen, and the introduction of nitrogen-fixing genes into cellulose-digesting organisms to utilize crop residues directly as a source for nitrogen fixation in the field. However, progress with some of these ventures could well be limited by the ability of host plants to provide all the biochemical conditions necessary in the cell for the introduced genes to function.

In the meantime, recombinant DNA techniques provide a particularly powerful research tool. For example, it has now been possible to sequence the major constituent of maize 'knob' heterochromatin, a type of DNA repeated many hundreds of thousands of times in one cell. Its isolation and characterization, along with other more complex DNA sequences in plants, should lead to a better understanding of gene structure and function.

Progress has also been made in understanding the genetic basis of photosynthesis. It has been known for some time that the genetic information for this process is found both in the cell nucleus and in the chloroplasts, which are the sites of photosynthesis. A physical map of chloroplast DNA has been constructed which provides a basis for isolating gene sequences for specific biochemical functions. Many of these sequences have now been cloned using recombinant DNA procedures. It is also possible that chloroplast DNA might serve as a site for inserting, or as a vector for transferring, new genes into plants.

The application of such basic information to plant improvement will depend on recent developments in plant tissue culture research. Tissue culture to vegetatively propagate some plant species has been in use for some years, but it is now possible to strip the cell walls off plant cells, thus providing the conditions necessary for inserting foreign DNA. In some species these naked cells, called protoplasts, can be induced to reform their cell wall, form colonies and then regenerate into fully mature, fertile plants. This allows for a greatly increased intensity of selection for biochemically defined plant characters, as millions of cells can be tested in the laboratory at any one time for useful combinations of genetic material. However, until a satisfactory means for recombining DNA in plants is developed, the techniques are most likely to be applied to facilitate the selection for desired characters from within natural or induced variation in crop species. Such a program was initiated by the Division of Plant Industry in 1979 and within the next two to three years is expected to produce sugar-cane lines that are resistant to eyespot and leaf-scald disease.

There has been some concern about the safety of recombinant DNA research, particularly in relation to the accidental production of virulent pathogens and cancer-inducing organisms. Such events are now considered to be highly unlikely, but nevertheless the Australian Academy of Science has established a standing committee to recommend conditions under which recombinant DNA research may be carried out, and to advise on procedures and developments in the field. With plants, the benefits certainly appear to outweigh any possible disadvantages, and there is considerable optimism that in 10-15 years time the new technology will be standard practice in plant breeding.

## Control of Water Weeds

Australia's scarce water resources need careful management and the control of water weeds is frequently an important aspect. Aquatic weeds may reduce both the quantity and quality of water resources. They can increase water losses from evaporation, pollute deeper layers, impede water flow and contribute to flooding, interfere with boat traffic, and generally disturb the overall balance of aquatic life.

They are also a potential threat to the long-term economic viability of irrigation areas of south-east Australia, where, in the Murrumbidgee and Coleambally Irrigation Areas alone, the return from rice exceeds $36 million each year and from other irrigated crops a further $34 million.

Current research on the control of water weeds by two Divisions is reported here.

Every growing season, State authorities spend at least $1 million on herbicidal control of water weeds in the irrigation areas. Where herbicides are used in supply systems, contaminated water must not be allowed to reach crops. Also, in drainage systems, it is important to prevent the movement of herbicides away from the target area, as water may be re-used for irrigation, stock or domestic purposes.

The Division of Irrigation Research, in association with State authorities, growers and the chemical industry, is studying the fate and behaviour of some of the herbicides that are used in irrigation canals. Tests on acrolein, an effective herbicide which is used extensively to treat about 4000 kilometres of canals and channels each season, have confirmed that it virtually disappears from treated waters after two days. However, because acrolein gives only temporary control, is potentially explosive and is also toxic to fish, use of alternative herbicides such as terbutryn and endothal-alkylamine is now being investigated.

Research has also shown that diuron, a soil-acting herbicide used to treat empty channels during winter for control of cumbungi (*Typha*) and some species of submerged weeds, is extremely persistent. The current practice of flushing surplus residues to the drainage system could therefore constitute a hazard unless properly managed.

Another soil-active herbicide, dichlorbenil, used against Canadian pondweed (*Elodea canadensis*) has been shown to dissipate rapidly by evaporation so that contamination of irrigation water in spring is very low. However, the treatment is only moderately effective and quite expensive; simazine is now being investigated as an economic alternative.

Careful management techniques are also required where herbicides reach the water during treatment of aquatic grasses and overhanging foliage. Increasing use of a new herbicide, glyphosate, has given rise to major concern about the safety of irrigated crops. Fluorescent dye techniques are used to complement analytical methods for detecting traces of glyphosate and to study the processes of dilution and dissipation, thus aiding prediction of the extent of contamination downstream.

Besides the economic and practical benefits flowing from this program, the research also has implications for preserving natural aquatic ecosystems.

Exotic weeds, that is those introduced from overseas, are the greatest threat to Australia's scarce water resources. Freed from the organisms that keep them in check in their native ranges, they may spread aggressively.

Biological control of exotic weeds seeks to restore the balance that exists in their homelands by introducing into Australia selected, host-specific natural enemies. If biological control can be established, then money and energy expended on chemical control, together with any associated environmental pollution, should be markedly reduced.

Over the past few years, the Division of Entomology has made marked progress towards the biological control of three South American water plants that have become weeds in Australia. Particularly striking has been the level of control achieved over alligator weed in the Sydney region, using the alligator weed flea beetle, *Agasicles hygrophila,* which was imported from South America during 1976 and released early in 1977 after quarantine studies had been completed. Stretches of the upper reaches of the Georges River which were infested by dense mats of this weed have now been opened up. Another natural enemy of alligator weed, the moth *Vogtia malloi,* has also been released. However, its potential contribution to control has been difficult to assess because of the devastation caused by the flea beetle.

There has also been progress towards the biological control of *Salvinia,* which is capable of doubling its size in as little as 36 hours in sewage lagoons or in three days in man-made lakes. *Cyrtobagous singularis,* a weevil, the only natural enemy of *Salvinia* so far imported, was obtained from Brazil in 1978 and is being tested in quarantine to ensure that it will attack only *Salvinia* if released.

Water hyacinth, whose presence in Australia was first noted as long ago as 1894, is now regarded as the world's most troublesome water weed. It has been recorded from all mainland States. Infestations can double in extent in as little as 12 days, and seeds of the plant may remain viable for at least seven years, making eradication a long and costly process. Two biological control agents, a weevil (*Neochetina eichhorniae*) and a moth (*Sameodes albiguttalis*), are now established and there is strong evidence that they are damaging mats of the weed. Though it will be some years before their general effectiveness in controlling the weed is known, it seems likely that importations of other, complementary insects will be needed to tackle water hyacinth over its whole range in Australia.

The results achieved in just five years highlight the potential for biological control of these aquatic weeds in Australia. Future work will be directed towards assembling groups of insects that complement each other in their effects so as to achieve country-wide control. In the longer term, there are other water weeds awaiting attention.

## The Use of Synthetic Pyrethroids Against Cattle Tick

Although increasing emphasis is being placed on developing tick-resistant cattle, there will probably always be a role for effective acaricides to supplement resistance. Experience suggests that ticks will eventually become resistant to compounds currently in use for chemical control, so the recently developed pyrethroids, which represent a totally new class of chemical compounds, are being investigated by the Division of Entomology as possible replacements.

Laboratory tests have shown that three pyrethroids—permethrin, cypermethrin, and decamethrin—provide effective control at considerably lower concentrations than any other previously used acaricides. However, it was also found that one strain of DDT-resistant tick could only be controlled by increasing the concentration of pyrethroids threefold. The potential problem was highlighted when permethrin-treated field populations containing only 2% of DDT-resistant individuals developed resistance equal to that of the laboratory reference strain in two generations. Furthermore, permethrin concentration had to be increased again for effective control after a further seven generations. As a result of this research, industry abandoned development of permethrin for control of cattle tick, and concentrated efforts on cypermethrin and decamethrin, both of which gave satisfactory control of the ninth generation of the selected strain.

Further experiments indicated that organo-phosphorus compounds could be used to enhance the activity of pyrethroids used against cattle tick. This synergistic effect has now been confirmed in field trials. Thus relatively cheap organo-phosphorus acaricides such as ethion or chlorfenvinphos, used in combination with the much more expensive pyrethroids, can reduce by 75% the concentration of pyrethroid required. Besides being economically attractive, this should help to overcome the problem of resistance to pyrethroids specifically associated with the DDT-resistant strain.

## Weedicides for $C_4$ Plants

Most of the world's plants employ a system of photosynthesis known as the $C_3$ pathway. In the early 1960s, it was found that some plants have a more efficient system, the $C_4$ pathway, which can give them a competitive advantage over $C_3$ plants under conditions of high temperatures and water stress. Most of our cereals, fruits and vegetables are $C_3$ plants, so it is not surprising to find that 8 of the 10 worst weeds in the world, including nut grass, Johnson grass (wild sorghum) and pigweed (*Amaranthus*), are $C_4$ species.

Herbicides with some selectivity for the $C_4$ pathway do exist, but they are few and expensive because of the trial and error methods used in their development. Some are also toxic to other life forms and pose long-term hazards to the environment. Consequently, the Division of Plant Industry recently initiated a program to develop a herbicide specific to $C_4$ plants, using basic knowledge gained over the past 15 years of research on the biochemical processes of the $C_4$ pathway. A number of compounds that may interfere with these processes are being developed and will be tested first against $C_4$ plants for effectiveness, then against $C_3$ plants to ensure that they are selective.

To date, more than 100 of these compounds have been tested for inhibitory effects on one or other of six different enzymes of the $C_4$ pathway. Several have proved to be effective at this level, and the information is currently being used to predict more precisely the likely structure of potential weedicides.

It is expected that a range of compounds for testing against $C_4$ plants will be developed in the near future.

## Forest Harvesting and the Environment

In recent years, there has been wide public concern about the effects of timber harvesting on the forest environment. To help minimize the problems, the Division of Forest Research has published a set of guidelines based on current knowledge in the Australian forest industry and identifying areas needing research. Entitled 'Environmental Considerations for Forest Harvesting', the publication was researched and compiled at the request of the Australian Forestry Council following a recommendation of the 1974 FORWOOD Conference. Contributors included forest and logging managers from forest services and industry, and wildlife, hydrology, harvesting and landscape researchers and specialists from CSIRO and other organizations.

Although many aspects of harvesting the forest are important, perhaps one of the most basic to environmental considerations involves the effect of logging machines and the way they are used on forest soils. The guidelines describe the characteristics of various extracting machines, and cover some recent technological developments resulting from increased pressure for economically and environmentally acceptable harvesting systems.

The guidelines also discuss the relationships between water catchments and harvesting operations. A number of options exist, and both their short- and long-term effects need evaluation before a choice is made. For example, clearfelling operations may cause high water turbidity for a short period whereas selection cutting will result in less turbidity but probably occurring at more frequent intervals.

Two research programs have already emerged from work on this publication, involving the way different types of machines and working patterns affect various forest soils. Preliminary work is also being carried out on the feasibility of using a United States Army computer program to predict the ability of different types of machines to operate on forest soils with various strength and moisture properties.

## Catchment Hydrology

Most of the water catchment areas for Australian population centres are in eucalypt forests which are subjected to increasing pressures on the one hand for timber production, woodchipping and conversion to softwood plantations, and on the other for biological conservation and recreation. Over the past 20 years, the Divisions of Forest Research and Plant Industry have mounted research programs designed to place multiple-use forest management on a rational basis.

In 1964, the Division of Forest Research (then a part of the Forestry and Timber Bureau of the Commonwealth Department of Primary Industry) established a series of experimental catchments in eucalypt and pine forests in the Australian Capital Territory to monitor the effects on water yield and quality of clearfelling, prescribed burning, thinning, and conversion of grassland to pine plantations. Medium-scale field plots, of about 250 square metres, were later located on two of the catchments to determine the fate of rainfall striking the forest floor. Because of the complex set of interactions involved, computer models have been applied to the available catchment-scale data through collaborative work with the CSIRO Division of Mathematics and Statistics (Institute of Physical Sciences) and the Australian National University.

The Division of Plant Industry has also used computer modelling in a recently completed study of the Shoalhaven catchment area for Sydney. Unlike other major urban water supply catchments throughout Australia, the Shoalhaven valley exhibits a wide spectrum of land use associated with primary production, with a general trend towards improving native pastures, clearing native forests for establishment of pine plantations and new pastures, and converting grazing lands to pine plantations. A computer model, SHOLSIM, was constructed from previously published data on the Shoalhaven area and used to predict the effects of changes in land use on water yield. For example, it was estimated that pasture improvement alone could result in a significant reduction in streamflow. It could be up to 28% in average years, but would be somewhat less in years of high rainfall. Afforestation of pastures with pines could produce a 32% reduction in streamflow in both average-rainfall and wet years.

Because of the prime importance of native eucalypt forests for water catchment, the Division of Plant Industry established a new project in 1977 on the South Coast of New South Wales to measure forest water use. This project is part of an overall study aimed at gaining a better understanding of the basic processes that control the growth, productivity and long-term stability of the forest ecosystem. The Divisions of Forest Research, Environmental Mechanics (Institute of Physical Sciences) and Land Use Research (Institute of Earth Resources) are collaborating in the study. It is expected that the work will provide information essential to the sound management of our valuable eucalypt forest resources in southern Australia.

# 14. Institute of Earth Resources

## Assessing and Managing Water Resources

Assessment of water resources involves more than the measurement of the resource. Complex interactions exist between water, its surrounding landscape and the atmosphere. A proper understanding of these interactions is necessary in order to forecast the effects that changes in land use will have on water resources.

The Division of Land Use Research is studying the processes involved in water/landscape interactions at the catchment and regional scales.

In one project the Division is aiming to develop and appraise a model to describe the relationships that exist in the hydrologic cycle within a water catchment. The model will then be used to improve the methods available for the hydrologic design of engineering structures such as culverts and weirs in ungauged catchments. It will also provide a basis for predicting the effects of changes in land use and management on catchment hydrology.

Member authorities of the Australian Water Resources Council have provided a substantial amount of data on streamflow, rainfall and evaporation, and an early version of the model is being tested in four representative basins.

To provide a means of extrapolating the information acquired in this work, a system of classifying stream catchments is being developed, based on terrain, geological and land-cover data obtained from published maps.

Good estimates of rainfall over a region are needed in order to monitor its water resources. Measurements made by rain gauges only provide information about single points, so the Division is examining methods of extrapolating single-point rainfall data to generate meaningful information for an area.

Long-term observations from a number of sites around Canberra have formed the basis for a computer model of rainfall in the area. The model shows how strongly mesoscale factors, such as local orography, influence the rainfall pattern, and also how changes in the placement and number of measuring sites can affect the conclusions reached.

Despite Australia's overall lack of water, floods can still be a problem in parts of the country. Good management of land and water resources may help to avoid or reduce flooding, but once the waters have spread, the primary need is to know how much there is and where it is going. The availability of LANDSAT satellite pictures has enabled many countries to get regular information on their land areas. In anticipation of the 1980 opening of Australia's LANDSAT receiving stations, the Divisions of Land Use Research and Mineral Physics have been developing flood-mapping techniques with the aid of pictures of past floods. The Division of Land Use Research is also making use of ESMR (microwave) satellite pictures for this purpose.

Assessment of water resources includes measurement of water quality. This can change greatly as land use changes. The Division of Land Use Research is examining relationships between land cover, land use and water quality in a rural catchment with the aim of establishing relationships between water quality and management practices. To do this, a detailed study is under way of the more important processes of change and transfer of chemical substances in the catchment. This includes biomass surveys and studies of rain interception and stem flow in plants, litter decomposition and soil-moisture relationships.

A second project is aimed at developing methods of detecting and mapping regional-scale occurrences of salt accumulation. Secondary salinization in the Murray-Darling Basin is being investigated, and a correlation has been found between certain soil properties (for example, the presence of unconsolidated clay) and salinity gradients. The researchers are also testing the efficacy of remote sensing techniques in detecting relevant soil properties.

Several techniques are being developed and used by the Division of Soils to study water in soil/plant systems. These are necessary because, for much of Australia, we know very little about how much rain is retained in the soil, how much drains to underground aquifers, how much is lost by evaporation from the soil surface and how much is lost by transpiration from plants.

The presence of tritium (produced primarily from atmospheric nuclear explosions in the recent past) in rainfall and groundwater has enabled scientists of the Division to measure how much water enters underground aquifers in the Gambier plain in the south-east of South Australia. This work has given precise figures for the maximum amounts of water that can be drawn safely from aquifers in the area, including the one that feeds Blue Lake, the source of water for Mount Gambier.

With the decline in tritium levels since atmospheric nuclear testing stopped some years ago, isotopes such as $^{18}O$, $^{2}H$ (deuterium) and $^{14}C$ are being assessed for their usefulness in dating water and tracing its movement. These newer techniques are being used to study how land use affects the fate of water in the semi-arid zone. In particular, changes in the levels of the different isotopes in water during evaporation from soils or transpiration from plants may give precise figures for the proportions of water lost from soils in these ways.

In Australian conditions, crop, pasture and forest yields are in general determined mainly by the availability of soil water, which in turn depends on the weather and on plant and soil characteristics. In a joint project, the Divisions of Land Use Research and Soils are studying the growth and yields of wheat crops on the major cereal-growing soils in eastern Australia in relation to the physical properties of soil, which affect water movement into, through and from the soils. An important aid in this research is a simplified neutron moisture meter developed by the Division of Soils and soon to be manufactured commercially.

Research in northern Queensland has shown that the red earths there have more vigorous communities of plants than do yellow earths, largely because they allow deeper penetration of rainfall and so hold more water for use in the dry season. Investigations are continuing with these and other soil types in order to assist the pasture-improvement programs being carried out by the Division of Tropical Crops and Pastures.

For thousands of years man has faced the problem of salinity in irrigated soils, and over the last hundred years or so similar problems have been recognized in non-irrigated areas. These areas of 'dryland salinity' appear to be restricted to the parts of North America and Australia that have been developed for agriculture in relatively recent times. The increase in salinity reduces the productivity of the land and increases the erosion hazard, and ultimately the salt finds its way into streams and rivers. The salt load in these streams and rivers can reach levels that make the water unsuitable for irrigation, domestic supply and other uses.

In Western Australia, where salinity has become a serious environmental problem, relevant CSIRO research has been under way since the mid-1950s. The Division of Land Resources Management is studying several aspects of the problem in an effort to help authorities to reduce salinity in water supplies.

One of the research projects, which evolved from previous work by the Division of Soils in Western Australia, is directed towards understanding how and when salt moves in the soil. Such information is in demand by water authorities so that they can ensure that the quality of water is maintained while allowing, where possible, multiple land use in the catchment areas.

Nine experimental catchments are being studied. The information gained from these areas serves two purposes. First, it provides details of the distribution of water and salt, as well as the physical properties of soils and deeply weathered subsoils in representative areas of the Darling Range. Second, by imposing various clearing regimes (such as full or partial clearing for agriculture or conventional bauxite-mining operations), the effects on stream salinity can be monitored for comparison with predictions about how any change in land use will influence salinity.

Although they are only in the early stages of development, the methods for predicting future changes in stream salinity are a practical result of the research. These methods have already been used by the Western Australian Government to aid its decisions on the control of agriculture and bauxite mining in important catchment areas.

While this work is centred on a regional problem in the south-west of Western Australia, the understanding of the processes involved has much wider implications. Closely related are the dryland and irrigation salinity problems in other parts of Australia, such as along the River Murray, and leaching problems, such as water pollution stemming from municipal refuse-disposal sites and mining and ore-processing wastes.

The Division is carrying out research on the rehabilitation of salt-affected lands by replanting trees and shrubs to enhance transpiration and interception on the cleared areas. But how much water do different trees 'pump' from the subsoil, and how can mining companies comply with the statutory requirement of providing evidence that their rehabilitation program will prevent salinity?

In the long term, the best trees could be selected by large-scale plantings of hundreds of different species—a technique wasteful in time and resources. To overcome this problem, the Division has developed a method for rapidly estimating the transpiration from ground flora and forest trees. The vegetation is surrounded with a transparent, vertical wind tunnel, air is blown through at a known rate and the flux of water vapour is determined with an infra-red gas analyser. In this way, different species can be quickly screened for their effectiveness as 'pumps', and the mining companies can quantify the transpiration from their replanted mine pits for comparison with that in nearby forests. Alcoa of Australia is collaborating with the Division in the development and application of the technique.

Engineering solutions to the salt problem may be feasible in some instances, particularly where a valuable asset such as a water supply is threatened. Drainage and pumping techniques are being investigated with the objective of intercepting the flow of saline groundwater at depth and preventing it from reaching the soil surface. The saline water is led through the drains and discharged into existing saline waterways. In areas too extensive or with insufficient slope for drains to be effective, pumped or siphoned wells are being tested and preliminary results show them to be effective.

Salt is only one of the potential pollutants of water supplies—industrial wastes, fertilizers, septic tanks and refuse-disposal sites can all contribute to pollution of rivers and groundwater.

In Perth, groundwater pollution is of particular concern because a high proportion of the domestic water supply is pumped from the groundwater under the metropolitan area.

The Division of Land Resources Management has been studying the flow of contaminants from septic tanks. (In all State capital cities, a high proportion of houses are not connected to a reticulated sewage system; in Perth, about 50% of the houses are served by septic tanks.)

Phosphorus and nitrogen flows have been defined and most of the reactions with the soil are now understood. With this information, it is possible to specify 'high-risk' areas for contamination of groundwater so that priority can be given to sewering those areas. Similarly, areas that should be avoided for use as refuse disposal sites can now be delineated.

## Extractive Processing of Metals

Unique features of the Australian situation influence both the economic viability and the technical feasibility of metallurgical processes. In most cases, existing technology must be adapted to meet the varied conditions of location and ore type. The Institute is studying aspects of hydro-, electro- and pyrometallurgical processes in order to improve the efficiency of existing plants and to assess the potential of new developments. Novel processes of particular relevance to Australia are also being investigated.

Hydrometallurgical processing consists of dissolving a mineral and subsequently recovering the desired compounds from solution. The Division of Mineral Chemistry is studying the steps involved, such as leaching, solution purification and metal recovery. The techniques it uses include precipitation, solvent extraction and ion exchange.

The hydrometallurgical processes presently under investigation are the extraction of cobalt, the production of magnesia, and the treatment of complex sulphide ores. The scarcity and high price of cobalt have prompted interest in methods of recovering this important metal, which is used in superalloys and permanent magnets, from hitherto uneconomic deposits, from by-products of other mineral processes and from waste materials. Hydrometallurgical processing is suitable for many of these sources.

The problem of producing pure magnesia, which is essential for making the refractory bricks used in steel-making furnaces, from a Tasmanian magnesite ore containing calcium and iron is being investigated. Several promising hydrometallurgical processes are being tested on a laboratory scale, and larger-scale tests of a selected process are planned.

Complex sulphide ores containing finely intergrown copper/lead/zinc/silver minerals are difficult to treat by conventional pyrometallurgical methods, and hydrometallurgy may be preferable. Various leaching techniques for such ores are being assessed, with emphasis on the use of chlorine as an oxidizing agent.

Research by the Division in the related field of electrometallurgy, that is, the recovery and refining of metals by means of electrolysis, covers both existing processes and new applications. The factors determining the efficiency of the electrical currents used in the electrolytic-zinc process, which is employed on a large scale in Australia, are being studied. For example, oxygen dissolved in the electrolyte has been shown to have a slightly deleterious effect, and the effects of other impurities are being investigated. Novel electrodes consisting of metal particles fluidized by a rapid stream of electrolyte have potential applications in electrometallurgy, especially in the recovery of metals from dilute solutions. A cell for recovering copper has been constructed to provide information on operating conditions.

Chemical analyses and measurements of electrochemical potential are being used in a continuing study of the mechanism by which lead is extracted from lead sulphate slurries by displacement with iron or zinc. The behaviour of iron in this process is markedly different from that of zinc, appearing to be less complex. When the process is applied to industrial residues, any elemental sulphur must first be removed by extracting it with solvents or by roasting it.

The environmental problems associated with the extraction of mineral ores by smelting, and the amounts of energy needed, are being researched by the Divisions of Mineral Chemistry and Mineral Engineering.

The Division of Mineral Engineering's research is currently focused on several new processes it has developed. SIROSMELT—a method of smelting by submerged combustion—has proved successful on a 50-kg pilot scale, and larger-scale tests are being carried out in industrial plants. A commercial pilot plant installed to recover tin on a production basis for reverberatory smelter slags is also being used as a pilot plant for the collaborative development of tin-concentrate smelting. At other smelting sites, pilot plants are being installed to test the recovery of tin by fuming and the direct smelting of lead-sulphide concentrates.

A new process for purifying lead by continuous crystallization with reflux is being tested on a pilot scale, and the use of this technique to refine other metals is being examined in the laboratory.

Research by the Division of Mineral Chemistry is concerned with the improvement of some industrial pyrometallurgical processes. The kinetics of smelting and roasting sulphide suspensions are being studied with the aim of improving efficiency and the rejection of impurities. The reactions of concentrates (such as pyrite, chalcopyrite, galena, sphalerite and nickel) with oxygen-containing atmospheres at high temperatures are being studied in a laminar-flow furnace with the aid of sensitive thermal-analysis techniques. Very short reaction times (70 ms for 45-$\mu$ particles of chalcopyrite) and extremely high peak particle temperatures (more than 3000 K for pyrite particles) have been observed.

The Division has considerable experience in the various processes of beneficiating ilmenite to obtain titanium dioxide. Current emphasis is on the coal-reduction process for removing iron from ilmenite, with the aim of characterizing the variables in the process so that a variety of ilmenite ores can be encompassed. The addition of sulphur to segregate manganese, which is a deleterious impurity, is now being practised, and the phase equilibria of the iron-manganese-titanium-oxygen-sulphur system under kiln conditions have been established.

Commercial briquettes of compacted nickel powder swell during sintering, making them unsuitable for use in electroplating processes or for incorporating in melts of cupro-nickel alloys. A new method of treating nickel powder prior to compaction has been developed; compacted anodes made from the treated nickel are now being tested in commercial electroplating processes.

Segregation-roasting processes are being developed to obtain nickel oxide from nickel matte. As part of this work, the mechanism by which copper is selectively segregated from oxidized nickel matte is being studied.

## Hydrocarbon Exploration

Exploration for coal, oil and gas can be an extremely expensive operation, with a great risk of failure. The Institute is helping industry to reduce both costs and failure rates by improving the exploration techniques used in Australia.

Geological investigations of coal deposits and their method of formation have been carried out by CSIRO for more than 30 years. The knowledge gained has been applied to exploration activities by companies and also to prediction of the properties of particular coal seams, and hence their most suitable use.

The Fuel Geoscience Unit is giving major emphasis to studies of coal seams in the Hunter Valley of New South Wales and the Wandoan area of Queensland. Its research is aimed at determining the influence of various geological factors on the way the seams were laid down and on their petrographic and chemical constitution. These studies have helped to explain the known variability of the seams and to enable predictions of properties to be made for concealed seams.

Fundamental studies of how plant material is transformed through a peat stage to coal have made significant progress. There is now a better understanding of the rate at which water, carbon dioxide and methane molecules are lost at each stage of the process.

The study of fossil magnetism is playing an increasingly important role in the dating of geological events. The Division of Mineral Physics has been using this method to provide a relative chronology of igneous events during the evolution of the Sydney Coal Basin in New South Wales. Researchers have been able to identify periods of removal of significant amounts of sedimentary overburden (related to the establishment of coal rank) and have linked these to the formation of the rifted eastern margin of the Basin. They are now constructing a model that gives an integrated geological picture of the evolution of the Sydney Basin during the past 200 million years.

Australian oil-shale deposits are noteworthy for their variability from both the geological and chemical points of view. Although most of these deposits have been known for many years, a great deal of exploration, characterization and assessment remains to be carried out. The Fuel Geoscience Unit's research covers aspects such as kerogen composition, the petrology of algal and other components, mechanisms of genesis and the nature of oils produced by pyrolysis and hydrogenation. Samples from the Sydney Basin, the Toolebuc Formation of the Eromanga Basin and the Rundle area of Queensland have been examined, and a major project has been carried out on the Tasmanite deposits of Tasmania.

Large areas of onshore and offshore Australia remain virtually unexplored for oil and natural gas. In planning exploration activities, therefore, the maximum use must be made of geological, geochemical, chemical and petrographic data to improve the probability of success. The Fuel Geoscience Unit has been collecting information about areas of Australia such as the Bowen, Cooper, Bass, Gippsland, Canning and Georgina Basins, with particular attention being given to the Exmouth Plateau, off Western Australia. To do this, the scientists work in close cooperation with oil companies and the Bureau of Mineral Resources, Geology and Geophysics.

A range of techniques is being applied to the examination of samples. For example, the Unit is using the established technique of petrography to study organic matter in oil basins and deduce the environments in which the oil was formed. It is also using a new computerized gas-chromatography/mass-spectrometer system to identify the type of organic matter in samples of oil-bearing rocks and the temperature to which the sample has been exposed.

In the Cooper Basin, a possible geochemical exploration technique is being investigated in collaboration with the South Australian Department of Mines and Energy. An initial survey has shown that gaseous anomalies, which might indicate underlying oil or gas reservoirs, can be detected at the surface of the ground. Further studies are planned to evaluate these anomalies and establish their relation to any buried deposits.

The analysis of isotopes present in oils, distillates, coals and gases from many well sites and cores can provide valuable information. Such analysis is being carried out on samples from the Cooper Basin to uncover similarities in the formation histories of hydrocarbons and to establish relationships between source rocks and hydrocarbons. It may also indicate which geological formations are, or may be, most likely to contain gas or oil.

In the Bass Strait region, coals buried deeply offshore are considered to be the probable source of the various Bass Strait crude oils. These coals also occur onshore (for example, the Yallourn brown coal) and thus are readily available for isotopic analysis, which can determine their prospective capabilities for generating specific crude oils.

The Division of Mineral Physics is investigating whether a geophysical technique, based on measurements of induced polarization in rocks, could be useful in detecting buried oil or gas reservoirs onshore. Instruments developed in the minerals research program are being modified for this purpose.

With increasing oil costs and looming shortages, greater emphasis is being placed by industry on enhanced recovery techniques of oil and gas from wells. One of the major factors leading to incomplete recovery of oil is the tension between the interfaces of oil, water and rock in a reservoir. Most methods of changing interfacial tension in the oil/water/rock system are expensive, owing to high consumption of the chemicals involved.

The Fuel Geoscience Unit is using a biological approach to this problem by attempting to produce surface-active materials, preferably *in situ*. The initial stage of this project consists of screening micro-organisms for their capacity to generate surfactants (surface-active materials) in reservoirs. A number of organisms able to grow in the absence of oxygen and at temperatures up to 65°C and pressures of 3500 kPa have been isolated from oil reservoirs and wells, and a system has been developed for the continuous growth of such organisms at higher temperatures and pressures.

# 15. Institute of Industrial Technology

## Liquid Fuels from Coal, Biomass and Agricultural Wastes

The Institute of Industrial Technology, in collaboration with the Institute of Earth Resources, is evaluating the technique of rapid, or flash, pyrolysis, which is a modern version of coal pyrolysis, as a source of liquid fuels. During flash pyrolysis fine coal is rapidly heated to approximately 600$^{\circ}$C and thermally decomposed in a few seconds. The products are gas, char and tar.

The gas and char will be used as fuels, while the tar is upgraded by treatment with hydrogen under pressure, a technique known as hydrotreatment, to an oil suitable for processing in a refinery. The pyrolysis and the hydrotreating steps will eventually be integrated.

In order to upgrade the hard black tar, it is melted and treated in the presence of a catalyst to convert any compounds containing oxygen into the more desirable hydrocarbons. The mixture also undergoes a process known as cracking, which converts the large hydrocarbon molecules in the tar to the smaller molecules of lower boiling point oils.

Three different continuous flow units have been built for the hydrotreatment step, so that different reactor designs, catalysts and catalyst life can be evaluated.

An important aspect of the project is the evaluation of the suitability of the product oils as refinery feedstocks by measuring boiling range and viscosity, and carbon, hydrogen and oxygen content, and by comprehensive spectroscopic examination.

In a parallel project, samples of chemical compounds known to be present in pyrolysis tar are hydrotreated under various conditions. This is leading to a greater understanding of the many chemical reactions occurring during hydrotreatment, and will enable the evaluation of new catalysts which are being designed and synthesized.

Successful hydrotreatment at a rate of 50 g/h has been demonstrated, and a new apparatus to hydrotreat 2 kg/h on a continuous basis is being built with the aid of a grant from the National Energy Research Development and Demonstration Council (NERDDC).

The Institute of Industrial Technology, in collaboration with the Institutes of Earth Resources and Biological Resources, has completed an assessment of the potential production of alcohol fuels from the agriculture and forestry resources that would be available over the next 20 to 40 years. The alcohols are ethanol (produced by fermentation of sugars or starch and distillation) and methanol (by gasification and catalytic synthesis) and the economic assessment was based on existing commercial technologies. The raw materials considered were existing residues and energy crops that could be grown on land not now being used for crops.

Ethanol and methanol have high octane ratings and can replace lead additives in blends up to 20% in motor spirit for existing engines. Methanol can be used as a straight fuel in standard engines with about 15% higher energy efficiency than petrol, and the gain in efficiency can be increased to about 28% by raising the compression ratio. On the other hand, ethanol can only be used efficiently in engines having a compression ratio greater than 10.5:1.

After allowing for the liquid fuels used directly or indirectly in the production and conversion of alcohol fuel, the net potential fuel production is approximately 60% of all the liquid fuel used in transport in Australia during 1977/78. While costs are not encouraging at this stage, there are prospects that the cost difference between alcohol fuels and other liquid fuels can be reduced with more research.

Ethanol production is a realistic option in rural localities where assurance of fuel supply for crop harvesting is as important as fuel price. However, a cheap source of process heat is necessary for the distillation. One such locality is north-west Tasmania, where sawmill wastes could be used as process fuel. The Division of Chemical Technology has been involved in a preliminary design study for a small ethanol plant in this region, using sugar- beet as the feedstock.

In its biosynthesis program, the Division is investigating the conversion of cheap fibrous wastes, such as bagasse and wheat straw, into industrial organic chemicals and motor fuels using naturally occurring anaerobic bacteria (that is, bacteria which do not need oxygen).

There are ways of pretreating the waste chemically and physically to increase the bacterial activity, and the fermentation process could be modified so as to improve the yield of the desired products, namely fatty acids.

The use of selective membranes to separate the fatty acids is being examined with a view to developing a less energy-consuming alternative to the traditional distillation process.

Further research is being carried out on converting the fatty acids into a group of chemicals known as ketones which have the useful liquid fuel properties of high octane ratings and high energy concentrations.

This work is supported by a NERDDC grant.

The anaerobic digestion of wastes to produce methane gas has been practised widely for many years. While not a liquid fuel, methane gas can be used to conserve liquefied petroleum gas and liquid fuels on the farm. A pilot-plant methane digester has been built at the University of Melbourne farm to utilize the waste from the piggery, and means of improving the digestion efficiency and methane productivity are under investigation.

## Energy Conservation in Buildings

Domestic energy usage accounts for a substantial proportion of the total energy consumed in Australia each year. In a joint project which is largely funded by NERDDC, the Divisions of Mechanical Engineering and Building Research are developing computer-based design procedures which will enable the likely energy consumption of a building and its services system to be estimated at the design stage.

The project has three main objectives:

- to assess the problems of incorporating present-day solar technology into a real domestic environment;
- to evaluate design procedures; and
- to find out exactly what energy savings are possible with one particular design of house.

The procedures are applicable to both residential and non-residential buildings and will be evaluated on various projects, including the low-energy-consumption house built at the CSIRO site at Highett, in Melbourne.

The house, which is considered suitable for much of southern Australia, where space heating is a major energy user, has now completed its first winter of automatic operation. Its total energy consumption is less than 25% of the mean of a survey of 22 occupied houses which have a similar floor plan but lack energy conserving features.

In both the computing and the experimental projects, the information obtained will be of direct use to industry. The computer-aided design procedures are specifically intended for Australian building designers and engineers, and active involvement by such people is an essential element of the project.

The Division of Mechanical Engineering is also testing a low-energy plastic-plate heat exchanger for air conditioning, and developing and field testing a low-energy regenerative dehumidifier.

## Purifying Water with Sirofloc

For the proper disinfection of water supplies, turbidity must be removed, since any microbes present in the water become adsorbed to clay or other particles and are then more difficult to destroy. Colour removal is necessary for aesthetic reasons and so that the reaction of colour bodies with the chlorine used for disinfection can be avoided. This will minimize the formation of halo-organic compounds which may pose a public health hazard.

The conventional process for removing the contaminants involves the formation of a precipitate of aluminium or ferric hydroxide onto which the turbidity and colour particles become bound, and which can be removed later by flocculation and sedimentation of the particles. However, the flocs settle slowly so that a large sedimentation vessel is necessary, and as settling is never complete the residual turbidity in the overflow must be removed by filtration through sand. The sludge obtained is voluminous and difficult to dewater, since it contains not only the impurities removed from the water but also a much larger amount of the metal hydroxide floc.

Following the research on magnetic ion exchange resins, magnetic adsorbents were designed which would remove turbidity and colour and give a loaded particle having rapid settling properties. The initial adsorbents consisted of charged polymers grafted onto a magnetic polymeric core, but the cost of the magnetic resins was too high.

Research on simpler magnetic materials led to the discovery that iron oxide itself could be utilized. Developed as the Sirofloc process, the concept relies on the variation of the surface charge of microparticles of magnetite as a function of pH. At slightly acidic levels, the iron oxide, which is specially cleaned and activated for the process, has a positive charge. This encourages adsorption of the turbidity and colour particles, which have a negative surface charge. In the regeneration step, the charge on the oxide is reversed by making the conditions slightly alkaline and the like-charged impurities are repelled. The magnetite is then recycled to a further adsorption step. For more turbid waters, it is necessary to add another coagulant in the form of a positively charged soluble polymer, as otherwise the surface area available on the magnetite would be insufficient to cope with the load.

A pilot plant has been built by the Australian Mineral Development Laboratories (AMDEL), capable of producing up to 140 kl/day of purified water for the Perth Metropolitan Water Board (MWB) at its treatment works in the Perth suburb of Mirrabooka. The feed water is a highly coloured, turbid underground water which is extremely difficult to treat by the conventional method. Underground water resources are a vital addition to Perth's water supply system, satisfying on an average about 20% of the requirement, and a much greater proportion in dry years. The pilot plant has been operating successfully since the beginning of 1978. It offers a faster and more efficient process, with improved kinetics of coagulation and colour removal, greatly accelerated sedimentation and a significantly reduced volume of sludge. Filtration of the product water, normally required by the conventional process, is not necessary. The results of the first trials have been so promising that the Perth MWB and CSIRO have jointly funded an extended trial under AMDEL supervision, and further development has been the subject of a joint effort with Davy Pacific Pty Ltd. Besides the treatment of underground and surface waters, it is planned to widen the application to the cleaning-up of effluents, whether of domestic or industrial origin. Fundamental studies of the surface chemistry of magnetite are part of a collaborative research effort at the University of Melbourne.

The increased use of water and the consequent need for recycling, with its attendant potential hazards with respect to contamination, make it essential that the purification methods used are as efficient as possible with regard to the removal of harmful pollutants. These pollutants include particularly the heavy metal ions, microbes, and the organic micropollutants such as pesticides and halo-organic compounds that are formed during the chlorination process.

Extension of the Sirofloc process to this area has shown that heavy metal ions at the levels commonly found in industrial effluents can be removed when use is made of a regeneration system akin to that described for clarification and decolorization. However, the regeneration routine is the reverse of that normally employed, because acidic conditions are necessary for the recovery of the metal ions.

Since the microbes usually encountered in water treatment are colloidal particles with surface charge properties similar to those of clay and colour colloids, they also bind very strongly to the surface of magnetite particles under the appropriate adsorption conditions. In joint research in two areas of microbiology at the University of Queensland, it has been shown that both viruses and bacteria behave in this manner. Apart from the role of the process in disinfection, the existence of an adsorbed species which is itself capable of exploitation as a water purification system offers exciting possibilities. Bacteria bound to iron oxide particles have been found to physically adsorb organic micropollutants. The bacteria and the impurities can be removed by the normal alkali treatment used to regenerate the magnetite.

It has also been shown that the bacteria, whilst adsorbed on the magnetite, are capable of carrying out their usual biological functions. Hence, by using the appropriate species, magnetically supported bacteria can be used for carrying out the biological reactions used in water treatment such as nitrification and denitrification, and could be used in highly efficient continuous contacting systems analogous to those already designed for the conventional chemical processes of water treatment. Bacteria known to be capable of destroying the organic micropollutants are also relevant in this regard.

The Department of Productivity, through the Australian Industrial Research and Development Incentives Board, has provided funds for the development of some of the new water treatment processes discovered by CSIRO. Initially, these include the Sirofloc process (for which Perth has an immediate need), magnetic dealkalization (of relevance to the Pilbara region) and magnetic Sirotherm desalination (seen as a long-term need in the coastal region south of Perth). Apart from confirming in large-scale demonstration plants the potential of the processes already indicated in the pilot trials, the aim is to open up valuable opportunities for Australian industry in future local and overseas water-treatment markets.

A joint venture company named AUSTEP has been formed by the Clough Engineering Group and Davy Pacific Pty Ltd to design and build the demonstration plants and to further develop the processes. Because of the ready availability of suitable water for treatment by the processes, the first plants will be located in Western Australia. If successful, they will have a strong role in supplementing water supplies in Western Australia, and possibly in other parts of Australia, where water quality is marginal.

Because the Sirofloc process is the simplest of the three to establish, progress has been rapid, and a 35 Ml/day plant is currently under construction. To prove the effectiveness of the concept as applied to dealkalization and Sirotherm desalination, plants capable of demonstrating continuous magnetic ion exchange on the 1 Ml/day scale will follow.

## Printing on Wool Fabrics

The printing of wool brings with it problems that are peculiar to the fibre. Wool, unlike other fibres, must be treated with chlorine before printing to ensure adequate penetration of the dyes from the print paste. Moreover, wool often suffers economically because only small lots of material are processed at any one time. The International Wool Secretariat (IWS) estimated that in 1978, as a result of these disadvantages, less than 1% of all wool was printed. Since the dyeing and printing industry is largely commission-based, it tends to install machinery suitable for mass-market fibres in preference to wool-specific machinery. The wool processor therefore suffers because there is a trend for machinery and chemical manufacturers to direct their developments away from wool.

Owing to the demand for exclusive wool fabrics, print-runs are often limited to hundreds of metres as compared with the tens of thousands for synthetics. The design and preparation of the screens for printing are therefore costly when spread over such short runs.

A machine that prints without the use of screens, a jet printer, is being developed at the Division of Textile Physics. It prints by directing charged droplets as they separate from a jet of dye. The path of the droplets is controlled by an electrostatic field. A prototype machine has been successfully developed to the point where four-colour printing has been demonstrated. A computer is used to control both pattern generation and the printing process, giving very rapid and easy production of a printed fabric and change of design.

A novel printing technique called transfer printing, developed principally for polyester fibres, has been available since the late 1960s. In this technique, a design is printed on paper and then transferred to the textile by hot pressing. This approach offers considerable commercial and technical advantages; for example, print faults are made on cheap paper and not on expensive fabric, and inventory costs are reduced. Unfortunately, however, it does not work well for wool because existing dyes with appropriate transfer properties have little attraction for it and the dyes remain on the paper or are readily washed out of the wool fabric. This problem has now been overcome and commercial-scale trials are being carried out in conjunction with an Australian transfer-paper printer using dyes made at the Division of Textile Industry; the IWS is negotiating with dyestuff makers overseas for the commercial manufacture of the dyes required.

Prior to printing, wool must be chlorinated to ensure adequate penetration of the dyes into the fibre. This treatment can lead to problems—it is often not uniform, damages the fibre, causes yellowing during steaming and lowers the resistance of the dyes to washing. Efforts are being made, therefore, at both the Division of Protein Chemistry and the Division of Textile Industry to develop an alternative pretreatment. Some success has been achieved with certain dyes by using the Sirolan BAP shrink-resist process, but a pretreatment suitable for all dyes is still being sought.

# 16. Institute of Physical Sciences

## The Violent Sun

The study of the physics of the sun is of fundamental importance. Variations in the solar emission have important terrestrial effects. Their influence on the Earth's upper atmosphere and so on radio communication is well known; there is also some controversial evidence that they may have a subtle influence on our weather. The solar corona provides plasma physicists with a 'laboratory' in which they can watch, mainly through radio frequency observations, the natural occurrence of processes which cannot be duplicated in the confines of a conventional laboratory. In this way solar astronomy can play an important part in achieving the understanding of plasma physics which is essential if we are ever to harness thermonuclear energy.

The dense interior of the sun is opaque, and direct observations by solar astronomers are therefore confined to the visible surface (the photosphere) and the outer layers, consisting of the chromosphere (the middle atmosphere) and the corona, the tenuous,highly ionized outer atmosphere which extends, with ever-decreasing density, outwards to beyond the orbit of the Earth.

The Culgoora Solar Observatory, near Narrabri, N.S.W., has been a world leader in solar astronomy for more than a decade. It comprises the solar radio observatory of the Division of Radiophysics and the optical observatory of the Division of Applied Physics. The Observatory is currently playing an important role in a major international program of solar research—the Solar Maximum Year (SMY). The SMY has been organised to cover the period from August 1979 to February 1981, which is a maximum in the Sun's 11-year cycle of activity. The primary indicator of this cycle is the number of sunspots, areas of comparative darkness in the photosphere which may be thought of as 'footprints' of strong magnetic fields, emanating from the core and resulting in various spectacular phenomena in the outer layers of the sun's atmosphere. The present maximum is a comparatively high one.

The object of the SMY program is to obtain and interpret coordinated and intensive observations of solar disturbances, and, in particular, of solar flares. The latter are vast explosions in the chromosphere and corona which are responsible for the emission of electromagnetic radiation, streams of energetic particles and, sometimes, interplanetary shock waves. The impact of the radiation and particle streams on the Earth's outer atmosphere gives rise to a number of important geophysical phenomena, including short-wave radio fade-outs, auroral displays at high latitudes and terrestrial magnetic storms. Flares are thought to be generated by sudden changes in sunspot magnetic fields. However, the physical mechanisms involved are not well understood and their elucidation is one of the major goals of the SMY.

Intensive radio and optical observations are under way at many ground-based observatories around the world, but also of vital importance to the SMY will be the data coming from sophisticated instruments on an unmanned orbiting observatory—the Solar Maximum Mission Satellite (SMM)—launched by NASA in February 1980. The SMM, orbiting high above the Earth's atmosphere, will provide comprehensive data on the solar emission in the gamma-ray, X-ray, ultraviolet and visible parts of the spectrum. Some of these radiations cannot be observed at ground level because they are absorbed by the atmosphere.

At Culgoora, the 30-cm refractor operated by the Division of Applied Physics is being used to take sequences of high-resolution photographs of active regions, flares and other phenomena at a number of wavelengths spanning the strong red ($H_\alpha$) line of hydrogen. Wavelength separation is achieved with the aid of the CSIRO 1/8 Å birefringent filter, tuned in tandem with a 1 Å prefilter to attain high spectral purity. The principles behind this technique are complicated, but it rests essentially on selective absorption and re-emission, at and near the $H_\alpha$ wavelength (6353 Å), by hydrogen atoms in the path of the white light radiating from the photosphere.

The main instrument at the Culgoora Radio Observatory is the radioheliograph, a unique image-forming radiotelescope which produces second-by-second high resolution 'radio pictures' or radioheliographs of the sun at three frequencies—43 MHz, 80 MHz and 160 MHz. Further radio data are provided by two other instruments, the radiospectrograph and spectropolarimeter, which record the variation with time and frequency, over a wide radio spectral range, of the intensity of the solar emission and its degree of circular polarization.

There is a general relationship between the height in the solar atmosphere of a source of radio emission and the frequency of the radiation. The frequency depends on the electron density and so decreases with increasing height in the corona. By virtue of this effect, the three-frequency radioheliograms taken at Culgoora furnish a vertical cross-section of the corona from about 200 000 km to 1 000 000 km above the photosphere. The spectra and radioheliograms can be used together to plot the outward motion of disturbances (usually initiated by flares) through the corona, and to study the distribution of coronal densities and magnetic fields associated with these disturbances.

Experience with the Skylab satellite mission in 1973 clearly showed that the use of radioheliograms in conjunction with X-ray and optical recordings of the same events is a very powerful method for studying processes in the solar corona. Direct contact is being maintained between Culgoora and the SMM Control Centre to ensure that, whenever possible, the instruments on the satellite acquire the maximum amount of data on solar disturbances recorded by the radioheliograph.

## Tornadoes

Tornadoes are generally associated with large, rotating thunderstorms and are usually first observed as a funnel cloud hanging from the parent cloud base. However, not all apparently suitable thunderstorms produce tornadoes; nor do funnel clouds always evolve into tornadoes.

Experimental observation of a tornado has in the past required the unlikely coincidence of a tornado vortex passing over an array of meteorological instruments rugged enough to survive its passage. Just how unlikely this is can be gauged from the fact that maximum wind speeds in a tornado are believed to be in the order of 350 km per hour, its width is only about 100 m to 1 km, and its contact time with the ground is limited to a maximum of about 1 hour and is commonly only a few minutes.

Until recently, therefore, little was known about the mechanism of tornado genesis or the structure of a tornado, once formed. In the U.S.A., new Doppler radar systems have been used in conjunction with conventional weather radars to obtain detailed quantitative information about the airflow inside storms. This has been supplemented by photographs taken by observers who, guided by the radar teams, chase and intercept the storms. One of the most significant results of this program has been the identification of a characteristic radar signature marking the presence of concentrated vortical air motion. Known as the 'tornadic vortex signature' (TVS), it shows a 1:1 correspondence with the observed behaviour of a tornado, descending from the cloud base with the funnel cloud, following the tornado path along the ground and disappearing with the demise of the tornado. It is, however, registered inside the cloud before there is any visual evidence of the tornado. Monitoring the TVS at this stage has shown that the incipient tornado develops first in the lower middle levels of the storm cloud and then extends both upwards and downwards. It appears that the mature tornado has in fact a vertical extent comparable with that of the parent cloud. This correlates with observations from high- flying aircraft of a distinct crater-like formation occurring in the cloud of a tornado-bearing thunderstorm whilst the tornado is on the ground. Clearly the possibility of detecting the embryonic vortex inside the cloud long before there are any visual signs at the cloud base has important implications for improved tornado warnings.

The Australian Numerical Meteorology Research Centre, in collaboration with Monash University, has developed a relatively simple mathematical tornado model which gives results in good agreement with the American observations and thus provides quantitative insight into the factors which govern tornado formation. The model was suggested by laboratory simulation experiments carried out at Cambridge University in which a vortex behaving similarly to a tornado was produced in a cylindrical container of water, which was rotating about its vertical axis, by releasing a continuous stream of fine air bubbles along the upper part of the axis.

The model simulates mathematically the observed characteristics of a tornado. It shows that a concentrated vortex forms along the axis of a rotating storm cloud for certain values of the updraught force and the swirling velocity of the air. The vortex then develops upwards and downwards. In greater detail, what happens is that the updraught creates a circulation of the air, with the motion occurring radially outwards at the top of the cloud, downwards at outer circumferences and inwards near the bottom. As rings of air converge towards the axis at the bottom, their angular momentum is conserved. Their velocity increases, but so does the outward centrifugal force acting upon them. A balance is reached when this force exactly counterbalances the force due to the inward pressure gradient. Further inward motion is then prevented. However, the rapidly rotating rings can be drawn freely upwards by the vertical pressure gradient, thus producing an upward-growing vortex. This acts like a pipe drawing in air from beneath, the effect of which is to extend the vortex downwards as well.

This phenomenon occurs for only a comparatively narrow range of values of updraught and velocity, explaining why so few thunderstorms spawn tornadoes. The calculated values are of the same order as those for the updraughts and rotational velocities in natural storm-clouds and the deduced core size, velocity and growth time of the vortex accord with those observed in real tornadoes. Downward growth of the vortex is impeded if the cloud rotation is stably stratified—a situation analogous to the formation only of pendant funnel clouds in nature. A thunderstorm updraught is much broader—typically 20 to 30 times—than a tornado, whereas in the Cambridge analogue experiments the bubble stream and the vortex were of comparable width. However, the mathematical model shows that this is not significant; a broad updraught is capable of generating a vortex core much narrower than itself and the vortex then evolves in the same way.

## Zeolite Catalysts

The increased price and decreased availability of crude oil in the future will necessitate more efficient conversion of crude oil to liquid transportation fuels, as well as the manufacture of substitute liquid fuels from such sources as shale oil, coal, biomass and perhaps natural gas. All of these processes will in turn depend upon the increased and improved use of heterogeneous catalysts.

Oil refineries already make extensive use of heterogeneous catalysts in the manufacture of liquid fuels from crude oil. A catalytic cracker is used to convert higher boiling fractions of the crude to more volatile fractions with boiling ranges suited to motor spirit, diesel fuel and aviation distillate. Further, the fraction to be used as motor spirit is generally 'reformed' over a supported platinum catalyst so as to increase the content of aromatic and branched chain hydrocarbons, thereby increasing the octane number.

Catalysts used in the manufacture and processing of hydrocarbons are normally based on refractory inorganic oxides (that is, oxides of high melting point), some of which possess the required catalytic activity in their own right, and others of which are used to support small particles of catalytically active metals. The catalysts usually consist of small particles of the oxides compressed into hard but porous pellets which allow the reactive vapours access to as large a surface area as possible. There is great variation in the size and type of the pores because the individual particles are irregularly shaped. Control over pore structure is very desirable.

An alternative way of exposing a large catalytically active surface to the reactive vapours involves use of the internal structure of zeolites. Zeolites are crystalline alumino-silicates, the structure of which always includes regular arrays of channels and cavities often having dimension (5-10Å) which allow the selective formation and diffusion of hydrocarbons in the motor spirit range. Although zeolites can occur naturally, those of catalytic interest are mostly synthetic. All zeolites contain cations and the porous skeletons of their structures allow these cations to be easily exchanged.

Two zeolites are of outstanding importance for hydrocarbon conversions. The first is Y zeolite into which rare-earth ions have been exchanged; it is greatly superior to the conventional amorphous silica-alumina as a cracking catalyst and is now being widely used in refineries. The second is the proton form of the ZSM5 zeolite discovered in the Mobil laboratories. With it, methanol can be converted to motor spirit and the New Zealand Government plans to operate this process on a commercial scale, making use of offshore natural gas and well-established technology to produce the methanol. A great variety of other uses for ZSM5 is likely to arise, especially in the manufacture of substitute motor spirit. The Division of Materials Science is studying methods of preparing ZSM5 and related zeolites, the ways in which such zeolites may be modified and activated, the nature and mechanism of the catalytic activity, and the ways in which the catalysts can be applied to the manufacture of substitute liquid fuels.

ZSM5 was originally made by the action of tetrapropylammonium hydroxide on sodium aluminate and finely divided silica in a pyrex-lined autoclave at 170°C, with the tetrapropylammonium compound apparently playing some critical role in determining the zeolite structure. Work in the Division has shown that in fact the tetrapropylammonium compound decomposes extensively under these conditions and is not an essential ingredient. The zeolite can be prepared in the presence of much simpler organic materials or even in their complete absence.

The mechanism by which methanol is converted to high-octane motor spirit over ZSM5 zeolite is a question of considerable interest and importance. Results obtained in the Division have cast doubt on previous hypotheses that the methanol is initially dehydrated to a reactive carbenoid species ($-CH_2-$) or converted to ethylene. They suggest instead that the methanol acts as an electrophilic methylating agent, extending the carbon-carbon chains of olefins produced by cracking reactions in the catalyst.

Prior to the discovery of the Mobil process for the conversion of methanol to motor spirit, synthesis gas (from coal, natural gas, etc.) could only be converted to liquid fuels by the Fischer-Tropsch process, which uses an iron catalyst of high surface area. This is a non-selective process producing a wide spectrum of aliphatic products. The possibility of making it more selective by incorporating zeolites into the catalyst is being investigated. Conversion to a narrow range of aromatic compounds can be achieved in this way.

Work is also being conducted, in conjunction with BHP Co. Ltd, on the conversion of liquefied petroleum gas (LPG) to aromatic hydrocarbons—benzene, toluene and xylenes—which are valuable in themselves and as high-octane components of motor spirit.

In all its applications, ZSM5 zeolite displays a remarkable product selectivity. This is thought to be due to its particular channel structure. Electron microscopy has been used to demonstrate and confirm existing ideas on the channel structure, determined originally by X-ray diffraction.

## Reaction Bonding—a New Technology

In 1968, two scientists of the Electron Diffraction Section of the Division of Chemical Physics heated a small crystal of magnesium oxide (MgO) on a palladium grid in an electron microscope. The aim of the experiment was to study the structure of MgO at high temperatures. As the temperature rose, they noticed a quite unexpected reaction between the MgO crystal and the palladium. At 1100°C, well below the melting point of either material, parts of the palladium grid close to the MgO crystal appeared to become fluid and were absorbed by the crystal. It was subsequently suggested by

Associate Professor H.J. de Bruin of Flinders University, South Australia, on seeing a film record of the experiment, that such a reaction could well indicate a previously unknown type of bonding between metals and ceramic oxides. The process, for which joint patents were taken out by the Division and Flinders University, has been christened 'reaction bonding'.

This discovery has aroused considerable interest, as the techniques available for bonding metals to ceramics have hitherto been limited to only moderate- temperature applications. The most frequently used process is based on a brazing principle in which a liquid metal or glass filler is used to wet the surfaces to be joined. It is limited to the few metals, such as titanium and titanium-based alloys, which are capable of wetting oxide ceramics. Other processes have been developed for metallizing the oxide surface prior to electrodeposition, followed by conventional brazing. However, they are difficult and time consuming and require special, often inert gas atmospheres during all stages of the process. All of these bonds are unsuitable for use at high temperatures.

The process developed by the Division and Flinders University is by contrast relatively simple to carry out and leads to strong, leaktight bonds which retain their strength up to quite high temperatures, usually to within $100^{\circ}C$ of the melting point of the lower melting component. The bond can also be at least as strong as the materials from which it is made.

One of the most interesting applications of the reaction bonding process occurs in the field of temperature measurement. In many industrial processes, temperatures must be measured in surroundings which are both hot and corrosive. Such measurements are usually made with a thermocouple. To protect the thermocouple from attack by hot, corrosive vapours, it is usually encased in a ceramic sheath. These sheaths, however, have a disadvantage in many applications; they conduct heat relatively poorly, and thus slow the response of the thermocouple to changes in temperature. The Division has employed the reaction bonding process to make thermocouple sheaths in which ceramic tubes are fitted with an end-piece consisting of highly conducting and inert platinum foil. Because the foil is reaction bonded to the ceramic, the sheath can be used up to quite high temperatures and the response time for the temperature measurement is reduced from minutes (in the case of the traditional all-ceramic sheath) to seconds. Sheaths of this type have been used for temperature control in a fibreglass manufacturing plant and are now being manufactured and marketed commercially by an Australian company, Novatech Australia.

Other applications of the reaction bonding process developed by the Division include high-frequency heat 'sinks' for solid-state electronic devices and gas analysis probes for use in high-temperature environments such as furnace flues and metallurgical heat-treatment furnaces. Gas probes, of which the oxygen probe has perhaps the widest potential use, depend on the properties of solid electrolytes which are sensitive to the particular components of the atmosphere being monitored. For an oxygen probe, reaction bonding is used to attach zirconia (the solid electrolyte) to an alumina tube via a metallic foil which is usually platinum.

The heat 'sinks' are formed by reaction bonding a 'Kovar' or copper lead frame to a small pellet of beryllia which, in the same operation, is bonded to a copper mounting screw, thus completing the thermal path to the panel or chassis of the unit. Beryllia has the unique property of having a high thermal conductivity and high electrical resistivity. These devices won a Technical Excellence Award at the Fourth Annual World Fair for Technological Exchange at Atlanta, Georgia, U.S.A., in March 1979.

There can be no doubt that there are many more potential uses for the reaction bonding process, particularly in manufacturing industry, and that these will emerge as the advantages of the process become more widely known and as more information becomes available concerning the properties of bonds made with various materials.

## A New Voltage Standard

At very low temperatures, a number of remarkable electrical phenomena are observed. Of these, the occurrence of superconductivity—the complete loss of resistance—in certain metals is the most dramatic and best known. Other effects, known as Josephson effects, are observed when a weak link or a narrow barrier is set up between two superconducting metals. One of these, the a.c. Josephson effect, is observed when a potential (V) is established across such a junction between superconductors; it results in the establishment of an alternating current across the junction, with a frequency (f) given by

$$f = (2e/h)V$$

where e is the charge on the electron and h is Planck's constant.

The Division of Applied Physics was in the forefront of international efforts aimed at utilizing this effect as a standard of voltage and was the first laboratory to set up such a standard on a routine basis. The procedure has since been adopted as the International Standard.

Junctions used to observe the Josephson effect are of the point contact or evaporated-film type. A point contact junction is formed by pressing a niobium point against a flat niobium anvil, while an evaporated-film junction takes the form of a sandwich of two evaporated lead films separated by a very thin insulating barrier.

The junction is immersed in liquid helium at 4.2 K, at which temperature both niobium and lead are superconductors. If the junction is irradiated with microwaves of a known frequency, its current-voltage characteristic exhibits steps. The constant voltage portions of the steps occur whenever the junction frequency, that is, 'f' in the above equation, is a multiple of the frequency of the microwave source. By selection of step number and microwave frequency the output voltage of the junction can thus be set to any desired value, up to a few millivolts.

Since frequency can be measured with great precision, we have here, therefore, a very precise way of establishing a known voltage. Moreover, any reference voltage so produced is independent of gross variation in the junction materials and of the geometry and environment of the junction. In practice, the voltage of a conventional Weston reference cell is measured in terms of a specific Josephson oscillation frequency by precision voltage-balancing methods. The overall uncertainty involved in this procedure is only one part in 10 million. Secondary groups of cells are then calibrated against the reference cell and used as standards for normal testing and calibration purposes.

The most accurate modern digital instrumentation is now calling for voltages to be measurable with a precision approaching one part in 100 000 and a number of commercial measuring instruments exceed this capability. Their calibration therefore requires a standard no less precise than that provided by the Josephson effect.

In setting up the Josephson effect voltage standard, the Division has developed a new expertise which is enabling it to participate in and advise on various new applications of the phenomena of superconductivity. These have centred on the development of SQUIDS (short for superconducting quantum interference devices) or, more simply, superconducting magnetometers. A SQUID consists of a superconducting ring into which is incorporated a weak superconducting link, that is, a Josephson junction. SQUIDS have unparalleled sensitivity and are finding application in the study of low temperature phenomena, new electrical measurement systems, geophysical and geological investigation and medical research.

One such application in the measurement field is as a sensor in a novel superconducting current comparator, which originated in the Division. By the application of a new principle, this comparator achieves a thousandfold improvement in precision of current ratio over conventional comparators. In the medical area SQUIDS are being employed overseas as extremely sensitive magnetometers in studies of magnetic fields in the brain, heart and eye.

# 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 |
| 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, PhD |
| 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 |
| Fisheries and Oceanography | D. J. Rochford, BSc |
| Forest Research | M. F. C. Day, AO, PhD, FAA |
| Horticultural Research | J. V. Possingham, DSc, FTS |
| Irrigation Research | P. E. Kriedemann, PhD |
| Plant Industry | W. J. Peacock, PhD, FAA |
| Tropical Crops and Pastures | E. F. Henzell, DPhil, FTS |
| Wildlife Research | H. J. Frith, AO, DScAgr, FAA, FTS |

## INSTITUTE OF EARTH RESOURCES

| | |
|---|---|
| **Director** | R. J. Millington, PhD, FTS *(Acting)* |
| **Divisions** | **Chiefs** |
| Applied Geomechanics | D. F. Kelsall, PhD, FTS |
| Land Resources Management | R. A. Perry, MSc, FTS |
| Land Use Research | J. J. Basinski, MA *(Acting)* |
| Mineral Chemistry | D. F. A. Koch, PhD |
| Mineral Engineering | D. F. Kelsall, PhD, FTS |
| Mineral Physics | K. G. McCracken, DSc, FTS |
| Mineralogy | A. J. Gaskin, MSc |
| Process Technology | A. V. Bradshaw, BSc |
| Soils | A. E. Martin, DAgrSc |
| **Units** | **Officers-in-Charge** |
| Fuel Geoscience | D. J. Swaine, PhD *(Acting)* |
| Physical Technology | E. G. Bendit, PhD |

## INSTITUTE OF INDUSTRIAL TECHNOLOGY

| | |
|---|---|
| **Director** | Professor Emeritus H. W. Worner, 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 | J. Warner, BSc, BE |
| Computing Research | P. J. Claringbold, PhD |
| Environmental Mechanics | D. E. Smiles, DScAgr |
| Materials Science | J. R. Anderson, ScD, FAA |
| Mathematics and Statistics | J. M. Gani, DSc, FAA |
| Radiophysics | H. C. Minnett, OBE, BSc, BE, FTS, FAA |
| **Units** | **Officers-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 Section | 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)* |

## 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** | I. C. Bogg, BEc |

## PERSONNEL

| | |
|---|---|
| **Secretary** | K. J. Thrift, BA |

## 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, former Resident Director, Cadbury Schweppes Pty Ltd

**Chairmen of State Committees**

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

L. C. Brodie-Hall, CMG, AWASM, Director of mining companies (*Western Australia*)

K. E. Gibson, BSc, former Managing Director and Deputy Chairman, ACF & Shirleys Fertilizers Ltd (*Queensland*)

J. E. Harris, BEng, Managing Director, Adelaide & Wallaroo Fertilizers Ltd (*South Australia*)

J. E. Kolm, IngChemEng, Executive Director, ICI Australia Ltd (*Victoria*)

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

**Other members**

Professor L. M. Birt, CBE, DPhil, Vice-Chancellor, University of Wollongong

Sir Alan Cooley, CBE, BEngSc, (until 9 June 1980). Secretary, Department of Productivity

N. S. Currie, CBE, BA, Secretary, Department of Industry and Commerce

J. L. Farrands, PhD, FTS, Secretary, Department of Science and the Environment

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, Past President, United Graziers' Association of Queensland

Professor P. H. Karmel, AC, CBE, PhD, LLD, DLitt, Chairman, Tertiary Education Commission

J. C. Kerin, BA, BEc, MHR 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, 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

I. H. Smith, OBE, BCom, (until 20 June 1980), Deputy Secretary of Primary Industry

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

J. H. Garrett, CBE, BCom, 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 Chemicals Pty Ltd

D. G. Badger, PhD, Senior Manager, Reserve Bank of Australia

C. S. Barnes, PhD, Manager Research, CSR 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, FIE, FAIM, Industrial Consultant

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, MSc, Managing Director, Nethel Pty Ltd

T. C. Clark, AASA, ACIS (*Secretary*), Regional Administrative Officer, CSIRO, Sydney

### Queensland State Committee

K. E. Gibson, BSc (*Chairman*), former Managing Director and Deputy Chairman, ACF & Shirleys Fertilizers Ltd

G. I. Alexander, PhD, Deputy Director-General, Department of Primary Industries, Queensland

J. A. Allen, PhD, Chairman, Board of Advanced Education, Queensland

A. J. Allingham, Grazier

G. L. Baker, MSc, Deputy Director (Technical), Commercial and Industrial Development Department, Queensland

W. G. Hamilton, BSc, Personnel Manager, Consolidated Fertilizers Ltd

J. C. Rivett, ME, FAIM, Chairman, Gutteridge Haskins & Davey Pty Ltd

E. P. S. Roberts, CMG, Grazier

D. M. Traves, OBE, BSc, Consulting Geologist

Professor D. H. Trollope, PhD, DEng, Deputy Vice-Chancellor, James Cook University of North Queensland

H. N. Walker, MIEAust, Chief Engineer, Railway Department, Queensland

C. D. Williams, MAIMM, Research Manager, MIM Holdings Ltd

D. B. Thomas, BA (*Secretary*), Regional Administrative Officer, CSIRO Brisbane

### 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, Department of Economic Development, South Australia

Sir Ben Dickinson, MSc, Company Director and Mining and Energy Consultant

J. M. Kerin, JP, United Farmers and Stockowners' Association of South Australia Inc.

M. Knapman, General Manager Corporate Engineering, Simpson Pope Ltd

J. C. McColl, MAgrSc, Director-General of Agriculture, South Australia

Professor J. P. Quirk, DSc, FAA, Director, Waite Agricultural Research Institute

K. J. Shepherd, ME, Director of Planning, Engineering and Water Supply Department, South Australia

P. M. South, BSc, DipFor, Director, Woods and Forests Department, South Australia
I. E. Webber, MAutoEng, Deputy Chairman, Chrysler Australia Ltd
B. W. Bartlett, AASA (*Secretary*), Divisional Secretary, Division of Human Nutrition, CSIRO

### 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. E. Caro, OBE, PhD, LLD, Vice-Chancellor, University of Tasmania
M. C. P. Courtney, Editor, Launceston 'Examiner'
R. J. Downie, Grazier
P. J. Fountain, BSc, Department of Agriculture, Tasmania
A. G. Kemp, AASA, Director, Kemp & Denning Ltd
J. B. Piggott, CBE, LLB, Chairman of Law Reform Commission, Tasmania
J. G. Symons, BE, Director of Mines, Tasmania
P. T. Unwin, DipFor, MIFA, Chief Commissioner for Forests, Tasmania
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

### Victorian State Committee

J. E. Kolm, IngChemEng (*Chairman*), Executive Director, ICI Australia Ltd
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, Railways Board, Victoria
R. Gottliebsen, Assistant Editor, Australian Financial Review
Professor K. H. Hunt, FTS, MA, Professor of Mechanism, 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, Chairman, West Gate Bridge Authority
L. M. 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

### Western Australian State Committee

L. C. Brodie-Hall, CMG, AWASM (*Chairman*), Director of mining companies
E. N. Fitzpatrick, MAgSc, Director, Department of Agriculture, Western Australia
E. R. Gorham, BE, Coordinator, Department of Industrial Development, Western Australia
R. M. Hillman, BEng, Director of Engineering, Public Works Department, Western Australia
R. D. Ireland, MBE, AASA, Chairman and Managing Director, Millars (WA) Pty Ltd
J. B. Kirkwood, FInstEngsA, FTS, Commissioner, State Energy Commission, Western Australia
J. R. de Laeter, PhD, Dean of Applied Science, Western Australian Institute of Technology
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

CSIRO Annual Report 1979/80

# Distribution of Research Effort

The central circle shows the breakdown of CSIRO's total research effort into four main sectors. In the first ring the sectors are broken down into sub-sectors, and in the second ring into research areas. The outermost ring shows the programs being undertaken in CSIRO Research Divisions and Units. The letters shown after each research program refer to the Divisions and Units carrying out the research (see key at right) and the numbers refer to professional staff involved. For further details about these programs see the directory 'CSIRO Research Programs 1979-80'.

The angle of arc in research sectors, sub-sectors and research areas represents the percentage of the Organization's total research effort, measured on the basis of the number of professional staff in any given area. For the distribution of research effort on the basis of funds expended, see Table 1 in this Report.

KEY

AC Applied Organic Chemistry – Institute of Industrial Technology
AG Applied Geomechanics – Institute of Earth Resources
AH Animal Health – Institute of Animal and Food Sciences
AN Australian Numerical Meteorology Research Centre – Institute of Physical Sciences
AP Animal Production – Institute of Animal and Food Sciences
AS Applied Physics – Institute of Physical Sciences
AT Atmospheric Physics – Institute of Physical Sciences
BR Building Research – Institute of Industrial Technology
CL Cloud Physics – Institute of Physical Sciences
CP Chemical Physics – Institute of Physical Sciences
CR Computing Research – Institute of Physical Sciences
CS Central Information, Library and Editorial Section – Bureau of Scientific Services
CT Chemical Technology – Institute of Industrial Technology
EM Environmental Mechanics – Institute of Physical Sciences
EN Entomology – Institute of Biological Resources
FD Food Research – Institute of Animal and Food Sciences
FG Fuel Geoscience Unit – Institute of Earth Resources
FO Fisheries and Oceanography – Institute of Biological Resources
FR Forest Research – Institute of Biological Resources
HN Human Nutrition – Institute of Animal and Food Sciences
HR Horticultural Research – Institute of Biological Resources
IR Irrigation Research – Institute of Biological Resources
LM Land Resources Management – Institute of Earth Resources
LU Land Use Research – Institute of Earth Resources
MA Mathematics and Statistics – Institute of Physical Sciences
MC Mineral Chemistry – Institute of Earth Resources
ME Mechanical Engineering – Institute of Industrial Techuiology
MI Mineral Engineering – Institute of Earth Resources
MP Mineral Physics – Institute of Earth Resources
MS Materials Science – Institute of Physical Sciences
MT Manufacturing Technology – Institute of Industrial Technology
MU Molecular and Cellular Biology Unit – Institute of Animal and Food Sciences
MY Mineralogy – Institute of Earth Resources
PC Protein Chemistry – Institute of Industrial Technology
PI Plant Industry – Institute of Biological Resources
PT Process Technology – Institute of Earth Resources
PU Physical Technology Unit – Institute of Earth Resources
RP Radiophysics – Institute of Physical Sciences
SL Soils – Institute of Earth Resources
TC Tropical Crops and Pastures – Institute of Biological Resources
TI Textile Industry – Institute of Industrial Technology
TP Textile Physics – Institute of Industrial Technology
WR Wildlife Research – Institute of Biological Resources
WU Wheat Research Unit – Institute of Animal and Food Sciences