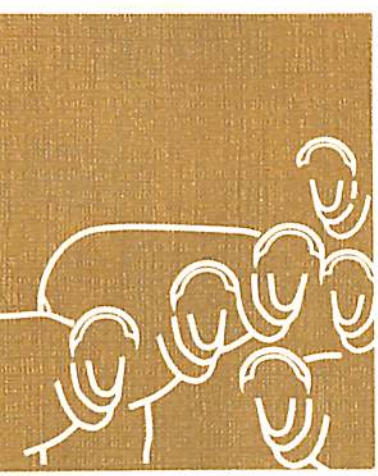
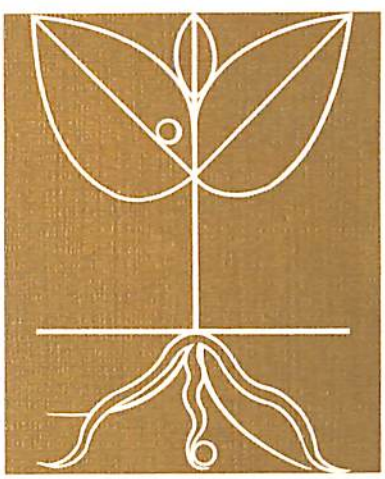
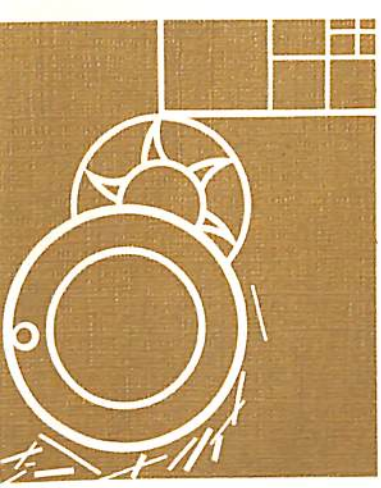
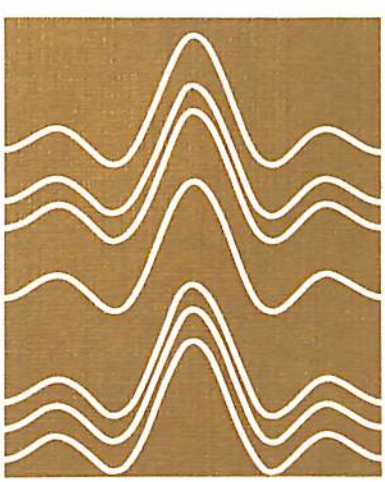
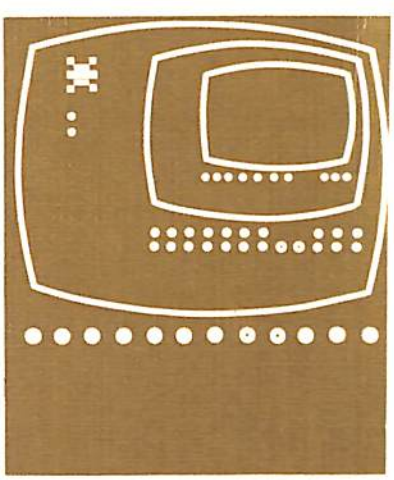
CSIRO

ANNUAL REPORT 1981/82

Commonwealth Scientific and Industrial Research Organization

ERRATUM

CSIRO Annual Report 1981/82

In Chapter 7 of this report (which is entitled 'Minerals', and appears on pages 73 and 74) the text of an agreement between the Chairman of CSIRO and the Secretary of the Department of National Development and Energy should have been reproduced verbatim. An abbreviated version appears on those pages. The text of the actual agreement is as follows:

RATIONALIZATION OF MINERALS (EXPLORATION) RESEARCH BETWEEN BMR AND CSIRO

Following the Government's decisions confirming CSIRO's national strategic research role and BMR's enhanced role in geoscience research, the activities of both bodies have been examined. In view of the great importance of the mineral industry to the Australian economy and the relatively low level of the total research effort, there is a clear need for the complementary research activities of the two organizations to continue in accord with their traditional roles and recent Government decisions relating to them. The expectation of industry and State Governments also needs to be taken into account.

BMR's research has been, and will continue to be, developed from the perspective of regional studies in order to provide the geoscientific basis for the development of successful exploration programs by private industry.

Thus, research into mineralization and the formation of ore bodies, and into the occurrence and genesis of fossil fuels, including the application of all available techniques to geological problems, is central to BMR's role and should be primarily BMR's responsibility. CSIRO will appropriately collaborate with BMR in areas where such studies are especially relevant to the development of exploration techniques.

While the development of exploration techniques is also appropriate to BMR's role, it is recognized that CSIRO has established itself strongly in this area particularly through its Division of Mineral Physics. Research into the initiation and development of instrumental techniques, both geochemical and geophysical, to assist the exploration industry in the search for ore deposits, will continue to be primarily the role of CSIRO for the foreseeable future, but with the collaboration of BMR as appropriate. BMR will in particular, collaborate with CSIRO in the development and testing of techniques as an adjunct to its regional studies.

It is recognized that it will take BMR several years to develop its research role fully and that it will take CSIRO several years to re-order its priorities and programs in accord with this functional rationalization. It is also recognized that there will be some inevitable and desirable overlap in the broad fields of interest of the two organizations as identified above. Accordingly, a Minerals (Exploration) Research Liaison Committee (MERLCO) was established in May 1982, with terms of reference and membership as in Attachment I* for the purpose of facilitating the rationalization process. The consultative mechanism represented by MERLCO will prevent duplication of effort and will allow research in areas of legitimate mutual interest to be tackled through collaborative projects.

*Attachment I reads as follows:

MINERALS (EXPLORATION) RESEARCH LIAISON COMMITTEE (MERLCO)

TERMS OF REFERENCE

(1) To propose the mechanisms and the timetable of functional rationalization in the light of the functional rationalization and demarcation guidelines agreed between BMR and CSIRO.
(2) To examine proposed research programs before they are implemented, in order to avoid overlap and to promote cooperation.
(3) To report annually (and at other times if necessary) to the Chairman of CSIRO and the Secretary, Department of National Development and Energy on appropriate action arising from the discussions in (1) and (2).

MEMBERSHIP

Director, Bureau of Mineral Resources	Director, Institute of Energy and Earth Resources, CSIRO
Chiefs of Divisions of:	CSIRO Chiefs of Divisions of:
Continental Geology, Petrology and Geochemistry Geophysics	Mineral Physics Mineralogy Fossil Fuels.

Commonwealth Scientific and Industrial Research Organization, Australia

CSIRO Annual Report 1981/82

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COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

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

The Executive of CSIRO has pleasure in submitting to you, for presentation to Parliament, its thirty-fourth annual report, which covers the period 1 July 1981 to 30 June 1982. 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
S.B. Myer
G.H. Taylor
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

Outside the communication industry there can be few organizations in Australia which are as ubiquitous as CSIRO. This is illustrated by the map enclosed at the back of this Report; it shows where CSIRO Divisions, field stations and operations are located and indicates the geographical distribution of programs conducted on behalf of industry and other community interests. It demonstrates that we are truly a national organization.

It is not uncommon for communities within Australia to bring to our attention the desirability of a more visible CSIRO presence in their area. This applies especially to the more distant communities isolated from the centroid of the national population. The Executive of CSIRO recognizes the substance and validity of such representations and strives to balance geographical distribution with the need for optimization of the yield from the research dollar.

Recent examples involving decentralization are the establishment of the Division of Tropical Animal Sciences in Queensland, the decision to establish the Marine Laboratories in Hobart and the establishment in Adelaide of a unit to develop micro-electronics. There has also been a redistribution of effort in Perth and an increase in effort is foreshadowed there in the near future.

On the other hand, there are often benefits of scale in geographical concentration of effort. Furthermore, research undertaken at place A may be of as much value to the community (or industry) at place B, 2,000 km from A, as to the community in the neighbourhood of A. The needs of a community, not a location, are being met. Misunderstandings between the roles of location and community may also occur in other fields of human endeavour. For instance, Law 3 of the Laws of Cricket reads 'two umpires shall be appointed, one for each end'. Neville Cardus wrote of the village umpire who had but one shortcoming: he had accidentally misread this law as 'one for each side'.

As was emphasized in last year's annual report, CSIRO is in a continuous state of change and redeployment of effort into programs of high national priority. The year 79/80 will be remembered especially for a new focus on manufacturing technology and marine science; 80/81 on energy and the northern cattle industry; and 81/82, the year of this report, on the vital and interrelated areas of water, land and soil research. In these fields

there has been a series of penetrating reviews and re-organizations, including the formation of a new Division of Water and Land Resources in Canberra (in place of the former Division of Land Use Research) and a Division of Groundwater Research in Perth (in place of the former Division of Land Resources Management), while a Centre of Irrigation Research has been formed at Griffith in place of the Division of that name.

Another major development of the year was the completion of a review of the broad field of agriculture. This review has fully involved the extensive machinery available to the Organization including the Planning and Evaluation Advisory Unit, the Advisory Council, State Committees and the research Institutes and Divisions. We also enjoyed the full co-operation of the Bureau of Agricultural Economics, the Commonwealth Department of Primary Industry, State agricultural departments and representatives of the agricultural industry. The findings are given in this report (Chapter 3). It is the first such review to be completed. Next year we hope to report similarly on the broad sector of manufacturing industry.

The history of this Organization, which began in 1926, has been marked by two major watersheds involving legislative change following extensive Government scrutiny. These occurred in 1949 when the Science and Industry Research Act was proclaimed and when CSIR gained an O on the end of its acronym; and in 1978 when the Act was changed following an Independent Inquiry under the Chairmanship of Professor Arthur Birch. It is now (June 1982) nearly 5 years since the Inquiry reported and 3½ years since we began operation under the amended Act; a review of the way in which we have responded to the new era forms the first chapter of this report. Considerable changes were prescribed by the Government, e.g. extended and more independent advisory and planning machinery; a greater sense of accountability; increased delegation down the line; and a new form of Executive and management structure. I believe all these changes have been shown by experience to have been wisely conceived and we are grateful to those responsible.

I wish to draw special attention to a thread that runs through the Birch Report. That is the principle that the CSIRO Executive should be allocated annually an agreed amount of directly appropriated funds and then be left to get on with the business of managing those funds to yield the maximum national benefits with the minimum of external interference. We strongly approve of this whole concept, subject to the need for the Government to make additional allocation for major new initiatives which it wishes to support. The Government has made commendable progress along the recommended path by introducing a 'global' budget for the Organization. Thus, for instance, we already have superannuation funds directly appropriated to us and may soon have funds for buildings and works directly under our control.

The Executive in turn applies a similar principle to the management of funds in Institutes and Divisions—each is given an allocation and told to get on with the job of making best use of it, subject to broad priorities and general guidelines. The principal constraint that the Executive applies is an insistence that the ratio of operating funds to salary funds (typically 30:70) is not allowed to fall too low; for if that were to happen decline would set in as surely as night follows day. Thus, if financial cuts are imposed by the Government or if inadequate allowance is made for inflation on operating funds (as has often happened in recent budgets) staff numbers must be decreased.

In spite of progress towards a global budget and an acceptance of the principle that all the various requirements of CSIRO should compete with one another, unnecessary constraints remain; some irritate, others do harm. Thus, the application of external controls over matters like staff ceilings and overseas visits are now totally unnecessary under these competitive conditions. I also believe that we should have greater flexibility to introduce early retirement suited to our own requirements: any population of research scientists should preferably include a strong component of youth.

It is probably true to say that the most significant outcome of the Inquiry and Government decisions was aimed at conservation rather than change. The Government gave us a resounding re-affirmation of our role as its principal strategic research organization. The Executive was to determine the policies and research priorities of the Organization and to report to Parliament annually. Furthermore, our Minister could, as a last resort, give a research policy directive to the Executive, such directive to be published in the annual report. I am glad to say that no Minister responsible for CSIRO has found it necessary to exercise this power of direction.

I believe the outstanding success of CSIRO in comparison with government research institutions of other countries stems from the wisdom of successive Commonwealth governments in ensuring that two basic requirements were satisfied. Firstly, the governing body of the Organization should consist of full-time members who are scientists and part-time members who are industrialists and community representatives. Secondly, the Executive (nowadays aided by an Advisory Council on which Government departments, industry and community interests are powerfully represented) should be fully responsible and accountable to Parliament, through the Minister, without the interposition of a Government department. The latest affirmation of this resolve was made in the Parliament by the then Minister when the 1978 Government decisions were announced:

> 'The findings of the Independent Inquiry into CSIRO have vindicated this Government's practice of minimizing bureaucratic influence on scientific research'.

From this basis we co-operate widely, harmoniously and in our own right with all relevant Government departments. We have also established consultative machinery to ensure that we take account of Government policies and that our activities are well co-ordinated with those of other agencies.

Scientific research must be excellent to be worthwhile and needs a very special environment. We look to the Parliament to maintain the same degree of independence and *accountable* freedom that we have thrived on since the days of Sir David Rivett, who passionately fought for these conditions.

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, which is reported on in the section entitled Advisory Council and State Committees.

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

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

The statement of research objectives and resources is presented in Chapter 2. The initial statement of general policies relating to research appeared in the 1978/79 CSIRO Annual Report. Policies relating to specific areas of research which were developed during 1981/82 appear in Chapters 3-9 of this Report.

1. Overview of changes: 1977-1982

The past five years have seen significant internal and external developments relating to CSIRO. Most of the important events in the period have been described in annual reports but, individually, these items do not convey the total picture. This chapter presents an overview of the changes and the reasons for them.

A strong influence during this period was the Independent Inquiry into CSIRO. Interaction with the Committee of Inquiry itself was followed by the implementation of some 120 decisions made by the Government on the Committee's recommendations. Almost all of these decisions endorsed the recommendations and many were subsequently embodied in the Science and Industry Research Amendment Act 1978. The remaining decisions have now all been acted upon and, to mark this, the chapter includes a summary of actions taken to implement the Government's decisions.

CSIRO's Role

A most important development relates to CSIRO's main role. CSIRO (as CSIR) began more than fifty years ago with a clear, coherent mission. Australia lacked a research infrastructure and its industries needed a strong injection of science and technology. Agriculture obviously had top priority, and an agreement on a division of labour with State Departments of Agriculture (which has recently been re-affirmed—see Chapter 3) was reached. Industrialization in the 1930s and 1940s stimulated a major expansion into research for secondary industries, and CSIRO entered the post-war period divested of responsibility for defence research but otherwise with a charter to undertake research in support of a wide range of industries and with an expanding role in support of other community interests.

Questioning of the Organization's role started in the late 1960s and increased in the 1970s. Debate on the proper role of government in Australia's market economy sharpened with the growing sophistication of Australia's public and private sectors. The application of Lord Rothschild's 'customer-contractor' principle to scientific research in the UK raised the question of whether a single independent statutory authority was the appropriate vehicle for meeting the Commonwealth's general responsibilities for scientific research. The creation of a science council (now the Australian Science and Technology Council, ASTEC), a department having special responsibility for science (now the Department of Science and Technology), and an alternative research institute for marine

science (the Australian Institute of Marine Science, AIMS) raised the question of whether CSIRO should leave to others the tasks both of planning national research strategies and making institutional arrangements for carrying them out. The maturing of the research capacities of universities and large sections of industry raised the possibility that they, rather than CSIRO, might be the best instruments for carrying out significant parts of the nation's public-interest research requirements.

By this time CSIRO had also assumed responsibility for a range of technical development and consulting service activities associated with its research, and realized that a choice had to be made between two divergent paths for its future development. Either it should increase its commercial activities, such as contract research, so that the Organization would become self-financing, or it should concentrate on work which it was appropriate for the Commonwealth to fund and perform. This choice had to be made in the context of the economic and political environment that had taken shape in the 1970s and appeared likely to remain.

In the wake of the Independent Inquiry, most of these uncertainties have been resolved. CSIRO's main role is now clearly recognized as being the planning and execution of general research required by the Commonwealth on behalf of industry, the community and other national and international interests of Australia. Exceptions include research relating to or involving defence, nuclear science, clinical medicine and other areas concerned with the operational responsibilities of certain Commonwealth instrumentalities. Even with these exceptions, however, the scope of CSIRO's responsibilities remains very broad. CSIRO has a statutory responsibility to plan its own work in cooperation with other bodies so that Australia's national research effort is properly coordinated. To discharge this responsibility across the whole of its wide research charter, CSIRO must develop strategies for research in all areas except those for which others have exclusive responsibility.

An important response to this mandate has been the institution of strategic research planning. This involves the examination, sector by sector, of national research requirements in terms of their economic and social importance and their scientific viability, and the setting by the Executive of broad priorities for research in these sectors. The process involves detailed consultation with all interested parties: industries, State government agencies, Commonwealth agencies, the tertiary education sector and representatives of other community interests. This and related processes are considered later in this chapter under the heading 'External Relationships'.

It follows from CSIRO's main role that the Organization's principal activity should be strategic research. This kind of research is characterized by both its purpose and the nature of the work involved. The purpose is to create an opportunity or to solve a

problem of national significance, and the work involves the investigation of major scientific unknowns or the application of advanced scientific knowledge. It is these characteristics that make strategic research particularly appropriate to be funded and performed by the Commonwealth.

Fundamental and tactical research are also undertaken by CSIRO in appropriate circumstances. Fundamental research, such as radio astronomy or basic studies of native flora and fauna, is undertaken where Australia has a national or an international responsibility to carry out the work. Tactical research, which differs from strategic research in that the problems are usually better-defined and the technology more widely understood, is undertaken where public concerns, such as the physical environment or human nutritional health, are involved, or in support of industry. In the latter case, however, CSIRO must ensure that it does not overstep boundaries set by general understandings about the respective roles proper to the public and private sectors in Australia, particularly where work involves the use of Commonwealth funds. This usually means that CSIRO should encourage industry to take over the further development of its research at the earliest opportunity, and should promote technological self-sufficiency in industry, including the fostering of commercial consultancies and the establishment of new ones.

CSIRO is progressively reviewing and, where necessary, reorienting its research activities to bring them into line with its main role. This is considered later in this chapter under the heading 'Research'.

Management

CSIRO was restructured following the passage of the Science and Industry Research Amendment Act 1978.

The number of full-time members of the Executive was reduced to three, and the number of part-time members increased to five. The latter are drawn from primary, secondary and tertiary industries, and from the tertiary education sector. The Chairman, who must be a full-time member, also became *ex officio* the chief executive of the Organization, responsible for its day-to-day operation to the Executive.

The Executive now operates principally as a policy board. Policy options for Executive consideration are developed by a range of people within the Organization, depending on the subject matter, and these are normally transmitted to the Executive by an Executive Committee, together with a recommended course of action. The latter body comprises the three full-time members of the Executive and the Directors of the Organization. This arrangement, and revised responsibilities for line management, have freed the Executive from dealing with much of the day-to-day

business of CSIRO and allowed it to concentrate on strategies for meeting the needs of Australia in the 1980s and beyond.

The 1978 Act also required the creation of up to six Institutes to manage CSIRO's research. Five such Institutes have been formed by grouping together Divisions and independent Units with related research interests. Each Institute is headed by a Director who is responsible to a nominated full-time member of the Executive for the effective and efficient running of his Institute. Chiefs and Officers-in-Charge (OICs) in turn are responsible to their Director for the effective and efficient running of their Divisions and Units. This chain of devolved responsibility is designed to ensure that decisions about the deployment of resources are taken, as far as possible, within Divisions and Units. This way of working is essential to the continuance of the highest standards of research within CSIRO. It does mean, however, that special care must be taken with the formulation of research policy guidelines within which discretions may be exercised. On one hand, they must be broad enough to allow research scientists to respond creatively to opportunities as they arise during the course of projects. On the other hand, they must be specific enough to ensure that resources are being deployed into projects having the highest national priority.

These guidelines are formulated through a variety of processes. At the highest level, strategic research planning provides broad policies and priorities. These will be translated directly into programs by Directors, Chiefs and OICs, and will also guide subsequent subject, Divisional and program reviews. In addition, the Executive each year approves priority areas for expansion, and areas in which research should be reduced or terminated, and these decisions feed into the design of annual budgets within the Organization.

The complexity of the issues involved in determining and updating a research strategy as wide as CSIRO's requires considerable internal consultation. Achieving this level of consultation without unnecessary duplication has been greatly facilitated by the workings of Institute committees, comprising the Director and his Chiefs and OICs, and of the Executive Committee, mentioned earlier.

Two further major elements in the restructured CSIRO are the Planning and Evaluation Advisory Unit (PEAU) and the Bureau of Scientific Services, each of which is headed by a Director. The Bureau carries out certain of CSIRO's non-research functions and also provides centralized professional support services to Divisions and other elements of the Organization. Technology transfer is seen as an integral part of each research program in CSIRO, and the Bureau has a special role in assisting Divisions to carry out this function. Other activities include the publication of scientific journals, the provision of library, information and public communication services, and support for international scientific activities including development aid. PEAU assists the Executive with

strategic research planning and provides economic analyses to Chiefs, Directors and committees of review, as required.

Administrative support services for all levels of management within the Organization are provided by officers responsible directly to line managers, that is, Chiefs, Directors and the Chairman in his capacity as chief executive. As mentioned, the Executive wishes to ensure that responsibility for the effective and efficient use of resources is devolved as far as practical to Chiefs, through Directors. To assist in this, and to promote greater efficiency in the use of administrative resources, the Executive has established a top-level working group to formulate a new administrative plan for the Organization. The implementation of such a plan is intended to be the final step in the adaptation of the Organization to the revised structure introduced by the 1978 amendments to the Act.

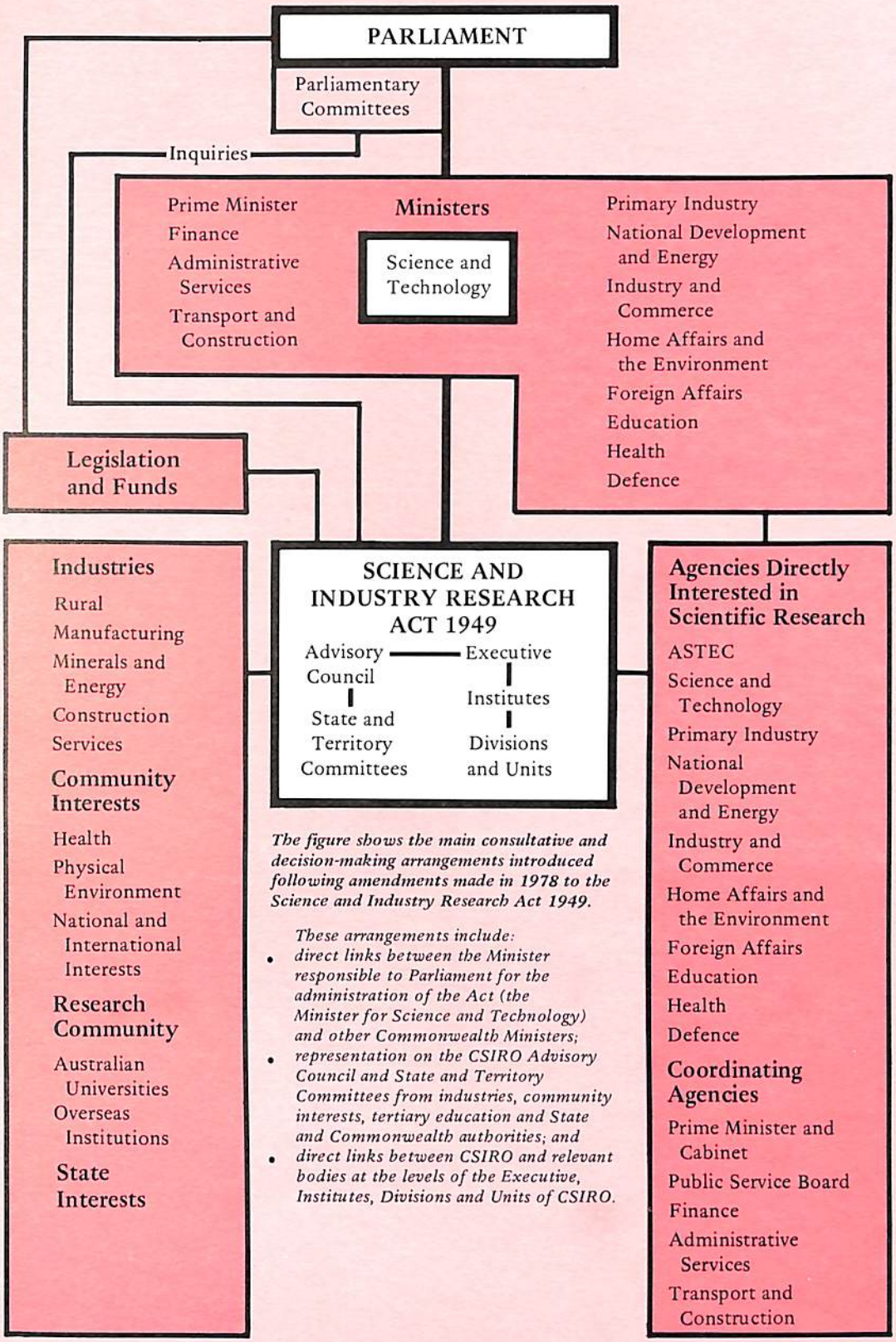
The internal structure of CSIRO is described further in Chapter 11.

External Relationships

Following the Independent Inquiry, the Government decided that revised consultative and decision-making arrangements should apply to CSIRO. Some of the arrangements were embodied in the 1978 amendments to the Science and Industry Research Act 1949, and the overall scheme is shown diagrammatically in the figure overleaf. While the inter-relationships appear rather complex, they are necessary to complement the philosophy underlying the new arrangements. The philosophy is that it is better to use a single, independent statutory authority to carry out the Commonwealth's strategic research than to have a multiplicity of special-purpose agencies. Inherent in this decision is the need to involve all relevant Commonwealth ministries and a wide range of State government, industry and community interests in the decision-making processes leading to the establishment of research priorities by the Executive.

The CSIRO Advisory Council and its supporting State Committees are key components in this broad decision-making structure. CSIRO and the Council have agreed that the Organization's strategic research planning process should be the principal vehicle for Council's advice on research policies and priorities. The Council has established standing committees for each of the major segments of the CSIRO Classification of Research, and these committees collaborate with PEAU in refining options until the final and more formal stages of interaction are reached. The latter are reported in CSIRO's annual reports (see Chapter 15).

State Government departments, industries and other community interests are also consulted widely by Divisions and Institutes in the formulation and conduct of research programs, and by the committees of review which are set up to look at every area of CSIRO's work on a regular basis. These committees



The figure shows the main consultative and decision-making arrangements introduced following amendments made in 1978 to the Science and Industry Research Act 1949.

These arrangements include:

- *direct links between the Minister responsible to Parliament for the administration of the Act (the Minister for Science and Technology) and other Commonwealth Ministers;*
- *representation on the CSIRO Advisory Council and State and Territory Committees from industries, community interests, tertiary education and State and Commonwealth authorities; and*
- *direct links between CSIRO and relevant bodies at the levels of the Executive, Institutes, Divisions and Units of CSIRO.*

normally comprise a majority of non-CSIRO members drawn from user-interests in Australia and from the top scientists in the field internationally.

The 1978 amendments to the Act also adjusted the formal relationship between CSIRO and the Minister responsible to Parliament for the administration of the Act. Previously, all of the statutory functions of the Organization had been subject to the approval of the Minister, giving the Minister very wide powers over its affairs. Following the Independent Inquiry, the Government decided that ministerial powers of direction over the Organization should be restricted to specific matters, placing greater responsibility for programs on the Executive. Any exercise of these ministerial powers is required to be reported in the Organization's annual report.

Prior to the Inquiry, CSIRO had a number of ad hoc liaison mechanisms with other agencies, but these were not sufficient to allow CSIRO's independent research role to take full account of government policies and priorities. Relationships between CSIRO and certain government departments and other agencies were strengthened by the appointment of the heads of these agencies to the CSIRO Advisory Council. This relationship is backed up where necessary by formalized liaison mechanisms, some at ministerial level, between CSIRO and other ministries and agencies. These agencies include ASTEC, the advisory structures supporting the Australian Agricultural Council and related bodies administered by the Department of Primary Industry, the Department of National Development and Energy and its Bureau of Mineral Resources, Geology and Geophysics (BMR), the Department of Health, the Australian Development Assistance Bureau and the National Library of Australia. In addition, there is liaison with the Department of Science and Technology on a range of matters including manufacturing industry, marine science and astronomy.

The Government accepted the Inquiry's recommendation that the respective roles of CSIRO and the Bureau of Meteorology, the BMR, the Australian National Parks and Wildlife Service, State museums and the Australian Biological Resources Survey should be defined and rationalized. Where necessary, joint reviews have been carried out by CSIRO and the appropriate agencies and new arrangements introduced.

Following the review of the Australian Numerical Meteorology Research Centre (ANMRC), arrangements to rationalize CSIRO's atmospheric research activities with those of the Bureau of Meteorology were agreed upon. Under these arrangements, the ANMRC will be closed when the current agreement expires in 1985 or at such earlier time as is agreed, and the resources will be redeployed within the Bureau and CSIRO. CSIRO and BMR have agreed to a rationalization of minerals exploration research. The establishment of a high level consultative committee will facilitate the rationalization process and promote cooperation between the

Organization and BMR. These developments are described more fully in Chapters 7 and 9.

An examination of the respective roles of CSIRO and the Australian National Parks and Wildlife Service, State museums and the Bureau of Flora and Fauna (previously the Australian Biological Resources Survey) has revealed no undesirable overlaps. These bodies have specific non-research functions and, where appropriate, enter into special agreements with CSIRO to carry out tactical research on their behalf. CSIRO also carries out its own strategic research related to Australia's flora, fauna and natural environment. With the support of all the agencies concerned, it also continues to maintain three major Australian biological collections covering plants, insects and wildlife.

Relationships with Tertiary Educational Institutions

Following decisions made by the Government that CSIRO should collaborate more actively with universities, CSIRO and the Australian Vice-Chancellors' Committee formed a committee in 1979 to identify broad areas in which interaction between CSIRO and universities might be enhanced. Following this, CSIRO and the Australian National University have recently agreed to fund a group of joint research projects, with each party contributing $50 000 p.a. to these projects. Proposals involving other universities are under consideration.

For many years it was CSIRO's practice to establish a proportion of laboratories within the grounds of universities. In recent times, however, pressure for space within universities has grown and CSIRO laboratories have been removed from university grounds and sited adjacent to universities. This policy continues to provide the advantage of easy collaboration between research workers from CSIRO and universities.

CSIRO and the Australian Vice-Chancellors' Committee are together exploring ways of establishing a more active staff interchange program between CSIRO and universities. Similar discussions with colleges of advanced education and technical and further education colleges have begun.

Research

To ensure that CSIRO's research effort conforms with the Organization's main role and that resources are deployed optimally, the Executive has reinforced its program of reviews. Since 1977, nearly all Divisions and Units have either been reviewed or are at present under review. These reviews have led to the closure of some Divisions, such as the Divisions of Mechanical Engineering and Irrigation Research, and the formation of new Divisions, such as the Divisions of Tropical Animal Science,

Groundwater Research, and Water and Land Resources. Broader reviews, for instance those concentrating on energy and manufacturing industry, have also led to the formation of new Divisions, such as the Divisions of Fossil Fuels and Manufacturing Technology.

The first of the Organization's strategic research planning studies, relating to agriculture, was completed this year and is reported in Chapter 3. Research in support of Australia's present and potential manufacturing industries was the subject of special recommendations by the Independent Inquiry. Some of these led to relatively straightforward actions, such as the transfer away from CSIRO of responsibility for funding research associations, the Standards Association of Australia and the National Association of Testing Authorities. Other recommendations, however, raised questions of principle about the appropriate role for the Commonwealth in this area. Particular policy problems relate to industries in which new technologies are kept confidential because they are central to the competitive position of individual firms. These and related problems are being considered in a second strategic research planning study which it is hoped will be reported in the 1982/83 CSIRO Annual Report. Studies in this series will focus on the balance of priorities between comparatively broad areas of research within an industry or community interest sector, and the outcomes will guide subsequent Divisional, subject and program reviews as well as day-to-day decision-making by Directors, Chiefs and leaders of research programs.

The effects of all these review processes on individual Divisions and programs may be found in Divisional reports and the annual reports of Institutes and CSIRO. The cumulative effect has been a greater emphasis on strategic research and a concentration of resources in higher impact programs. This policy of selective concentration has been implemented during a period of severe resource constraint, which has affected the rate at which progress can be made.

Staff vacancies are usually the main source of resources for redeployment, but externally imposed reductions in staff ceilings have first call on these resources, and the general economic environment has led to a reduction in staff turnover. Despite these constraints, considerable progress has been made. In particular, research to meet Australia's energy requirements in the face of diminishing reserves of liquid fuel, and research to help Australian manufacturing industry adapt to modern production techniques, have been increased significantly. Shifts in the distribution of CSIRO's research effort are now reported regularly in the Organization's annual report (see Chapter 2).

The Division of Applied Physics (formerly the National Measurement Laboratory) was the subject of specific recommendations by the Independent Inquiry. The Government accepted a recommendation that the Division should continue as the custodian of the national standards of measurement but that

consideration should be given to extending the Division's standards work to other areas such as safety, pollution and performance standards. However, following a review of the Division, the Executive decided that its work should not be extended to the formulation of non-physical standards because such work is the responsibility of other agencies and, to the extent that it requires research support from CSIRO, this is better carried out by other Divisions with the appropriate expertise. CSIRO advised the Minister of this decision in June 1979. The establishment of branch laboratories of the Division of Applied Physics in Adelaide and Melbourne, following a recommendation of the Inquiry, allows for better dissemination of the Division's expertise to the main centres of manufacturing industry in Australia.

Provision of Information and Implementation of Research Results

As mentioned earlier, the Government accepted a number of recommendations by the Independent Inquiry relating to the confirmation of CSIRO as the Commonwealth's national research organization. One of these recommendations was a requirement that CSIRO should set out its policies relating to research objectives and priorities for the purpose of regular Parliamentary and public scrutiny. Since 1978/79, the CSIRO annual report has concentrated on reporting matters of legislation, policy, organization and the allocation of resources, and Institutes have produced their own annual reports in which research results are presented more comprehensively than would be practical in a single report. In addition, detailed research policy statements will be published following Executive decisions on strategic research planning studies.

A detailed 'Directory of CSIRO Research Programs' is also published annually.

A joint review of the Australian Journals of Scientific Research by CSIRO and the Australian Academy of Science led to a decision to continue the arrangement under which CSIRO publishes the journals. A report of the review was included in the 1979/80 CSIRO Annual Report.

A review of the CSIRO information and library services, as recommended by the Inquiry, is also nearing completion.

The amended Science and Industry Research Act directs that CSIRO should 'encourage or facilitate the application or utilization of research', 'make available to a person on such conditions and on payment of such fees or royalties . . . a discovery, invention or improvement of the Organization' and that CSIRO may 'join in the formation of a partnership or company for the purpose of the commercial development of a discovery, invention or improvement, the property of the Organization'. In accordance with these functions and powers, it is Executive policy to take positive steps to encourage and facilitate the use of CSIRO's research wherever

possible. A full policy statement on the Organization's current policies, strategies and procedures relating to the use of its proprietary rights was included in the 1978/79 CSIRO Annual Report. Also, a review of CSIRO's commercial activities has recently begun.

International Relations

One of the functions of CSIRO under the Act is that the Organization should 'act as a means of liaison between Australia and other countries in matters connected with scientific research'. For many years CSIRO was responsible for the Australian Scientific Liaison Offices in London and Washington, and more recently, Tokyo and Moscow (when operational). The Independent Inquiry found that these offices were of considerable value. However, following the Ministerial Review of Commonwealth Functions in 1981, the London and Washington Scientific Liaison Offices were closed and the responsibility for the other offices was transferred to the Department of Science and Technology (see Chapter 10).

Following the Independent Inquiry, a Centre for International Research Cooperation (CIRC) was established in 1978. The Centre provides a focal point for CSIRO's research support for developing countries and is also responsible for planning and evaluating CSIRO's contribution to the science and technology component of Australia's assistance to less developed countries. It does this in consultation with the Australian Development Assistance Bureau of the Department of Foreign Affairs. CSIRO also contributed to the establishment of the Australian Centre for International Agricultural Research and looks forward to fruitful cooperation with that body.

Staff and Financial Policies

The Government reaffirmed the role of CSIRO as a single multidisciplinary scientific research entity, funded mainly by a specific Government vote, with its staff employed under its own Act. It agreed that the personal classification system applying to all except administrative staff should continue; however, consideration was to be given to the introduction of a vestibule grade into which all new research staff were to be appointed. The Executive subsequently examined the scheme but concluded that any benefits likely to flow from its introduction would be small and would not outweigh the potential disadvantages. The question of voluntary retirement at age 55 is also being investigated, following the Independent Inquiry's recommendation that it should be introduced.

As recommended by the Inquiry, CSIRO has been documenting classification criteria and incorporating these into CSIRO's appointments and promotion manual. These guidelines are

important in maintaining standards and relativities when appointing and promoting staff. Following the formation of the Institutes, the Executive delegated responsibility for appointments and promotions, up to and including Principal Research Scientist, to Institute Directors.

A research staff manpower model has also been constructed, allowing prediction of the composition of the research population, and the Organization's policy on term appointments has been reviewed and the appointment percentage increased following the Inquiry.

Surveys have been undertaken of the incidence of staff interchange with other bodies and of impediments to higher levels of exchange. Impediments perceived by staff include the potential damage to current programs and adverse effects on career prospects, particularly when a significant period away from CSIRO is involved. To understand better industry's views on impediments to higher levels of staff interchange, and the measures that can be taken to promote interchanges, the Executive has commissioned Sir Victor Burley (the previous Chairman of the CSIRO Advisory Council) to report on this matter.

The Science and Industry Research Amendment Act 1978 provided for the establishment of a Consultative Council 'to consider, and 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'. Reports on the work of the Consultative Council are included in the Organization's annual reports (see Chapter 12).

The Inquiry concluded that the attraction of revenue for the conduct of either ongoing or intended research should only be pursued in a manner consistent with the role and objectives of the Organization. The Government accepted this conclusion and decided that, given the comprehensive role of CSIRO, research of general interest to the Commonwealth Government should be funded as far as possible through a budgetary appropriation direct to CSIRO. There are, however, occasions where CSIRO is the only body in the country with the expertise and resources appropriate for the undertaking of particular tasks. While resources should not be diverted from its major role, CSIRO gives sympathetic consideration to specific industry needs. In such circumstances, the full commercial cost of providing this assistance is charged to the industry. The Government has agreed to this policy.

2. Distribution of research effort

This chapter sets out the current distribution of CSIRO's research effort and briefly describes areas of research designated for expansion or reduction. It forms part of the Organization's response to a requirement in the Science and Industry Research Act 1949 that each annual report should describe the research policies current at the beginning of the reporting year and any developments in those policies during the year. The selection of particular research objectives from among all those possible within CSIRO's statutory charter, and the relative levels of financial and manpower resources allocated to the pursuit of selected objectives, are the principal expressions of CSIRO's research policies. The chapter includes tables summarizing the distribution of CSIRO's research effort to selected objectives.

Table 1 shows the distribution of resources to research areas according to the classification being used by CSIRO for strategic planning. The nature of research means that a program may benefit a number of diverse industries and provide other community benefits as well. In Table 1, each research program is assigned to the research category to which the current work is primarily relevant. In some cases, a comparatively small shift in the balance within a research program has meant a reclassification of the whole program from the 1980/81 research area to another research area. Some other variations from figures in the corresponding table in the 1980/81 annual report have arisen from refinement of the system of classification. For example, following the closure of the Division of Mechanical Engineering and a reclassification of the Agricultural Engineering Group's research to Agricultural Systems, the classification of Agricultural Engineering has been deleted from the CSIRO Classification of Research.

The nature of CSIRO's research means that recruitment of suitably qualified staff often takes a considerable time which can lead to time lags before significant changes are achieved. Furthermore, owing to turnover of staff, some areas earmarked for expansion may suffer limited temporary reductions in staffing.

Table 2 shows the distribution of financial and manpower resources according to the Divisions, Units or Laboratory groupings of the Organization's Institutes.

Areas of High Priority

CSIRO has established six areas of high priority for expansion. These broad topics usually include more than one of the research areas mentioned in Table 1.

The six areas are:

- energy
- manufacturing industry
- biotechnology
- water and soils
- plant pathology
- oceanography.

Major changes in research effort in these areas of high priority are described below.

To reflect the designation of energy as a research area of high priority, a new Institute of Energy and Earth Resources containing new Divisions of Energy Technology and Energy Chemistry was formed on 1 September 1981. These changes are described in Chapter 11. The majority of the staff in the Division of Energy Technology was transferred from the now disbanded Division of Mechanical Engineering. Also, following the Government decision to transfer research resources from the Australian Atomic Energy Commission Research Establishment to expand CSIRO's non-nuclear energy research program, 64 professional staff were transferred to the Divisions of Energy Chemistry, Mineral Physics, Energy Technology and Chemical Physics. As they did not join CSIRO until 1 April 1982, these staff are not included in Tables 1 and 2.

Areas of energy research that received increased support during 1981/82 were Coal, Substitute Liquid and Gaseous Fuels, and Energy Conservation. Efforts to improve coal recovery and safety in mining and to improve coal cleaning and ancillary processes expanded during the year. Since liquid fuels are unlikely to be replaced in the short term as the prime energy source for transport, increased effort is being given to research aimed at conservation, especially in urban transport. Liquid fuels are also used in industry, and CSIRO is expanding its work on reducing the use of these fuels through conservation and substitution by other energy sources. Oilseed crops are being studied as sources of substitute liquid fuels. Tests of these oils in diesel engines commenced during the year. Increased emphasis is also being given to the production of fuels and useful chemicals through the chemical conversion of plant materials.

Reduction of effort has occurred in the area of Renewable Energy. CSIRO has achieved its strategic goals of developing solar energy equipment and design and evaluation procedures for domestic and industrial application. Programs in these areas are now being reduced or brought to a conclusion. CSIRO's research results in the field of domestic solar energy are being adopted and developed by the private sector. The solar industrial demonstration program is being phased out as similar programs are being undertaken by State authorities in collaboration with consultants and industry. Solar energy research is continuing on the development of improved surfaces for solar collectors, photovoltaic systems and the solar decomposition of water to produce hydrogen.

Engineering aspects of wind power studies have been terminated as similar studies are being conducted by several universities and other bodies. However, research on assessment of geographical areas suitable for collection of wind power is continuing.

In the area of **manufacturing industry**, there has been no major change in the overall level of resources devoted to Resource-based Industries, but there have been significant shifts of emphasis within this category. For example, research effort on Food Processing is now giving emphasis to engineering aspects of meat handling, food manufacturing technology and the properties and protection of processed foods. In research on Textiles, priority has been given to work on early-stage processing of wool for improved quality and productivity in the manufacture of yarns and fabrics.

There has been a significant increase, however, in research effort directed towards Technology-intensive Industries. In the area of Instruments and Electronic Equipment there has been an expansion of research on the application of optical holography to industrial problems and on the design of very large scale integrated (VLSI) circuits. In the field of signal processing, research in the Division of Radiophysics is continuing in a number of diverse areas and will increase in 1982/83. Major growth also occurred in the area of Materials Fabrication where emphasis was placed on integrated engineering manufacture (including automation and robotics) and improved technology for the production of high precision engineering components. Increased emphasis has also been given to a range of smaller research programs in the Division of Applied Physics that aim to assist industry in its efforts to reduce inefficiencies, wastage of materials and variability in product quality through manufacturing innovation. Staff for some of these expanded activities were redeployed from research on Standards, which consequently decreased substantially.

In the category of **biotechnology**, research efforts on animal cell growth and development, gene technology, and the biological defleecing of sheep through the use of epidermal growth factor have increased, while biotechnology research in other areas is continuing. These areas include animal breeding, the molecular basis of plant improvement, understanding the mechanisms involved in the production of cell mutations, the manufacture of vaccines, hormones and rare proteins, and the use of micro-organisms in industrial processes. Other developments in the field of biotechnology are mentioned in Chapter 4.

Water and **soils** research in CSIRO underwent major changes in 1981/82. As described in Chapter 6, a Division of Water and Land Resources in Canberra and a Division of Groundwater Research in Perth were established from the Division of Land Use Research and part of the Division of Land Resources Management respectively, and other existing resources. The Division of Irrigation Research will become the CSIRO Centre for Irrigation Research to facilitate research collaboration with CSIRO research groups in several fields dealing with irrigated agriculture and water

resources management. These changes will enable CSIRO to respond better to national needs in this area.

The main emphasis in 1981/82 was on the consolidation of existing programs in water research. However, there was a redeployment of resources from research on coastal and subcoastal lands to water management. Salinity and other aspects of water quality, groundwater and catchment hydrology have been identified as areas for expanded research effort. During the year, a group studying forest hydrology in Tasmania was transferred from the Division of Soils to the Division of Forest Research, and there was expansion in the program on studies of Australian soil and water resources. A number of new positions have been allocated to Water and Soils research, and considerable changes are expected in 1982/83 as the new Divisions and the Division of Soils examine and expand their research programs in the directions indicated in the review of water research (see Chapter 6).

Plant pathology was designated a high priority research area in 1981. There has been a redeployment and strengthening of resources in the Division of Plant Industry where a new project on virus diseases of subterranean clover has begun. As mentioned in more detail in Chapter 10, a review of plant pathology research is also under way. It is expected that this will influence research in several Divisions concerned with agriculture and forestry in future years.

Research effort in **oceanography** is expected to increase as the transfer of the Division of Oceanography to the new CSIRO Marine Laboratories proceeds. The laboratories are being constructed in Hobart and the transfer will commence in early 1983. Research effort in Physical Oceanography increased in 1981/82 and will continue to increase, as will Chemical Oceanography, as suitable staff are recruited. Research programs in Ocean Production and Biological Oceanography, both related to the living resources of the sea, were transferred to the Division of Fisheries Research.

Other Research Areas

In 1980/81 the Executive adopted a policy of selectivity and concentration of research effort. Rather than applying a *pro rata* cut to all Divisions, it called on each Institute, in consultation with an Executive sub-committee, to identify areas for reduction, termination or expansion.

The aims of this policy are:

- to ensure that adequate resources are available for high priority areas and programs;
- to achieve a greater selectivity and concentration of research effort; and
- to ensure that programs with an inadequate level of resources do not continue.

Table 3 lists programs and subprograms affected by the application of this policy during 1981/82 and indicates whether they were expanded, reduced or terminated.

TABLE 1	% of Total Research Expenditure		% of Total Direct Professional Staff	
Rural industries				
Agriculture				
Plant improvement	2.3		1.9	
Plant physiology and biochemistry	2.6		2.7	
Soils and plant nutrition	2.5		2.4	
Crop and pasture pests and diseases	4.5		4.0	
Livestock production	5.8		4.4	
Livestock health	5.7		4.1	
Agricultural systems	3.0		2.5	
		26.4		22.0
Forestry				
Forest biology	3.8		3.8	
		3.8		3.8
Fishing				
Marine biology	3.3		2.8	
		3.3		2.8
Total – Rural industries		33.5		28.6
Mineral, energy and water resources				
Mineral resources				
Exploration	2.6		3.0	
Mining and beneficiation	2.9		3.6	
Environment	0.5		0.5	
		6.0		7.1
Energy				
Coal	2.6		2.8	
Petroleum, gas and oil shale	0.4		0.6	
Substitute liquid and gaseous fuels	2.8		3.3	
Renewable energy	1.0		1.1	
Energy storage	0.3		0.5	
Energy conservation	1.0		1.1	
		8.1		9.4
Water resources				
Water management	1.9		2.1	
Water technology	0.5		0.6	
		2.4		2.7
Total – Mineral, energy and water resources		16.5		19.2

TABLE 1 continued	% of Total Research Expenditure		% of Total Direct Professional Staff	
Manufacturing industries				
Resource-based manufacturing industries				
Food processing	5.2		6.4	
Textiles	5.4		4.2	
Hides and leather	0.5		0.4	
Cellulose and forest products	1.5		1.7	
Basic metal products	1.1		1.5	
		13.7		14.2
Technology-intensive industries				
Instruments and electronic equipment	2.9		3.0	
Advanced materials	2.2		2.3	
Specialty polymers	0.5		0.4	
Agricultural chemicals, pharmaceuticals and veterinary products	2.0		2.1	
Materials fabrication	2.7		2.5	
		10.3		10.3
Standards		2.9		2.7
Total – Manufacturing industries		26.9		27.2
Community interests				
Knowledge and management of the natural environment				
Fauna	2.5		2.3	
Flora	0.8		0.8	
Land	4.9		5.3	
Oceans	1.6		0.6	
Atmosphere	2.0		2.1	
Environmental protection	1.2		1.2	
Astronomy	2.7		2.5	
		15.7		14.8
Tertiary industries				
Building and construction	2.9		3.1	
Mathematics and statistics	1.7		3.1	
Computing	1.4		2.3	
Information services	0.1		0.2	
		6.1		8.7
Public health				
Human nutrition	1.3		1.5	
Industrial hygiene	–		–	
		1.3		1.5
Total – Community interests		23.1		25.0
CSIRO – Research total		100.0		100.0

TABLE 2	% of Total Research Expenditure		% of Total Direct Professional Staff	
Institute of Animal and Food Sciences				
Animal Health	4.4		3.2	
Animal Production	5.5		4.3	
Fisheries Research	3.2		2.8	
Food Research	4.9		6.0	
Human Nutrition	1.3		1.5	
Molecular and Cellular Biology	1.0		1.2	
Project for Animal Research and Development	1.0		0.4	
Wheat Research	0.3		0.4	
		21.6		19.8
Institute of Biological Resources				
Entomology	5.2		4.3	
Forest Research	3.1		3.0	
Horticultural Research	1.1		1.5	
Irrigation Research	1.0		1.1	
Land Resources Management	2.5		2.4	
Land Use Research	2.2		2.5	
Plant Industry	5.5		5.4	
Soils	3.1		3.6	
Tropical Crops and Pastures	3.9		2.6	
Wildlife Research	2.0		1.9	
		29.6		28.3
Institute of Energy and Earth Resources				
Applied Geomechanics	1.5		1.6	
Energy Technology	1.2		1.3	
Minerals Research Laboratories	9.7		11.9	
Physical Technology	0.4		0.5	
		12.8		15.3
Institute of Industrial Technology				
Agricultural Engineering	0.2		0.3	
Applied Organic Chemistry	1.8		1.7	
Building Research	2.8		3.1	
Chemical Technology	2.7		3.1	
Manufacturing Technology	1.8		1.7	
Protein Chemistry	1.9		1.8	
Textile Industry	2.8		1.9	
Textile Physics	1.7		1.5	
		15.7		15.1
Institute of Physical Sciences				
Applied Physics	5.9		5.6	
Atmospheric Physics	1.5		1.3	
Australian Numerical Meteorology Research Centre	0.3		0.4	
Chemical Physics	1.8		2.2	
Cloud Physics	0.9		0.9	
Computing Research	1.8		2.6	
Environmental Mechanics	0.4		0.5	
Materials Science	1.5		1.7	
Mathematics and Statistics	1.7		3.1	
Oceanography	1.6		0.6	
Radiophysics	2.9		2.6	
		20.3		21.5
TOTAL		100.0		100.0

TABLE 3

Variations in Professional Staff Deployment in Programs and Subprograms[1]

(E = expanded; R = reduced; and T = terminated programs and subprograms)

Research area	Program/subprogram
RURAL INDUSTRIES	
Agriculture	
Plant improvement	Horticultural production—grapevines (R)
	Forage legume breeding for the tropics (R)
Plant physiology and biochemistry	Crop-environment interaction (E)
Management of crop and pasture pests and diseases	Nematodes for insect control (E)
	Biochemistry of insect cuticle (R)
	Control of aphids by wasp parasites (R)
	Orchard pests (R)
	Natural mechanisms by which insects resist bacterial infections (T)
	Development of C_4 herbicides (E)
	Virus diseases of subterranean clover (E)
	Fungicide synthesis (R)
	Phytophthora root disease in forests (T)
Livestock production	Biology of the skin (R)
	Physical and physiological factors affecting viability of lambs in early life (R)
Livestock health	Control of screw-worm fly and buffalo fly (E)
	Bovine brucellosis (R)
	Physiological and biological effects of internal parasites (T)
	Lupinosis (R)
	Poultry mycoplasma infections (T)
	Ultrastructure and physiology of mycoplasmas (T)
	Australian National Animal Health Laboratory (E)
Forestry	Water and other factors affecting forest tree growth (E)
	Project Aquarius—'water bombing' of bushfires (E)
	Forest harvesting (R)
	Minor element deficiencies in sub-tropical plantation pines (R)
	Genetics and ecology of moist temperate forests (T)
	Forest resource assessment (T)
	Silviculture of tropical plantation species (T)
	Biological control of sirex wasp in pines (T)

TABLE 3 continued

Research area	Program/subprogram
Fishing	Australian salmon (T)
	Pelagic fish production (T)
MINERAL, ENERGY AND WATER RESOURCES	
Mineral resources	
Exploration	Mineral exploration techniques (R)
Mining and beneficiation	Mining (R)
	Extractive processing (R)
Energy resources	
Coal	Coal storage and transport (E)
	Coal utilization (E)
	Coal exploration and characterization (R)
Petroleum, gas and oil shale	Oil shale exploration and characterization (E)
Substitute liquid and gaseous fuels	Internal combustion engine fuels (E)
	Chemical treatment of plant materials for the production of useful chemicals and fuels (E)
Renewable energy	Solar conversion (R)
	Wind energy for isolated users (T)
Energy conservation	Energy conservation in transport (E)
MANUFACTURING INDUSTRIES	
Resource-based manufacturing industries	
Food processing	Food safety and nutritional quality (E)
	Post-harvest physiology of fruit and vegetables (E)
	Engineering aspects of meat research (E)
	Food structure (R)
	Chemical bases of food acceptance (R)
	Applied food science (R)
	Biological aspects of meat research (R)
Textiles	Processing of wool from scoured material to finished fabric (E)
	Testing and spinning of cotton (T)
	New methods for dyeing and printing of wool (T)
Technology-intensive industries	
Instruments and electronic equipment	VLSI (E)
	Holographic and speckle interferometry (E)
	Spectroscopy (R)
Advanced materials	Glassy metals (E)
	Ion implantation (E)
	X-ray diffraction (R)
	Electron microscopy (R)

TABLE 3 continued

Research area	Program/subprogram
Agricultural chemicals, pharmaceuticals and veterinary products	Gene technology (E)
	Animal cell growth and development (E)
	Influenza virus studies (T)
Materials fabrication	Gas discharges (E)
	Laser-material interactions (E)
Standards	Electrical standards (R)
	Mass standards (R)
	Length standards (R)
	Hydrogen masers (T)
COMMUNITY INTERESTS	
Knowledge and management of the natural environment	
Fauna	Biology of bandicoots (T)
	Ecology of ground-dwelling birds (T)
	Pelicans and cormorants (T)
Oceans	Physical oceanography (E)
Atmosphere	Cloud processes (E)
	Cloud seeding (T)
	Airglow and upper atmosphere (T)
Environmental protection	Air pollution abatement (E)
	Nitrogen dioxide in urban areas (R)
Tertiary industry	
Mathematics and statistics	Sydney and Melbourne consulting service (E)
Public health	
Human nutrition	Brain development in iodine deficiency and excessive alcohol consumption (R)
	Nutrition and development of nervous systems (R)

1 Research priorities in the Divisions of Tropical Animal Science, Groundwater Research, Water and Land Resources, Soils, Protein Chemistry and Building Research were being assessed and adjusted during the year (see Chapter 10) and a complete list of changes is not available.

3. Agriculture

The Executive's agricultural research policy concerns research directed wholly to agricultural production and does not include related research areas such as soil and water salinity, ecology of plants and animals, processing of agricultural products, agricultural chemicals and veterinary products. However, some of these have been taken into account by the Executive in determining where emphasis needs to be placed in future agricultural research.

The Organization's policies and priorities for agricultural research set out in this chapter follow an extensive planning review commissioned by the CSIRO Executive. The review was conducted against the background of general Government policies for agricultural research. These policies, and suggestions by authoritative bodies such as the National Farmers Federation, provide a general basis for determining broad objectives for the Organization's agricultural research effort. However, the Executive was conscious of the need for a more detailed study of scientific opportunities and of market needs.

The strategic planning review comprised four elements. These were:

- development of socio-economic perspectives for the future of agriculture in Australia;
- internal and external consultation to define the scientific opportunities of greatest promise;
- inputs from CSIRO's internal review process; and
- external consultation, particularly with the CSIRO Advisory Council, to seek views on the conclusions reached.

The Executive believes that its extensive planning and review process will provide a sound basis for setting program priorities for the Organization's agricultural research effort. While the outcome of this review sets a broad framework for planning research, continued close attention will be paid to further scientific advances and changes in economic factors. Continuing Divisional and subject reviews in specific areas will be important inputs to this process. The aim will be to maintain flexibility in setting priorities while ensuring that the Organization's research effort is selective and concentrated in the areas of greatest promise.

The CSIRO Advisory Council's advice to the Executive on policies and priorities for agricultural research, together with the Executive's response, is reported in the chapter 'Advisory Council and State and Territory Committees—Advice and Activities'.

Commonwealth Agricultural Research Policies

Commonwealth agricultural research policies have been reviewed through several inquiries in recent times. Two of the most significant of these have been the Industries Assistance Commission (IAC) inquiry on 'Financing of Rural Research' and the Independent Inquiry into CSIRO.

The IAC examined the various arguments put to it on the case for public subsidy of rural research during its 1976 inquiry and considered that three factors contributed to the case for subsidy. Firstly, it accepted the argument that rural research, in aggregate, has been and will continue to be an investment activity with a high social rate of return. In making this judgment, the Commission was influenced by various economic analyses of the rates of return from research published both overseas and in Australia. Secondly, it was impressed by the 'extensive degree to which the results of research done on rural problems is applicable to problems in other sectors of the economy' and concluded that these wider benefits were rarely captured by the individual producer or industry financing the research. Thirdly, it considered that research was a highly uncertain investment activity, both in terms of the end result of a project and its ultimate benefits. Producers adopt a risk-averse attitude to such activities, and consequently under invest, whereas society can adopt a risk-neutral position.

These three factors were seen as providing a strong case for public subsidy, and the Commission concluded that:

> 'In the absence of Government subsidy, investment in research by farmers and corporations servicing agriculture would, the Commission considers, be much less than optimal from the community's viewpoint, because of the high risk and uncertainty of research, the difficulty faced in appropriating the full commercial benefits of research and because of large external benefits to the community. Accordingly, it is the Commission's judgment that the Government should continue its major financial support for rural research.'

In 1977 the Government accepted the recommendations of the IAC arising from this conclusion, and also its general assessment that the level of funding of such research by the Commonwealth should be maintained.

The Independent Inquiry into CSIRO in 1977 confirmed that CSIRO's agricultural research should be strategic in nature and funded in the main by direct appropriations, and that CSIRO should also compete for funds from the various Rural Industry Research Funds. However, it concluded that the latter form of funding should not be the major component in any broad area research program.

A further proposal of the Inquiry was the need for enhanced advisory mechanisms for research to ensure that the views of industry users, the community generally, and Government

agencies, both Commonwealth and State, are taken into account by CSIRO in the formulation of its research priorities. These advisory mechanisms have figured prominently in the analyses reported in this chapter.

These recommendations of the Independent Inquiry were accepted by Government in 1978.

The other relevant Commonwealth Government review conducted in recent years was by the Australian Science and Technology Council (ASTEC) in its review of 'Science and Technology in Australia; 1977-78'. ASTEC concluded in 1979, as had the IAC three years earlier, that funding of rural research should be maintained at its existing level.

Also, since 1927 there has been an arrangement between the Commonwealth and the States that CSIRO concentrate on those aspects of agricultural research which are 'regional or national in range or scope, fundamental in character, and which require concentration of effort and highly specialized research for their solution'.

The Organization is conscious of the need to contribute to the formulation of national agricultural research policies, including making submissions to Government and Parliamentary Inquiries, and to be responsive to changes in these policies. Accordingly, it has recently made submissions both to the inquiry into rural research and extension being conducted by the Senate Standing Committee on National Resources, and to the preparation of a Policy Discussion Paper on Agriculture being prepared under the auspices of the Minister for Primary Industry. The terms of reference for this latter inquiry include agricultural research.

The Organization contributes to the deliberations of the Standing Committee of the Australian Agricultural Council and, in recent months, has further strengthened its direct links with the appropriate State Government agencies at the most senior level.

CSIRO's Role and Policies for Agricultural Research

Role of CSIRO's Agricultural Research

CSIRO's agricultural research is directed primarily to aspects of agricultural production of widespread significance which require mid- to long-term research. It is aimed at establishing principles, practices and technologies that will improve the efficiency and long-term viability of Australian agriculture and its capacity to respond to changing needs.

This work ranges from studies in basic biology to those designed to integrate new plant varieties, animal breeds and production technologies into sound production systems. The Organization's scientists maintain a close watch on world developments in agricultural and biological research to capitalize on innovations that may be applicable to Australian agriculture.

CSIRO, with its strategic research role, is well placed to undertake work on, for example, new crops of potential economic

importance as well as undertaking fundamental studies on those aspects of agriculture whose economic significance is already established. The value of maintaining a core of expertise and excellence which can contribute towards solving unexpected problems of national significance was demonstrated by recent work on lucerne aphids and bluetongue.

CSIRO's work complements that of the other agricultural research organizations, and considerable importance is attached to collaboration with them. The exchange of staff and sharing of research facilities are valuable means of fostering collaboration. CSIRO will continue to make available facilities and scientists for these purposes. It also welcomes the concept of producing a compendium of agricultural research in Australia and stresses that its Institutes, Divisions and individual research groups have a responsibility to maintain awareness of related work being undertaken in other organizations.

CSIRO accepts its responsibility to assist in the co-ordination of the national rural research effort. It sees both industry groups and its own advisory mechanisms, which include State agency representatives, as facilitating such co-ordination of research effort.

Although much research on plant and animal processes must necessarily be carried out in laboratories and controlled-environment facilities, it is not always possible to extrapolate to field performance from such research. For this reason, CSIRO carries out field research at a number of key locations throughout the country. CSIRO also conducts some of its experiments on farms with the participation of the farmers concerned.

The Executive recognizes the need for the Organization to continue to run a limited number of agricultural field stations and to maintain collaborative research with State departments at their field stations. These have proved valuable in developing the farming community's awareness of CSIRO's research work while increasing the Organization's understanding of industry problems. CSIRO seeks to increase these forms of collaboration.

Although CSIRO does not carry out direct extension services for primary producers, it has an obligation to ensure that the results of its research are made available to potential users promptly and effectively. To this end, CSIRO makes use of existing extension services and its own and other information transfer networks wherever possible. The Executive, therefore, encourages collaboration with State departments in programs which also have an extension component.

Two aspects of CSIRO's role, namely regional balance and industry funding, warrant particular attention.

Regional balance of CSIRO's agricultural research. The Executive aims to maintain a reasonable regional balance in its agricultural research, based on perceived research needs and opportunities and the economic prospects and social implications of the agricultural industries in the various regions of Australia.

Basic and longer-term strategic research, which constitutes

the major part of CSIRO's agricultural research, tends to be applicable to many regions. Some strategic and tactical research is directed to problems related to particular environmental regions, such as the tropics and sub-tropics. For research in this latter category, the Executive aims to locate laboratories, where feasible, in the specific regions to which the work is most relevant.

For example, in 1981, in recognition of the particular difficulties facing animal producers in Queensland, the Northern Territory and the north of Western Australia, it announced its decision to establish a Division of Tropical Animal Science in Queensland. The applicability of CSIRO's agricultural research to the Mediterranean climatic regions of Australia, particularly in Western Australia where soil characteristics pose particular problems, will be examined further. As a first step, the Organization decided in June 1982 to focus better its existing rural research effort in Western Australia by establishing a CSIRO Laboratory for Rural Research (Perth).

The Executive realises the importance of ensuring that research results, arising from either generally applicable studies or from regionally specific work, are transferred into agricultural practice. It seeks to improve collaboration with State Departments of Agriculture to facilitate such transfer, recognizing that work conducted originally for one environmental region may often require substantial adaptation in order to be applicable in another environmental region.

Industry funding of CSIRO's agricultural research. CSIRO's rural research is financed primarily by direct Commonwealth Government appropriations and by rural industries through the various Rural Industry Research Funds. These latter funds are financed by levies either on the volume or the sales value of production, with expenditure of levy moneys being matched by a Commonwealth contribution.

As indicated previously, the Independent Inquiry endorsed the continuation of support for CSIRO's research through these funds, while pointing out that they should not dominate any particular broad area research program.

CSIRO recognizes the benefits which result from the financing of its agricultural research, directly or indirectly, by rural industries, since this ensures close interaction and collaboration with these industries and facilitates the transfer of the results of its research to them. With the exception of the Wool Research Trust Fund, which is important in financing major on-going research programs in CSIRO Divisions, rural industry research funds provide finance for specific short-term projects proposed by CSIRO and approved on the basis of advice from the relevant research committee. It is the Executive's policy that these funds should be used to enhance the capability of existing core research programs financed from Commonwealth Government appropriations.

CSIRO's Policies for Agricultural Research

The policies determined by the Executive for the Organization's agricultural research effort arose from consideration of Commonwealth agricultural research policies and of CSIRO's role, and from an assessment of the appropriateness of CSIRO's present research effort in relation to these.

Policies endorsed by the Executive for its agricultural research effort are:

- CSIRO will continue to direct its agricultural research primarily to aspects of agricultural production of widespread significance which require mid- to long-term research. It will aim to establish principles, practices and technologies that will improve the efficiency and long-term viability of Australian agriculture and its capacity to respond to changing needs. It will also continue to contribute to solving unexpected problems of national significance.
- CSIRO's agricultural research will be more selective in future. Particular attention will be paid to the priority topics identified through the planning review.
- Research priorities will be reconsidered in the light of changing economic needs and scientific opportunities; while comprehensive reviews of the agricultural research sub-sector will only be undertaken at intervals, subject and Divisional reviews will have an important influence on priorities in the interim.
- CSIRO will continue to undertake collaborative programs, exchange scientists and share facilities with State Departments of Agriculture.
- CSIRO recognizes the need for its research to cover all of the environmental regions of Australia and will keep under review the regional balance of its activities.
- CSIRO recognizes the benefits associated with industry funding of some of its research and will ensure that such funding does not dominate any particular broad area research program, but rather is used to enhance the capability of core research programs financed from Commonwealth Government appropriations.
- CSIRO will further assist in the co-ordination of the national agricultural research effort.

Present CSIRO Agricultural Research Effort

A full description of CSIRO's agricultural research programs is contained in the 'Directory of CSIRO Research Programs', which is produced annually. The classification of agricultural research in CSIRO and the broad objectives for each category in this classification are set out in Table 4.

The relative contribution of CSIRO's research to the various categories of animal and plant production are presented in Table 5, and the contribution of the CSIRO research effort in relation to State Departments is shown in Table 6.

TABLE 4	Present CSIRO Research Effort and Broad Objectives	
	Research areas	Broad objectives
Plant production	Plant improvement	To collect, conserve, evaluate and breed plants that are adapted to the range of agricultural environments in Australia; and to undertake basic research to define specific breeding objectives and develop new methods of plant breeding.
	Plant physiology and biochemistry	To understand the molecular and physiological basis of plant growth and development in order to improve plant production.
	Soils and plant nutrition	To understand and modify the physical, chemical and biological properties of soils which, together with the nutrient requirements of plant species, influence plant growth. Acidity, salinity, water relations, disease organisms and erosion are important soils aspects and the uptake and translocation of nutrients and their effects on yield and quality are major plant nutrition aspects.
	Crop and pasture pests and diseases	To develop improved methods for the control of plant diseases, pests and weeds using chemical, biological and agronomic means.
Animal production	Livestock production	To understand the genetic, nutritional and physiological bases of animal functions with the aim of improving the efficiency of livestock production.
	Livestock health	To understand the pathology, immunology and epidemiology of disease with a view to developing more efficient methods of controlling parasites and the principal diseases affecting livestock production.
Agricultural systems		To understand the interactions between soil, plant, animal and climatic factors with a view to developing productive and sustainable agricultural systems.

TABLE 5 Industry Spread of CSIRO's Agricultural Research 1980/81

Industry	Professional staff involved as at 30/6/1981	Percentage staff
Plant production		
Pastures	62	11.5
Cereals	66	12.3
Grain legumes	17	3.1
Oilseeds and new crops	39	7.3
Horticulture	42	7.8
Animal production		
Cattle	107	19.9
Sheep	102	19.0
Pigs	3	0.5
Poultry	8	1.5
Goats	1	0.2
Multi-industry (Mainly related to plant production)	91	16.9
Total	**538**	**100.0**

Aspects of other research programs of direct relevance to agriculture which do not have agricultural production as the primary aim, have not been included in Table 5.

The time-scale of potential applicability of the present CSIRO agricultural research effort in two categories (near-term: within the next 10 years; and long-term: beyond 10 years) is presented in Table 7. Table 7 demonstrates the strategic emphasis of CSIRO's agricultural research.

Determination of Research Priorities

The planning procedure used for determining research priorities had three distinct phases. These were:

- an analysis of socio-economic trends and developments;
- an analysis of scientific opportunities; and
- a synthesis of the outcome of these two analyses to identify the areas of scientific research where significant advances are most likely to be made and where such advances are likely to have a major economic impact.

TABLE 6

Comparison of Research Effort in CSIRO and Commonwealth and State Departments in June 1981

Industry	Professional staff (man-years)									
	NSW	Vic.	Qld	SA	WA	Tas.	NT	BAE*	CSIRO	Total
Extensive livestock (including pastures)	142.5	163.6	115.8	49.5	67.0	18.4	16.3	84.1	319.9	977.1
Intensive livestock	11.8	25.3	20.0	8.7	6.0	2.6	0.1	1.7	11.2	87.4
Horticulture	61.4	78.6	62.5	24.7	11.0	16.8	3.0	20.9	39.0	317.9
Field crops	97.3	77.9	137.2	18.7	57.0	8.5	5.6	34.3	104.0	540.5
Multi-industry	54.9	86.5	94.5	25.4	20.0	4.6	2.6	68.8	128.0	485.3
Total	367.9	431.9	430.0	127.0	161.0	50.9	27.6	209.8	602.1	2408.2
%	15.3	17.9	17.9	5.3	6.7	2.1	1.1	8.7	25.0	100.0

* Bureau of Agricultural Economics.

Source: Based on a survey by the Standing Committee on Agriculture in June 1981, using a broader definition of agriculture than that used by CSIRO in its planning review. The figures include agricultural chemicals, fertilizers, land and water resources, soil erosion and vertebrate pests.

Note: Professional staff includes research scientists and experimental officers in CSIRO and research scientists in State Departments of Agriculture.

CSIRO's Planning and Evaluation Advisory Unit was responsible for designing and co-ordinating the inputs to each of these phases, and drew on a wide range of experts, both inside and outside the Organization, for contributions and comments at each phase. The final definition of major areas of scientific opportunity and economic impact, and subsequent identification of research priorities, was undertaken by a committee comprising the full-time Member of the Executive responsible for agricultural research, Dr N.K. Boardman (Chairman), the Director of the Institute of Animal and Food Sciences, the Director of the Institute of Biological Resources and the Director of the Planning and Evaluation Advisory Unit.

TABLE 7

Project Application Periods for CSIRO's Agricultural Research

Research area	Professional staff as at 30/6/1981	
	Near term* (0-10 years)	Long term* (more than 10 years)
Plant production (252 staff)		
Plant improvement	8 (1%)	37 (7%)
Plant physiology and biochemistry	6 (1%)	50 (9%)
Soils and plant nutrition	26 (5%)	35 (7%)
Crop and pasture pests and diseases	24 (4%)	66 (12%)
Animal production (221 staff)		
Livestock production	26 (5%)	97 (18%)
Livestock health	15 (3%)	83 (15%)
Agricultural systems (65 staff)		
Agricultural systems	25 (5%)	40 (8%)
Total	130 (24%)	408 (76%)

* Time in which research results will be available to farmers through extension and related services (i.e. including the research, development and demonstration phases).

Socio-economic Analysis

An analysis of social and economic trends in the agricultural sub-sector was undertaken jointly by CSIRO and the Bureau of Agricultural Economics (BAE). This included an examination of historical data, the current situation and emerging trends for the agricultural industry generally and for particular constituent industries.

Broad characteristics of the Australian agricultural production system, government policies, cost-price effects, structural changes and world trade influences were examined. Industry perspectives for four broad categories of agriculture—the extensive livestock and cropping (broadacre) industries; the intensive livestock industries; the horticulture intensive cropping industries; and other crop industries—were then obtained. Finally, for each of these categories, a detailed examination of the major constituent industries was undertaken and the views of a wide range of government, industry and community representatives was sought.

The following is a summary of the future directions for agriculture, as presented in the joint CSIRO/BAE paper. Included among the BAE's perceptions are the following:

- The contribution of the agricultural sector to the Gross Domestic Product is expected to continue to grow in absolute terms but its proportion of total GDP will decline. This means that resources will continue to flow into agriculture but will be in competition with demands from other sectors.
- Agriculture will continue to be dependent on export markets for most of the major commodities, as the domestic market is only expected to grow slowly, more or less in line with population growth. The major industries such as wheat, wool, beef, sugar and coarse grains are already strongly dependent on the export markets and, as production of these products expands, this dependence is likely to increase. In contrast, fruit crops and dairying industries are likely to contract further toward the relatively protected domestic markets in the foreseeable future.
- Rural exports will continue to expand and contribute a substantial proportion of total exports. However, this proportion, which is currently about 45%, is expected to fall with the continued expansion of exports from the mineral sector.
- The world food situation is likely to have a significant impact on the major food exporting countries. There are conflicting views on this subject although there is a possibility that food prices could rise should production shortfalls eventuate.
- Pressure on world food supplies will be felt most by the developing countries, especially those that are basically subsistence economies with limited foreign exchange necessary for purchase of food supplies. Therefore, they may be increasingly dependent on food aid to supplement commercial purchases.
- The diminished access to traditional markets such as Britain and the other EEC countries has had the effect of a redirection of Australian exports. Australia's exports are now directed more to Asia and the Middle East. This trend is likely to continue, with growing opportunities for trade with these countries.
- Historically, the terms of trade facing Australian primary producers have exhibited a continued downward trend, albeit with substantial fluctuations. In the mid-1970s, considerable pessimism prevailed but in recent years the picture is more optimistic. It is likely that farmers will face continuing pressure from the terms of trade effect, although the pressures may not be as great as occurred in the mid-'70s.

Continuing pressure, as a consequence of the ratio of prices paid to prices received by farmers, will necessitate continued adjustment at the farm level to maintain real income levels. Farmers will be under pressure to increase their productivity through size economies by amalgamation of farms, through further intensification of production, and through application of new technologies. Alternatively, they may have to leave the industry. Greater diversification in conjunction with productivity gains may also be effective. Certainly the short-term measure of reduction in the level of inputs as occurred in the mid- to late-1970s cannot be sustained if stable and productive farming systems are to be maintained in the long term.

- Adjustment is likely to be greatest in those industries such as dairying (except cheese), apple and pear, and canning fruit, where the long-term export prospects are not favourable. The major extensive industries such as grains, sheep and beef cattle (subject to cyclical effects) and also the more intensive sugar industry appear to have favourable export prospects. However, world market prices will continue to fluctuate and growers may need to maintain diversification.
- Government intervention in the rural sector has been changing in character over the last decade. The emphasis on price stabilisation as a means of stabilising incomes is being steadily replaced by greater use of tax averaging, income equalisation deposits and underwriting schemes. More emphasis is being placed on measures to facilitate increased productivity and provide information on adjustment options through extension services.

The socio-economic examination of the individual industries led to the identification of areas where technical research was likely to result in economic benefit. These are presented in the 'Major Conclusions' and 'Summary' chapters of the joint BAE/CSIRO document 'Working Paper on Socio-economic Developments and Trends in the Agricultural Sector: Implications for Future Research'.

Assessment of Scientific Opportunities

The assessment of scientific opportunities also took into account the relative importance of the various agricultural industries to the economy, and the areas where research was likely to lead to significant gains in productivity and a lowering of the cost of production or to the production of new or improved products. However, in contrast to the socio-economic analysis, emphasis was placed on an examination of the 'state of the art' in the relevant field of science, particularly the opportunities for major advances in the understanding of plant and animal systems and relevant environmental factors of crucial importance to agriculture.

Integration of the areas identified in the socio-economic analysis with the scientific opportunities resulted in a list of major research themes for emphasis by CSIRO. These are presented in the final chapter of the document 'CSIRO Agricultural Research Planning Review'.

Perception of Major Agricultural Research Needs

The areas identified in the socio-economic analysis and the scientific opportunities were examined against the broad economic characteristics and the more specific economic factors influencing agricultural production.

The continued major importance of the extensive livestock and cropping industries to the Australian economy and the need to maintain and improve the competitiveness of agricultural production are dominant economic factors. Moreover, the long-term stability of agricultural systems, including soils, pastures and water supply, are crucial to the maintenance of productivity.

Increasing use of marginal lands and the expansion of cropping in the tropics will increase the likelihood of the degradation of soil and vegetation, and place greater importance on agricultural practices, including tillage techniques. The introduction and maintenance of viable cropping in these new areas, both in the short and long term, will depend on the development of improved species, the control of pests and diseases, and the determination of appropriate minimum levels of chemical fertilizers and pesticides. Many of these requirements are similar to those required for increasing productivity on existing crop lands, although the extension of cropping to new lands will doubtless give rise to new problems requiring new solutions.

The potential of the tropics for increased beef production will receive increasing attention. While Australia's extensive arid and semi-arid grazing lands will not contribute an increasing proportion of animal production, there may well be economic pressure to maintain production in these areas at a maximum sustainable level. The susceptibility of these areas to permanent damage through incorrect utilization will be an important consideration.

It will be increasingly important to maintain a balance between CSIRO's work aimed at improving animal production and work concerned with maintaining the ecological balance in fragile rangeland environments. Similar considerations will apply to the projected extension of cropping into more marginal lands, including the possibility of periodic cropping in semi-arid regions.

The view has been expressed that, over a period of time, there should be some shift in resources from research for animal industries to research for plant industries, and within the animal industries from cattle to sheep production. Others have queried this conclusion and the basis on which it was reached. All these views will be considered by the Executive, and a more detailed analysis carried out as part of its implementation of the research priorities described later in this chapter.

Major scientific opportunities exist for significant contributions to be made to identified agricultural research needs. For instance, new developments in molecular biology including gene transfer capability and cell tissue culture have the potential to revolutionize some aspects of plant and animal production, and improve methods of pest and disease control in both animals and plants. Similarly, advances in the field of immunology offer marked prospects for improved resistance to and control of animal diseases and parasites. At the same time, the more traditional methods of research in plant and animal breeding and production and in soil fertility, must be continued in order to meet the research requirements for maintaining an efficient and sustainable agricultural industry.

Research Priorities

Research priorities were determined on the basis of the needs identified by the socio-economic study and the analysis of those areas of science which showed both promise for significant advances and potential for contributing to these needs.

While a precise listing of priorities in ranked order was not feasible, research areas identified were classified into highest and other high priority categories.

Highest Priority Areas

Plant production

- New methods for breeding established crops of high economic importance.

  New methods of plant improvement using techniques such as recombinant DNA and tissue culture offer substantial prospects for developing crops with marked improvement in production efficiency.
- Biological control of weeds.

  Weeds significantly reduce the yield and quality of crops and pastures and some are toxic to livestock. Chemical control methods are both costly and environmentally undesirable. Biological control can provide a suitable alternative.
- Biological control of insect pests, including genetic techniques.

  Insect pests are responsible for substantial losses of crop and pasture production. Chemical control methods are both costly and environmentally undesirable and, in addition, the development by pests of resistance to chemicals reduces the effectiveness of pesticides. Biological control, particularly when used in conjunction with chemicals and special management practices, offers prospects for effective means of integrated pest control.
- Mechanisms of disease, pest and herbicide resistance and the breeding of resistant plants.

  There is a dearth of knowledge concerning the mechanisms by which plants develop resistance or tolerance to diseases,

pests and herbicides. This is needed to provide a basis for breeding plants that are resistant to diseases and pests, and for finding ways of making herbicides more effective.

- Management of soil-borne plant diseases.

  Soil-borne plant diseases cause substantial reductions in crop productivity and are less well understood than those gaining entry above ground. There are good opportunities for innovative research to provide a basis for the development of improved management practices.

- Enhancing biological nitrogen fixation.

  As the cost of chemical nitrogenous fertilizer rises, the economic advantages of using biologically-fixed nitrogen will increase.

  Recombinant DNA research offers possibilities for manipulating nitrogen-fixing organisms and, in the longer term, for the development of non-leguminous crop plants capable of fixing nitrogen.

- Improving the efficiency of root function.

  Improved efficiency of root function could be expected to result in increased crop and pasture production through better plant growth, reduced fertilizer use and improved plant/water relations. However, there is at present a lack of knowledge of root function compared to knowledge of the rest of the plant. Fundamental research is needed to increase understanding of root function and the root environment.

- Soil engineering for increased fertility.

  A number of the areas identified for future research emphasis are concerned with soil engineering. Soil engineering provides an essential input to the multi-disciplinary research required in such fields as tillage, erosion and drainage. It is used mainly in the development of design theories based on physical principles to enable soil manipulative systems suited to Australian conditions to be produced.

Animal production

- Identifying characteristics for breeding easy-care, productive and well-adapted genotypes of sheep and cattle.

  Fundamental research is needed to identify the physiological, biochemical and behavioural characteristics that determine high productivity, increased efficiency of feed utilization, fecundity and adaptation to the environment for use in the selection of improved sheep and cattle.

- Biological defleecing.

  Wool harvesting is at present a major component of total on-farm costs. Biological defleecing promises to reduce this cost substantially.

- Immunology of animal diseases for the development of more efficient vaccines and the breeding of resistant animals.

  Animal diseases and infestation by internal and external parasites are a major cause of losses in livestock production. Research in immunology shows promise for reducing these

losses through developing vaccines against diseases and parasites, and through providing means for the selection of animals resistant to diseases.

- Mechanisms and genetics of the acquisition of resistance by parasites of livestock to pesticides and anthelmintics.

  Internal and external parasites cause substantial production losses in the extensive livestock industries. The development of resistance by parasites to pesticides and anthelmintics reduces the effectiveness of these control agents. Long-term research is needed to improve our understanding of the genetic mechanisms by which resistance is acquired so that it can be reduced or avoided, and to guide the development of new pesticides and anthelmintics.

- Epidemiology, diagnosis and control of exotic animal diseases which present a threat to Australia.

  A number of major livestock diseases and pests exotic to Australia could, if introduced, have devastating consequences for the livestock industries and the economy as a whole. Research is needed to identify the insect vectors of viruses and provide the knowledge necessary for improving diagnostic and control procedures, as well as for developing more effective vaccines where appropriate.

- Biological control of insect parasites such as sheep blowfly and screwworm fly, including genetic techniques.

  The development of resistance to pesticides lends urgency to finding alternative means for controlling insect parasites of livestock.

Other High Priority Areas

Plant production

- Identification of characteristics important in breeding well-adapted plants.

  More accurate identification of useful adaptive characteristics, such as tolerance to moisture stress and salinity, and improved commercial quality of products, will greatly increase the opportunities to apply successfully and rapidly the sophisticated methods of genetic manipulation being developed for plants.

- Development and improvement of field crops and pastures for tropical Australia.

  For long-term development of more intensive agriculture in the Australian tropics, there is a need for improved lines of the recognized crops and pastures, and for new food, fibre and energy crops. Material from International Centres in the tropics overseas is not necessarily well adapted to Australian conditions.

- Development of pastures of high nutritive value.

  There are problems in efficiency of utilization by livestock of highly productive introduced pastures. These are due in part to the deficiencies of some pastures in their value as feed and to their agronomic characteristics. Improved lines will need to be

selected, in conjunction with studies on livestock nutrition.

- Development of integrated management systems for irrigated cropping.

  Irrigated cropping requires high levels of material inputs and skills in determining the best management options. This is a field which lends itself to the development of computer-based or other systems which assist in decision-making.

- Development of integrated pest management systems.

  Planning of integrated strategies for management of pests needs to include biological control, agronomic practices, selection of crops resistant or tolerant to the pest, and limited judicious use of chemicals.

- Increased efficiency of fertilizer use, including cycling of nutrients in crop-pasture-livestock systems.

  Fertilizer is normally a major input into any intensification of an agricultural production system, yet the efficiency of utilization of the nutrients in fertilizers is often low. Since costs of chemical fertilizers are increasing substantially, means of improving efficiency of utilization of fertilizers are needed.

- Salinity management.

  Control of the increasing incidence of salinity problems in both irrigated and dryland farming requires the development of better means of minimizing the movement of salt into the root zone and into surface waters and of reducing the amount of salt where there has been a build-up.

- Management of poorly drained and impermeable soils.

  Many Australian soils have poor drainage because of their texture, structure or stratification. Improved management practices are required to improve drainage, avoid unduly long periods of waterlogging and allow more efficient root growth.

Animal production

- New methods of livestock breeding.

  Such methods include the use of embryo manipulation, cloning, genetic engineering, insertion of genes, coding for particular traits, chimaeras and generation of animals from cells in tissue cultures.

- Improving the reproductive efficiency of sheep and cattle by increasing ovulation rate and reducing post-natal mortality.

  Experimentally controlled immunization of sheep against the gonadal steroid hormones increases ovulation rate and lambing percentage. Further research is needed to develop the method for commercial application and to extend it to other species of livestock. Experiments are in progress to improve the genetic basis of livestock fecundity and survival.

- Use of growth factors for enhancing livestock productivity.

  An increasing range of substances that regulate growth and production is being discovered. The characterization and physiological actions of these substances are being investigated to explore the possibilities of using them to enhance productivity. Such possibilities include the manufacture of

suitable growth factors by recombinant DNA technology and the use of vaccines to modulate their activity and enhance livestock productivity.

Implementation of Priorities

The planning, analysis and identification of priorities required a significant involvement for those in CSIRO ultimately responsible for making decisions on the resources to be allocated to broad lines of scientific investigation in defined areas (Institute Directors) and to individual programs (Divisional Chiefs). This not only allowed the Executive to make full use of the wide range of scientific expertise available when deciding broad priorities, but will also considerably facilitate the subsequent implementation of priorities.

The Organization will now examine what changes to the existing research effort are necessary in the light of the priorities determined. This will be done using procedures recently introduced by the Executive to give effect to its policy of concentration and selectivity. These involve the submission to the Executive by Institute Directors, following consultation with their Chiefs of Division, of significant proposals for initiation or expansion of research activities on the one hand or for their termination or reduction on the other.

While comprehensive reviews of major research sub-sectors will only be undertaken at intervals, subject and Divisional reviews provide an important means of reassessing priorities in the interim. These enable Directors and the Executive to evaluate the existing research effort and suggest new directions or emphases and complement the evaluations regularly conducted by Chiefs and their research staff. They have the additional advantage of subjecting internal decisions to external scrutiny and validation. Reviews of relevance to agricultural research which are under way include plant pathology, rangelands research, agricultural engineering, and the Division of Animal Health.

The comprehensive planning review has also provided the opportunity to assess in a broader context the priorities determined through the more specific on-going internal examinations, external reviews and assessments by Rural Industry Research Committees. In general there is a marked correlation between the priorities determined by these individual review processes and those adduced from the broad planning review. Consequently, there is broad consistency between existing research programs and the priority areas identified in the planning review. In the implementation phase, the main emphasis will be on the balance of effort among the priority areas.

Changes in emphasis resulting from implementation of priorities reflect the emerging opportunities afforded by significant scientific developments, the changing requirements of important areas of the agricultural industry, and particular regional require-

ments identified through planning and other review activities. These are reported in the appropriate Divisional, Institute or CSIRO annual reports.

As stated at the beginning of this chapter, there are important research areas not considered in this review which have a significant impact on agriculture. These include ecology of plants and animals, water, land use, processing of agricultural products, agricultural chemicals and veterinary products. Priorities for water research are reported in the chapter on 'Water'. Planning of CSIRO research for the other related activites will be reported in subsequent statements of policies and priorities.

Advisory Council Advice

The CSIRO Advisory Council's advice to the Executive on agricultural research and the Executive's response to this advice are reported in the chapter on 'Advisory Council and State and Territory Committees—Advice and Activities'.

4. Biotechnology

In July 1979, the Executive decided that biotechnology should be recognized as a high priority area of research for CSIRO. This recognition followed the report of a committee established to review recombinant DNA techniques. The decision was reinforced by a subsequent more broadly-based review, commissioned in 1980, covering the potential for industrial and research applications of biological systems generally. The second review committee report, Biotechnology for Australia, was presented to the Executive in June 1981.

The two review reports were updated and issued as a single volume, 'Biotechnology Research and Development', which was released in November 1981. The publication deals with the application of recombinant DNA technology to plant and animal breeding, and with the potential for biotechnology in Australia.

In the publication, the term biotechnology encompasses:

- industrial processes based on biological systems involving naturally occurring micro-organisms, micro-organisms that have been modified by genetic engineering, or isolated cells of plants or animals; and
- the genetic manipulation of cells to produce new strains of plants or animals.

Genetic engineering refers to the alteration of the genetic material of living cells so that they produce more or different products, or perform new functions. Such alterations may be achieved using recombinant DNA or induced mutation techniques. These methods enable the pool of genes available for breeding and selection to be widened.

The application of recombinant DNA techniques is of special relevance to CSIRO's research and the Executive has decided that high priority will be given to the continued development of these techniques.

To enable the Organization to undertake studies in the broader area of biotechnology, particularly investigations of the industrial applications of micro-organisms, the CSIRO Executive decided to create an industrial microbiology unit at Clayton, Victoria, to investigate the industrial applications of micro-organisms. It is envisaged that genetic manipulation of micro-organisms, including recombinant DNA techniques, will be explored for tailoring micro-organisms for particular industrial uses, including the conversion of raw materials such as starch and ligno-cellulose to high value products, and the treatment of industrial wastes, including waste water.

CSIRO undertakes genetic engineering research in the following areas:

- plant breeding and plant biology;
- animal breeding and animal biology;
- production of vaccines, hormones and rare proteins; and
- virology.

Plant Breeding

The genetic modification of plants by traditional cross-breeding procedures is restricted to the characteristics that already exist within the species. Natural barriers inhibit crosses between species and, within species, the transfer of desired genes is often accompanied by the increased probability of enhancement of deleterious factors. An extensive back-crossing program may be required to eliminate these. Recombinant DNA techniques may provide the capability to transfer genes or blocks of genes from one plant to another without these difficulties.

The goals of plant genetic engineering include:

- improving resistance of plants to diseases and insects;
- improving plant yields;
- increasing the nutritive value of cereals;
- increasing the tolerance of plants to drought and saline conditions; and
- enhancing the efficiency of photosynthesis.

Genetic engineering for plant improvement involves the isolation of a plant gene and its amplification in bacteria, followed by insertion into a recipient cell in a stable heritable form, then selection of the transformed cell and the regeneration of fertile plants. Since knowledge of the organization and function of plant genes and of the mechanisms regulating gene expression is still limited, each step is itself a subject for research.

Animal Breeding

The main drawbacks to the successful breeding of animals with desired characteristics are the long time-scales required by breeding programs, the limited gene-pool available and the failure of the physical characteristics (phenotype) of the animal to reflect exactly its genetic make-up (genotype). The goals for recombinant DNA techniques in animal breeding and animal biology therefore include:

- analysis of genetic information (genome) at the molecular level and the identification of desirable genotypes;
- genetic modification and transplantation of nuclei; and
- construction and manipulation of hybrid embryos.

In CSIRO's research, recombinant DNA techniques are being applied to the understanding of the genes which direct the synthesis of keratins, the proteins of which wool is composed, with the aim of breeding sheep with improved wool growing qualities. This research may also lead to the identification of the genetic factors that control wool shedding.

Similarly, the study of the structure and function of the genes that control the synthesis of key reproductive hormones may lead to improved reproductive efficiency.

Vaccines, Hormones and Rare Proteins

Recombinant DNA techniques have been used to analyse the genes which direct the synthesis of the major antigenic proteins of viruses. Cloning the appropriate gene in a bacterium (for example *E. coli*) or yeast may enable an effective and safe vaccine to be produced.

The availability of effective vaccines with minimal side effects is important in combatting diseases in animals, particularly diseases of economic significance.

Growth factors, which are hormones or proteins, are present in the body in small amounts. They act on specific tissue, causing it to proliferate or maintain its specialized function, or to direct its specialization and thus accelerate its development. These factors include growth hormone, epidermal growth factor, nerve growth factor, somatomedins and fibroblast growth factor.

Growth factors are of obvious significance in human medicine. They are also of considerable importance to the Australian rural sector, particularly in their potential application to improving livestock production. Recombinant DNA techniques offer the potential to produce these factors commercially.

One such factor, epidermal growth factor (EGF), has potential as a commercial wool defleecing agent, and research is under way to isolate the genes which direct the synthesis of EGF. The use of enzymes to synthesize EGF is also being explored.

Recombinant DNA techniques have potential for the production of specific diagnostic probes for plant and animal viruses of importance in Australian agriculture.

The research program at the Australian National Animal Health Laboratory (ANAHL) will include means of producing highly specific probes for the identification of exotic animal diseases.

Monoclonal antibodies, which are produced using cell fusion techniques, will complement DNA probes and will also have wide application in human medicine for diagnosis, tissue typing and immunotherapy.

Other Applications

The CSIRO report, 'Biotechnology Research and Development', identified other opportunities in the broader area of biotechnology. These opportunities are associated with a wide range of products and processes, and include the use of genetic engineering to manipulate micro-organisms. The conversion of raw materials

such as starch and ligno-cellulose to high-value products and the treatment of industrial wastes, are important examples.

The report also draws attention to the potential of microbiological processes for mineral recovery, including *in situ* leaching, and the tertiary recovery of oil. It also identifies the production of methanol from natural gas as a potential bioconversion process of considerable significance.

Conclusion

The Executive accepted the Committee's recommendation 'that high priority be given in CSIRO to the continued development of the techniques of genetic engineering'. Recommendations relating to particular applications of the techniques were endorsed by the Executive and referred to the appropriate Institute Director for implementation. A research group with expertise in microbial genetics, gene technology and industrial microbiology will be created.

Effective collaboration between industry, CSIRO and universities is recognized as a crucial factor in the successful realization of the potential of genetic engineering and biotechnology for Australian research and Australian industry.

In CSIRO's research so far, recombinant DNA techniques have been directed mainly to an understanding of gene organization in plants, and to the structure of genes which code for the keratin proteins of wool. The objective of research in gene manipulation, however, is the development of plants and animals with superior characteristics and better adaptation to the environment. Recombinant DNA and gene manipulation techniques are also being applied to the analysis of viral antigens with the aim of producing more effective vaccines, and to the production of growth substances. Recombinant DNA methods and cell fusion techniques are used for the production of specific DNA probes and of highly specific monoclonal antibodies as diagnostic agents.

Advisory Council Advice

The CSIRO Advisory Council's advice to the Executive on biotechnology research and the Executive's response to this advice are reported in the chapter 'Advisory Council and State and Territory Committees—Advice and Activities'.

5. Australian National Animal Health Laboratory

In 1980/81, production from the Australian livestock industry was provisionally valued at $6228M. It is vulnerable to the introduction of some twenty exotic livestock diseases. The introduction of an exotic livestock disease would affect the productivity and competitiveness of the industry and the availability of overseas markets for its products.

Construction of the Australian National Animal Health Laboratory (ANAHL) at Geelong, Victoria is scheduled for completion by March 1983. The Laboratory should be fully operational, following demonstration of microbiological security, by mid 1984.

The Laboratory is being built on a 36.03 ha site, 1.5 km east of the Geelong City centre. Construction commenced in March 1978 and is under the direction of the Department of Transport and Construction. The Department has contracted John Holland Constructions Ltd to act as Construction Managers. The completed cost of the facility was estimated in June 1982 to be $145M.

ANAHL's primary function is to provide a diagnostic service to support the control and eradication of exotic diseases of livestock should they occur in Australia. It will also be used to ensure that livestock imported into Australia from the high security offshore quarantine station at Cocos Island are free from exotic diseases. If required, the Laboratory will produce foot and mouth (FMD) and other vaccines requiring high security facilities. It will also have a substantial program of research on exotic animal diseases and will be used to train selected field veterinarians in the diagnosis of exotic diseases.

When fully operational the Laboratory will have a total staff of approximately 200, including 35 research staff. Annual operational costs were estimated in April 1982 to be of the order of $7M. Formal liaison with relevant Commonwealth and State Departments will be made through the Standing Committee of the Australian Agricultural Council and its sub-committees. The ANAHL Consultative Committee advises CSIRO on the operation of ANAHL. The ANAHL Security Assessment Group is being established to develop testing protocols, supervise security tests and develop security procedures, and thus provide the initial and continuing pronouncements about ANAHL's microbiological security.

ANAHL is the most complex and one of the largest projects ever undertaken by the Commonwealth. It will be the world's most microbiologically secure animal health laboratory. Its

commissioning will be an important milestone in the protection of the Australian livestock industry.

Importation of Live Exotic Disease Viruses

In its report in 1974 relating to the proposed construction of ANAHL, the Parliamentary Standing Committee on Public Works concluded, *inter alia*, that after a suitable proving period the Laboratory should be authorised to handle foot and mouth disease virus prior to an outbreak of the disease in this country. The conclusions of this report were accepted by Parliament in the same year.

In September 1979 the third meeting of the ANAHL Consultative Committee (Alternates) adopted the following resolution:

> 'This Committee is aware of international trends and improving confidence in FMD vaccines and believes it to be increasingly likely that vaccination would be used in Australia in any eradication campaign. Whether or not Australia becomes involved in a development such as the establishment of an international FMD vaccine bank, this Committee strongly recommends acceptance of the policy that ANAHL be used for research and development of FMD vaccines. As this would involve the handling of FMD virus in ANAHL in advance of any diagnosis or outbreak of the disease in Australia, this policy needs to be endorsed at the highest level'.

This resolution was endorsed by the Animal Health Committee of the Standing Committee on Agriculture, by Standing Committee itself, and finally by the Australian Agricultural Council in February 1980. Council's agreement to support the proposal to allow ANAHL to handle live FMD virus in advance of an outbreak was conditional upon completion of a satisfactory proving period for microbiological security. The Council also strongly endorsed a proposal that the livestock industries should be made aware of the reasons for this course of action and agreed that an extension campaign should be mounted jointly by the Commonwealth and States before ANAHL handled the virus.

Subject to the adoption of appropriate safeguards, the proposal was also supported at that time by two independent authorities—Sir Gustav Nossal (Director, Walter & Eliza Hall Institute of Medical Research) and Professor G L Ada (Head, Department of Microbiology, John Curtin School of Medical Research, Australian National University), whose views had been sought by the CSIRO Executive.

In view of these developments the CSIRO Executive advised the then Minister for Science and the Environment that it would be in the national interest for ANAHL to have access to FMD virus in advance of an outbreak. The Minister accepted this advice and

The Australian National Animal Health Laboratory under construction at Geelong, Vic.

wrote to the Ministers for Primary Industry and Health in July 1980 seeking their support for a joint approach to the Prime Minister for re-endorsement of the Parliament's 1974 decision. These Ministers agreed to support the proposal subject to appropriate safeguards and consultations with primary industry groups with a view to obtaining their support. A joint approach was then made to the Prime Minister who, on the basis of the advice provided by the three Ministers, re-endorsed Parliament's 1974 decision in November 1980.

The Ministers for Primary Industry and Science and Technology have since assured various producer groups that consultation with the livestock industry will occur before any exotic disease agent is introduced to ANAHL.

Consultation with Primary Producer Groups

CSIRO commenced formal consultation with the National Farmers Federation (NFF) on 27 August 1981 and has since maintained regular consultation with the NFF, its Commodity Councils and affiliated groups, and pig and poultry producer groups. However, there is still substantial opposition by producers to the introduction of live exotic disease agents, especially FMD virus.

There has been a natural concern among some livestock producers about the possible escape of live exotic disease viruses introduced to ANAHL. Unless the present lack of consensus by

primary producers and their organizations about the importation of live viruses in advance of an outbreak is resolved quickly, it could hinder the recruitment of scientists for ANAHL and the development of its research programs. This could mean that when ANAHL has been shown to be microbiologically secure (by about mid-1984) it will be inadequately prepared for an outbreak of exotic disease.

There has also been concern expressed by some scientists that the resources required to operate ANAHL might be at the expense of resources devoted to other areas of scientific research. For its part, CSIRO has continually advocated to Government the need for additional resources to be provided to meet the on-going costs associated with ANAHL's operations, and the Government has responded positively to the requests.

CSIRO has also sought to make a clear distinction between the concerns of scientists based on the resources question, and questions of a scientific nature concerning ANAHL, for example risk assessment, and the need for importation of live viruses in advance of an outbreak. Confusion over these differing aspects, and their differing motivations, do not assist primary producers in their deliberations, and the Organization has taken a number of steps to present factual scientific information in a readily comprehensible form.

CSIRO has acknowledged in correspondence with primary producer organizations that its desire to have access to FMD virus in advance of an outbreak is at variance with the original plan for ANAHL as accepted by the Australian Agricultural Council in 1970 and subsequently developed by CSIRO in its building proposal to Government in 1972. The reasons given for this change in policy are as follows:

- the improvement in the potency of FMD vaccines and developments in the use of vaccination of livestock as a means of FMD control;
- the greater knowledge acquired on the mechanisms of spread of FMD virus; and
- the greatly improved physical security measures developed for high security laboratories in the past decade.

CSIRO has requested the Committee reviewing its Division of Animal Health to investigate and report on the live virus import issue. This Committee, which is soon to report, has sought submissions widely from State Departments of Agriculture, Universities, the NFF and its Commodity Councils, and other bodies and individuals.

CSIRO is assisting the NFF to conduct a Forum at Geelong on 23/24 August 1982 at which the various issues relating to the import of live viruses will be debated. CSIRO expects that the NFF Forum will assist producer groups to clarify their attitudes to the import issue by the end of 1982. CSIRO is also contributing to the ASTEC Working Party's examination of this issue.

Conclusion

CSIRO believes importation of live FMD virus (and other exotic disease viruses) in advance of an outbreak to be essential for ANAHL to meet national needs in diagnosis, training and vaccine production in the event of an outbreak and during the subsequent eradication campaign. Improvements in diagnostic and control measures for exotic diseases are dependent on the recruitment of highly qualified staff and continued research. CSIRO would not wish to allow ANAHL to be in the position of having to tackle any possible exotic disease outbreak in the future without having taken adequate steps to ensure that the Laboratory was in the best possible position to do so.

CSIRO will continue to consult with interested groups about the importation of live viruses, including the ASTEC Working Party that is addressing the issue, and to provide appropriate documentation.

6. Water

As reported in the CSIRO Annual Report 1979/80, the Executive is giving priority to the expansion of water and soils research. Following further consideration of the matter, the Executive decided that expansion should take place over the next three years. In reaching this decision, it took into account the following national problems:

- increasing competition between urban, industrial, agricultural and recreational demands for water;
- increasing requirements for water, and the environmental and community impacts associated with prospective mining and energy developments;
- increasing salinity problems in particular regions;
- requirements for pollution control for health and environmental reasons; and
- rapidly escalating costs involved in harnessing water resources.

It is recognized that many of the problems that arise from the way Australia uses its water supplies, including those associated with the Murray-Darling system, require political, social or engineering solutions rather than research. However, the Executive believes that future long-term management will require information based on strategic research initiated now, and it is on this basis that a substantial build-up in such research capability by CSIRO is seen as necessary.

During 1981/82, proposals were put forward in Parliament for the creation of a new Water Research Institute. CSIRO believes that an orderly expansion of established research organizations represents a far more practical and cost-effective approach to meeting the needs of water research to the end of the century than the establishment of a new institution. In this way, Australia's current expertise, long experience and institutional arrangements related to water research matters will be further developed to provide a more complete understanding of water management problems unique to Australia.

These matters were canvassed in the Organization's submission in October 1981 to the review of water resources research being conducted under the auspices of the Australian Water Resources Council (AWRC). Organizational arrangements along the lines advocated by CSIRO were subsequently recommended to, and endorsed by, the AWRC and, as at June 1982, were under consideration by the Government. The AWRC also recommended

expansion of CSIRO's strategic water research activities, confirming the priority given by the Executive by such expansion.

In July 1981, the Executive commissioned a review of the Organization's water research activities with a view to identifying priority areas for future research, resources required to undertake this high priority work, and organizational and co-ordinational arrangements.

Research Opportunities

For planning its strategy for water resources research, the CSIRO Executive arranged for a special study and review by a working group to identify the major opportunities for CSIRO to contribute in this area. The working group, in approaching its task, explored the areas of concern identified by State authorities and others. Topics considered by the working group on which opportunities and needs for further research were identified are described briefly below.

- Salinity

  A long-term improvement of salinity concentrations in stream flow and the landscape can only be sustained by proper identification of the causes and processes involved. This identification is only possible by research concerning the physics and chemistry of salt mobilization and transport, and development of field techniques for the application of the appropriate sciences.

- Erosion

  In spite of erosion-control measures, there remain serious problems of soil stability related to the way soil accepts rainfall, and, when saturation occurs, the way the soil surface resists the mechanical and chemical effects of the free water moving across it. Proper understanding of the processes involved in water erosion and sediment transport is needed.

- Catchment hydrology

  Great difficulties are encountered in quantifying the spatial variability of those characteristics which affect the hydrology of catchments. Determination of rainfall inputs, variations in infiltration rates and storage capacity of soils as well as the way in which heterogeneous vegetation evaporates soil moisture all require greatly increased research effort.

- Agricultural water management

  Methods of applying water for agriculture are based on simplicity and convenience rather than efficiency. Australian irrigated soils are by world standards shallow, relatively impermeable and with low available water storage capacity. Significant research and development is required into irrigation methods and management tools and strategies which will

optimize growth of irrigated crops under Australian conditions.

- Limnology and management of freshwater ecosystems

  Little is known of the consequences of Australian inland water bodies of increased levels of salinity, eutrophy and turbidity. Those studies that have been completed point to the possibility of accelerating deterioration and difficulties. The interactions between biological, physical and chemical processes which constitute the ecology of water bodies under Australian conditions are of prime importance for the development of viable management policies for natural and man-modified aquatic environments.

- Management strategies in storage, regulation and supply of surface waters

  Water supply management is influenced by complementary and sometimes conflicting economic and social considerations. Escalating costs for developing new resources and increased competition for existing water supplies place severe constraints on management options available to operating agencies. In addition, limitations are also being enforced on the sources for new supplies due to conflicts between the requirements for the use of catchment land and for the production of usable water resources.

  Research needs are seen to be the development of simulation techniques for management options and the technological resolution of management conflicts between biological and social requirements.

- Groundwater hydrology

  Groundwater reserves provide a great deal of water in Australia for urban and agricultural use. In some situations the aquifers are so permeable and extensive that their current use is unrestricted but, with time, serious consideration will need to be given to aquifer management.

  Major difficulties are encountered in the assessment of a groundwater resource, and the delineation of its extent and its long-term sustainable yield. Similarly, techniques for enhancing the recharge of significant aquifers require research inputs.

- Water quality criteria

  The establishment of water quality criteria for different forms of water use is a matter for determination by the users, and CSIRO would not be expected to be involved beyond the provision of advice and, if necessary, appropriate data. However, specific criteria to be used for setting the quality of effluent discharge waters depend upon the effect of the effluent on natural systems. To be able to select the most effective criteria for this purpose, greater knowledge is required of the environmental consequences, demanding fundamental studies that could fall within CSIRO's role.

- Environmental impact of water development

  Proper environmental impact assessment should take into account all aspects of all the preceding topics. Many are ill understood and research is necessary for reliable environmental impact assessment.

  Research opportunities exist for the development and utilization of environmental data banks for design and assessment of water resources, and for the development and application of environmental assessment methodologies for water resource in the Australian environment.

- Water and wastewater treatment, disposal and reuse.

  This area of research is increasing in importance as water supplies from unalienated catchments become more fully exploited and man's activities impose stresses on many streams, particularly within those catchments where waste-producing activities occur. There is also the need to investigate possible harmful by-products of conventional treatment processes.

  Stress is developed on water supply agencies through increased demand for and deteriorating quality of supply resources. Increased costs of supply and penalties for discharge of untreated waste make the development of recycling techniques more attractive for many industrial processes. Ultimately, sewage effluents will have to be utilized by industry.

  Increasingly, future water supplies will have to make use of lower quality natural waters. Turbidity and colour, together with microbial pollutions, are the most serious contaminants, followed by alkalinity and hardness, salinity, nitrate and fluoride. Major strategic research opportunities exist for the devising of new water purification processes.

Future Developments

CSIRO is conducting a review of the environmental problems of the Murray-Darling Basin. This review is aimed at:

- identifying those areas and issues most in need of scientific investigation; and
- determining how CSIRO's research can best be directed to providing possible solutions to the problems.

The Executive will use the review to develop research programs specifically aimed at ameliorating the salinity and water use problems of the region.

Priority Areas for Expansion

Significant research opportunities and needs exist in all the areas examined by the CSIRO working group. However, the Executive decided that immediate expansion of its research in the three important areas of salinity and other quality aspects, groundwater, and catchment hydrology was essential.

The Organization believes that expansion of its research in these areas will enable the generation of the information needed for effective long-term planning and management of those aspects of Australia's water resources that are of national importance. In the expanded program of research, a strong emphasis will be given to these aspects and to the separate but related problems involved in predicting catchment behaviour on the basis of short-term records. The main issues in these three areas are described briefly below.

Salinity and Other Quality Aspects

A large proportion of Australia's soils contains high levels of water-soluble salts. Normally the interaction of vegetation and climate results in only local areas of saline soil. However, changes in the management of land and vegetation have resulted in substantial relocation of salts and caused harmful effects in a wide range of urban and agricultural enterprises.

In the long term, ways of reducing salt concentrations in streams and soils will require identification of the causes of salinity and the soil processes involved. Research is needed in order to develop strategies for controlling the distribution of water soluble salts in potentially saline and alkaline landscapes, and for managing the 'sacrificial' areas needed for the disposal of high-concentration saline water. Research on the transport of salt and water in soils of high colloid content will be central to this program.

The salinity of municipal and industrial water supplies is a particular problem for Australia; salt is also the major contaminant restricting the reuse of water. In addition, there is a pressing need for more economical methods of desalting low-salinity waters.

Research is also needed into the non-salinity aspects of water quality such as turbidity, chemical and microbiological pollutants, the reuse of water for human and industrial consumption, and the development of management policies for multi-purpose natural and man-modified aquatic environments.

Groundwater

Groundwater resources provide about 20 per cent of Australia's water supplies and this proportion is increasing as full development of surface water resources is approached in some regions. The greatest use of groundwater occurs in populated areas of the east coast, the south-east and south-west. Moreover, much of the inland is totally dependent on local groundwater for domestic uses, irrigation, consumption by stock, and mineral processing.

Almost every known groundwater problem occurs in Australia. Some of the more important ones are:

- over-development of the resource;
- deterioration of quality due to waste disposal, other sources of pollution and salt water intrusion; and
- waterlogging and salinity of surface soils and water due to land use changes and/or inefficient irrigation practices.

Many factors contribute to the existence of these problems, including inadequate data on local aquifer characteristics and

inadequate understanding of the physical, chemical and biological processes in soil and groundwater systems. More effective management of our groundwater resources is now needed, and the need will increase as aquifers are further stressed by pumpage, industrial and mining waste disposal, and land development in intake areas.

A significant expansion of research is needed to improve groundwater management in Australia. CSIRO's research will concentrate on the following:

- the mechanics of groundwater systems, including the transport of chemicals, other materials and heat in groundwater; and
- the development of better methods for estimating and managing the rate of replenishment of groundwater.

Catchment Hydrology

The objectives of the Organization's catchment hydrology studies are to improve understanding of how the characteristics and use of a landscape affect the quantity and quality of the water that flows from it, and to use this knowledge to predict catchment behaviour as a guide to land and water management and engineering design.

Studies directed towards improving our understanding of the processes that determine the water balance of a landscape need to be undertaken.

These processes include rainfall; soil characteristics such as infiltration behaviour and storage; and plant characteristics including, interception, evapotranspiration and root zone properties. Since so many diverse processes are in operation, it is often difficult to predict catchment behaviour accurately.

Organization of Water Resources Research in CSIRO

CSIRO's existing water research programs have been seen as lacking focus because they are distributed across a wide range of Divisions and localities. This has raised questions about the relevance of CSIRO research to the perceived needs of potential users of this research. As a result there has been pressure from interested parties, both inside and outside the Organization, for CSIRO to establish a single Division of Water Resources Research. There are a number of practical and scientific reasons why this is inappropriate, the most significant being that water research involves many scientific disciplines and fields of application, cutting across CSIRO Institute and Divisional boundaries.

Water research in CSIRO will continue to be conducted in more than one Division but the focus of water research is being sharpened, the level of coordination raised, and the internal and external transfer of information on water research greatly improved. The objectives for water research in each relevant Division have been re-assessed and, where necessary, redefined by reference to the recently-determined Organization-wide perspective.

The Executive decided that organizational changes were

essential if the expanded program of research in the three important areas of salinity and other quality aspects, groundwater, and catchment hydrology were to be undertaken effectively. These changes were effected during June 1982. They include:

- The establishment of a Division of Groundwater Research with headquarters in Perth. The Division has been created from a nucleus of research staff carrying out research related to groundwater from the previous Division of Land Resources Management. The Division forms part of the Institute of Energy and Earth Resources, and has the following objectives:
  - to investigate the physical and chemical processes affecting the quality and quantity of groundwater, including natural interactions between surface water, groundwater, soils and rocks; and the responses to man-made factors such as mining, waste disposal, agriculture, artificial recharge and pumpage.
- The Division of Land Use Research in Canberra has become the Division of Water and Land Resources. Its existing effort in water resources research is to be strengthened and will include cooperative research programs with the Divisions of Plant Industry and Forest Research. All three Divisions form part of the Institute of Biological Resources. The Division of Water and Land Resources is to be concerned principally with catchment and water quality (including salinity) research. A senior scientist is to be recruited to lead the enhanced water group.
- The Division of Irrigation Research, located at Griffith, NSW, is no longer a separate Division. Its facilities are now known as the CSIRO Centre for Irrigation Research. The Centre is under the control of an Officer-in-Charge who reports directly to the Director, Institute of Biological Resources. The creation of an Institute research centre will facilitate active interdisciplinary research collaboration with other CSIRO research groups in several fields dealing with irrigated agriculture and water resources management and will give the Centre a clear identity of national significance.

  Of the existing research programs at Griffith, the two concerned with physics and biology of the soil/water zone system and management of irrigation water in rural ecosystems will be strengthened and will continue at that location. Of the remaining research activities, some will be progressively phased out, while the continuation of others will depend on the availability of external research grants.
- The water research activities of the Divisions of Soils and Environmental Mechanics in Canberra will be strengthened.
- Support will continue for the research being conducted by a group in the Institute of Industrial Technology concerned with water purification and reuse. The group is remaining in Melbourne.

Resources

The level of additional resources required to enable effective programs to be undertaken in these areas was determined as part of the review of water research activities. Ideally, it would involve an increase in the 1980/81 expenditure of some $4 million, rising to an amount of some $8 million over a three-year period. This level of expansion would require the allocation by Government of additional resources to CSIRO. Approaches will be made to Government, through means including consultative and advisory mechanisms currently under consideration, to obtain additional resources. In the interim, the Organization will expand its research in the three priority areas more modestly by redeployment of resources from other areas of lower priority.

In 1982/83, the Executive will allocate 16 additional positions, withdrawn from other research areas of lower priority, to the three priority water areas. In allocating the 16 positions and in implementing the organizational changes referred to above, the CSIRO Executive is putting into effect its commitment of the past two financial years to enhance the water research conducted by the Organization.

Arrangements for Co-ordination of Water Research

The Executive also concluded that improved co-ordination of water research activities was needed both within CSIRO and with other agencies involved in water research or with policy responsibilities for water resource matters. To achieve internal co-ordination, the Executive decided to establish a Water Research Committee to co-ordinate CSIRO's water research and review CSIRO's effort in this field annually. The Committee will report direct to the Executive.

The Organization also proposes improved arrangements for consultation with the Department of National Development and Energy (including the Bureau of Mineral Resources, Geology and Geophysics (BMR) and the Australian Atomic Energy Commission), and with the Bureau of Meteorology within the Department of Science and Technology, to facilitate the policy co-ordination of the total national water research effort.

While detailed arrangements are still to be finalized, CSIRO reached agreement in 1982 with the Department of National Development and Energy on appropriate arrangements for rationalization of groundwater research. With respect to BMR, the following agreement has been reached for each organization's involvement in groundwater research:

> BMR undertakes groundwater research in connection with the assessment of groundwater resources, and with the study of geological processes, particularly as they relate to the formation and modification of mineral deposits, including

hydrocarbons. Its research into groundwater as a commodity is concerned primarily with geological aspects as they affect distribution and quality. Emphasis is on sedimentary basin and fractured rock aquifers. This accords with BMR's role as a geoscientific research organization.

CSIRO undertakes research involving the interrelationship between surface water and groundwater in studies of environmental and land use aspects of groundwater use by the community and industry and of effects on groundwater of industrial and mining activities; research on groundwater analysis as a technique for mineral exploration is also undertaken. This accords with CSIRO's role in undertaking research in relation to mining, agriculture and other industry and on the environment and matters of broad community interest.

Detailed arrangements for ensuring complementarity of the two organizations' groundwater research will be instigated and monitored through the proposed co-ordination arrangements.

Policies for Water Research

The Executive's policies for water research are reflected in the foregoing statements concerning priorities, organizational arrangements, research resources and arrangements for co-ordination. In summary, these are:

- CSIRO will continue to give high priority to water research as an area of national importance warranting expansion of strategic research effort;
- water research activities which will be given the highest priority for expansion are salinity and other quality aspects, groundwater, and catchment hydrology;
- water research will continue to be conducted in a number of Divisions but the focus for CSIRO's water research will be sharpened, the level of internal co-ordination raised, and the transfer of information on water research, both internally and externally, will be improved;
- Divisional arrangements for water research have been reorganized to provide this sharper focus;
- the total CSIRO water research effort will be better co-ordinated through establishment of appropriate internal consultative arrangements;
- arrangements will be made with the Departments of National Development and Energy and Science and Technology to facilitate co-ordination of the Commonwealth's water research effort; and
- CSIRO will continue to press Government for additional resources for expansion of its water research effort and, in the interim, will redeploy available resources to realize a moderate expansion of such work.

Advisory Council Advice

The CSIRO Advisory Council's advice to the Executive on water resources research and the Executive's response to this advice are reported in the chapter on 'Advisory Council and State and Territory Committees—Advice and Activities'.

7. Minerals

Agreement on the Role of CSIRO and BMR in Minerals Research

CSIRO and the Department of National Development and Energy reached agreement early in 1982 on arrangements for rationalization of minerals research with the Bureau of Mineral Resources, Geology and Geophysics (BMR) and for future liaison on the particular topic of minerals exploration research in the two organizations.

This agreement stemmed from Government decisions in 1978 on the report of the Independent Inquiry into CSIRO and in 1979 on the future role of the BMR. The former confirmed CSIRO's role in undertaking research, primarily of a strategic nature, for the mining industry, and the latter set a future role for BMR as a geoscientific research organization with a substantial capacity to undertake strategic research. The following is the text of the agreement.

> Following the Government's decisions confirming CSIRO's national role in strategic research and BMR's enhanced role in geoscience research, the activities of both bodies were examined. In view of the great importance of the mineral industry to the Australian economy and the relatively low level of the total research effort, there is a need for the complementary research activities of the two organizations to continue in accordance with their traditional roles and recent Government decisions relating to them. The expectations of industry and State governments also need to be taken into account.
>
> BMR's research has been, and will continue to be, developed from the perspective of regional studies in order to provide the geoscientific basis for the development of successful exploration programs by private industry. Thus, research into mineralization and the formation of ore bodies, and into the occurrence and genesis of fossil fuels, including the application of all available techniques to geological problems, is central to BMR's role and is primarily BMR's responsibility. CSIRO will collaborate with BMR where appropriate in areas where such studies are especially relevant to the development of exploration techniques.
>
> Although the development of exploration techniques is also appropriate to BMR's role, it is recognized that CSIRO has established itself strongly in this area, particularly through its Division of Mineral Physics. Research into the initiation and

development of instrumental techniques, both geochemical and geophysical, to assist the exploration industry in the search for ore deposits, will continue to be primarily the role of CSIRO but with the collaboration of BMR as appropriate. BMR will, in particular, collaborate with CSIRO in the development and testing of techniques as an adjunct to its regional studies.

It is recognized that it will take BMR several years to develop its research role fully and that it will take CSIRO several years to re-order its priorities and programs in accordance with this functional rationalization. It is also recognized that there will be some inevitable and desirable overlap in the broad fields of interest of the two organizations as identified above. Accordingly, a Minerals (Exploration) Research Liaison Committee (MERLCO) was established in May 1982, for the purpose of facilitating the rationalization process. MERLCO consists of the Directors and senior scientists of the CSIRO Institute of Energy and Earth Resources and the Bureau of Mineral Resources respectively. It will provide advice to the CSIRO Chairman and the Secretary, Department of National Development and Energy. The consultative mechanism represented by MERLCO will prevent duplication of effort and will allow research in areas of legitimate mutual interest to be undertaken through collaborative projects.

Reviews of CSIRO Minerals Research

A major review of the Divisions of Applied Geomechanics and Mineral Engineering and CSIRO research in mining, mineral processing and extractive metallurgy was completed during the year. The main decisions made by the Executive on the review committee's recommendations are reported in the chapter on Reviews. Also, as reported in that chapter, a review has commenced of the Division of Fossil Fuels and of fossil fuels research in CSIRO.

8. Atmospheric sciences

The Government, in its decisions in 1978 on the report of the Independent Inquiry into CSIRO, recognized the Organization's role in climatology and atmospheric research, and noted the need to rationalize CSIRO's work in these areas with that of the Bureau of Meteorology. It was recommended in the Review of Commonwealth Functions report in 1981 that the Minister for Science and Technology place high priority on completing the process of rationalization.

The Department of Science and Technology, the Bureau of Meteorology and CSIRO advised the Minister for Science and Technology that the basis for rationalization should be:

- CSIRO's primary role will be to carry out research into physical and chemical aspects of atmospheric processes and phenomena, especially basic aspects and those related to environmental, industrial and community needs and problems, bearing in mind the role of the Bureau;
- the Bureau will have primary responsibility for research in support of its operations and services, and for liaison with the World Meteorological Organization on relevant Australian research;
- the Australian Numerical Meteorology Research Centre (ANMRC), which is run jointly by CSIRO and the Department of Science and Technology, will close before, or at, the expiration in October 1985 of the agreement under which it currently operates and staff will be re-absorbed into CSIRO and the Bureau;
- the operation of the Australian Ozone Monitoring Network will transfer from CSIRO to the Bureau at the end of June 1982;
- regular consultative meetings will be held between CSIRO and the Bureau at appropriate levels.

The Chairman of the Review of Commonwealth Functions approved this as a satisfactory response to the Review's recommendation.

The review of the Division of Cloud Physics and the subsequent, wider review of atmospheric science in CSIRO are reported in the chapter on 'Reviews'.

9. Computing

A Computing Policy and Facilities Advisory Committee was formed in April 1979 to advise the Executive on a number of policy issues associated with the Division of Computing Research and the operation of the CSIRONET computing network. The Committee, which included both internal and external members, focused on CSIRONET as a computing service.

In December 1981, the Executive endorsed a set of recommendations arising out of the Committee's report as policy for the future development of computing services in CSIRO.

Consequently, the opening paragraph of the CSIRONET charter, which reflects the Executive's policy on computing services, was amended. The revised charter is as follows:

> The Division of Computing Research (DCR) will, in accordance with policies determined by the CSIRO Executive in the normal way, be responsible for the development and operation of CSIRONET computing service and for undertaking research in computing.
>
> DCR will have the responsibility for the research into, and development and provision of, computing services including a specialist consultative service.
>
> DCR will give priority to the introduction and provision of advanced computing services (i.e. those not available commercially in Australia) of benefit to Australian Science, Government or industry.
>
> DCR may provide a range of standard computing services (as a by-product of advanced services) unless directed by the Executive not to provide particular services.
>
> DCR services will be available to arms of Government, tertiary educational institutions and industry. During periods when a service is overloaded, preference will be given to established users of that service.
>
> CSIRONET service charges will be set at such a level that the projected revenue meets all estimated direct and indirect costs. CSIRONET will recognize categories of users for the purpose of service charges. Charges made for standard computing services provided to trading companies, societies or individuals will be comparable with commercial bureau rates. Actual categories and charges will be determined by the Executive on the recommendation of the Chief, Division of Computing Research.

In addition, the Executive endorsed the Committee's recommendations relating to monitoring computing developments

throughout the Organization, including the acquisition of equipment. In relation to the future acquisition of equipment, the Executive decided that the Chief of the Division of Computing Research, in consultation with a policy committee on computing, should produce as soon as possible a plan for equipment options and the development of the computing system as the basis for the future development of CSIRONET.

Other decisions by the Executive were that Divisions may develop in-house computing facilities; that the Division of Computing Research should be consulted on acquisition proposals estimated to place the expenditure within the Major Items of Equipment category (currently $25 000); and that proposals for any further expansion of the network would require Executive approval.

The Executive also decided to establish a Policy Committee on Computing whose membership would include the appropriate Member of the Executive as chairman, the Director of the Institute of Physical Sciences and one other Director, the Chief of the Division of Computing Research and one other Chief of Division, the Director of the Bureau of Scientific Services, and the Secretary (Finance and Administration). The Term of Reference for this Committee is 'to advise the Executive on, and of, computing policy issues related to CSIRO and CSIRONET'.

A review of the research activities of the Division of Computing Research is also being undertaken by a separate committee. The review committee is examining, in particular:

- research into the application of computers in science and engineering being undertaken in CSIRO, and the effectiveness of the interactions between participating CSIRO Divisions, including the Division of Computing Research;
- the future direction and organizational arrangements for CSIRO research in computing and related areas;
- the needs, costs and benefits of setting up a scientific computation service, separate from the Division of Computing Research and with adequate processing capacity, to provide computing and associated advisory services to all Divisions of CSIRO; and
- opportunities for increased interaction and collaboration between the Division of Mathematics and Statistics and the Division of Computing Research, and the need for any rationalization of the work of the two Divisions.

10. Reviews

CSIRO's research effort is examined regularly through program, Divisional and subject reviews. Divisional and subject reviews are considered by the Executive. Those that have been considered or initiated during the year are discussed below.

Reviews of Divisions and Units are concerned with their roles, research priorities and management, and examine the effectiveness and efficiency with which their objectives have been met over the period of review, usually five to seven years. The opportunity is also taken to examine national priorities for research in the Division's or Unit's areas of interest.

Subject reviews are concerned with broad areas of national interest, and occasionally with major scientific disciplines, and aim to assist the Executive in determining policies and priorities for research in the relevant area. They form part of the Organization's strategic research planning system which was described in CSIRO's annual reports for 1979/80 and 1980/81.

Completed Reviews of Divisions and Units

Division of Animal Production

As reported in the 1980/81 annual report, the review committee's report on the Division of Animal Production was submitted to the Executive in June 1981. The Executive endorsed a number of proposals of the review committee, including the creation of a new Division of Tropical Animal Science.

The research of this new Division, which has its headquarters in Brisbane, is concerned with improving the efficiency of tropical cattle production by studying the linked problems of adaptation, nutrition, reproduction and disease in the tropical and sub-tropical environments of Queensland, the Northern Territory and Western Australia. At a later stage, research on sheep production in the arid tropics may be initiated.

Until recently, CSIRO's work in tropical animal science was carried out in the Divisions of Animal Production, Animal Health and, to a lesser extent, the Divisions of Entomology and Tropical Crops and Pastures. The new Division comprises the former Brisbane laboratory of the Division of Animal Health, the Rockhampton laboratory of the Division of Animal Production, and a nutrition group to be established at Townsville in association with the Division of Tropical Crops and Pastures. Some of the Division of Entomology's Brisbane staff have also joined the new Division. The total staff of the new Division is about 180, including some 50 professional scientists.

Research on tropical animal health will be largely centred at Brisbane, physiology and genetics at Rockhampton, and nutrition at Townsville. However, the three groups will collaborate, especially on immunological and nutritional characteristics which influence animal selection criteria.

The restructured Division of Animal Production is continuing its work in temperate Australia of extending the understanding of basic processes in livestock, with emphasis on ruminants; devising ways to manipulate these processes for increasing productivity and meeting the demands of the marketplace; and contributing to the solution of nationally-important problems of livestock production. In so doing, it will continue to place emphasis on medium- to long-term interdisciplinary strategic research for Australia's livestock industries.

The Executive endorsed the review committee's positive assessment of the role of the Division of Animal Production and the quality of its research. In particular, it has agreed that the Ian Clunies Ross Animal Research Laboratory at Prospect should continue as a centre of excellence for research on ruminant nutrition, reproductive physiology, fleece and skin biology, and genetics. However, it also directed that increased attention be given to the national problems of Mediterranean-zone livestock, and requested the Chief to review the Division's involvement in several areas—notably the Australian Milking Zebu program and pig and poultry research—and to reduce the present effort where appropriate.

Divisions of Applied Geomechanics and Mineral Engineering

As foreshadowed in the 1980/81 annual report, the committee reviewing the Divisions of Mineral Engineering and Applied Geomechanics reported to the Executive in September 1981. The review, which was undertaken in advance of the retirement of the then Chief of both Divisions, was aimed at evaluating the Organization's contribution to the minerals industry, the community and the national and international objectives of mineral science and engineering. The review committee also reported on:

- CSIRO's ability to anticipate the research requirements of the industry;
- the effectiveness of liaison between CSIRO and the industry, with particular reference to the communication of research results; and
- possible research activities for CSIRO in the fields of mining, mineral processing and extractive metallurgy, fields which included research in the two Divisions under review and allied research in the Divisions of Fossil Fuels, Mineral Chemistry, and Mineral Physics.

The review committee stated that several advances in mining technology, achieved through field-based research carried out jointly by the Division of Applied Geomechanics and the Australian Mineral Industries Research Association, had received

international recognition. Although the committee noted an industry-wide consensus that the research program of the Division of Applied Geomechanics has been successful, it concluded that the scientific basis and management of the Division's research should be improved. The Division is renewing its efforts to develop the basic science of geomechanics as it applies to mining, and provide a common framework for the conduct of research into coal and metalliferous mining. Within this framework the Division will continue to undertake large, field-oriented research and development projects.

Of the mineral processing and extractive metallurgy research conducted by the Divisions of Mineral Engineering and Mineral Chemistry, the review committee noted that work in the electrochemical field and in ore dressing has an international reputation, but that the work of the two Divisions should be better coordinated. Consequently, the Director of the Institute of Energy and Earth Resources is considering expanding the mineral processing work of the Division of Mineral Engineering to include the use of the QEM*SEM (quantitative evaluation of minerals by scanning electron microscopy) equipment that is being developed by the Division of Mineral Chemistry, including appropriate staff transfers. The new Chief of the Division of Mineral Engineering and the Chief of the Division of Mineral Chemistry will formulate medium-term research programs in consultation with the Director.

To obtain constructive comment and criticism from the mineral industry in the planning of research programs, the Review Committee recommended improved planning processes at both Institute and Divisional levels. Those for the Divisions will be put into effect but those for the Institute are being considered further in view of the need for them to complement the Executive's strategic planning activities for the whole Organization.

The Organization is examining the review committee's recommendations on the coordination of research on mining, mineral processing and extractive metallurgy among the Divisions conducting it and with related research elsewhere in CSIRO, and the location of those Divisions. Options include some research groups sharing sites with interested tertiary institutions.

Division of Building Research

A review of the Division of Building Research was initiated in mid-1981, following Executive consideration of a series of associated reviews which had touched on the organization and operation of the Division. These reviews included:

- the 1979 review of Forest and Forest Product Problems;
- the 1980 review of Wood Science in CSIRO;
- the reviews, also in 1980, of the Divisions of Chemical Technology and Mechanical Engineering; and
- the 1981 Executive review of Institute structures.

These reviews, and the Executive's decisions on the review committee's recommendations, pointed to the need for reconsideration of the role of the Division, especially in the light of

other changes in the Divisional and Institute structure of the Organization.

The major tasks of the review committee were to examine the Division's objectives and programs in the light of national needs and priorities for building and construction research, to consider the quality and effectiveness of the Division's research and management, and to recommend on the Division's organization and management, and the priorities of its research programs.

The review committee reported to the Executive in February 1982. It noted the extent of national needs in building and construction research, and concluded that the Division had a significant role to play in meeting a range of those needs. It also noted that research in building and construction needed to concentrate increasingly on problems that span more than one scientific discipline, or that address the relationships between industries in the sector rather than problems within those industries. Accordingly, the review report recommended that the Division should continue to exist, and should continue to direct the emphasis of its programs towards interdisciplinary research rather than work on individual disciplines and industries. There should also be a continuation of the current organizational initiatives within the Division, involving the creation of supra-disciplinary groups of researchers, to facilitate the change of emphasis.

The Executive endorsed the bulk of these recommendations in May 1982. The Executive noted recent changes in the organization of research for the industry, arising in part from Government decisions in early 1981 on Commonwealth involvement in building and construction research, and decided that initiatives to increase industry contributions to building research, through promotion of an industry research association, should be pursued. Also, the question of the promotion, in the longer term, of a contract research organization for the industry should be pursued.

Division of Cloud Physics

The Division of Cloud Physics was reviewed in late 1980, in anticipation of the retirement of the Chief of the Division. The major tasks of the review committee were to examine the Division's objectives and the extent to which they were being achieved; to report on the Division's rainmaking program and the use of its aircraft for rainmaking and other studies, and to advise the Executive whether to continue the Division's activities and, if so, to advise on its future role, organization and resources.

The review committee submitted its report to the Executive in May 1981. The report noted the world-class work of the Division in its field, particularly cloud seeding for rainmaking. It noted, however, that research (including the Division's own work) had shown that meteorological conditions in many areas of Australia are either not conducive to the success of present cloud-seeding techniques, or are so variable that results are inconclusive. The review report also noted that, since aircraft costs were rising well above the general inflation rate, it had become increasingly

difficult to justify the cloud-seeding program in terms of its economic benefit to agriculture. The review committee therefore recommended that the Division should cease to be actively engaged in cloud-seeding experiments.

The review committee also noted that the role and future of the Division was closely connected with CSIRO's efforts in the atmospheric sciences generally, particularly the work of the Division of Atmospheric Physics. It proposed that the Division should continue as a separate entity within CSIRO, provided a suitable appointment to the position of Chief of the Division could be made. If such an appointment could not be made, the committee proposed that the future of the Division should be re-examined concurrently with an early full review of the Division of Atmospheric Physics.

The Executive agreed, in September 1981, that cloud-seeding experiments should be discontinued. In view of the potential interaction between the remaining work of the Division of Cloud Physics and atmospheric science research in other CSIRO Divisions, the Executive decided to defer a decision on the future of the Division. It agreed that a wide-ranging review of atmospheric science research in CSIRO should be undertaken. Should it be decided ultimately to retain the Division, its future objectives should, as recommended in the review committee's report, centre on the physical study of clouds and cloud processes on all scales, and their relation to precipitation, air pollution and climate.

Division of Irrigation Research

An internal review of the Division of Irrigation Research was commissioned by the Executive in June 1981 following an examination of the Organization's Institute structure. The review committee concluded that the value to CSIRO of the Griffith location for irrigation research lies in the opportunities afforded for research and field studies into agricultural, hydrological and biological problems associated with the main irrigation areas of south-eastern Australia.

The Executive accepted the recommendation that the research emphasis should be in the two important fields of:

- physics and biology of the soil/water/root zone system; and
- management of irrigation water in rural ecosystems.

The Division of Irrigation Research will not continue as a separate Division but a CSIRO Centre for Irrigation Research will be formed as a separate unit of the Institute of Biological Resources. The Centre will facilitate interdisciplinary research collaboration with other CSIRO research groups undertaking work in these fields of water resources management and irrigated agriculture.

Division of Mathematics and Statistics

A review of the Division of Mathematics and Statistics was initiated in 1980, in anticipation of the end of the term of appointment of the Chief of the Division. The review committee's tasks were to advise the Executive on the Division's objectives, and on the

research, management and organization of the Division in pursuit of those objectives, and on ways of improving mathematical competence within the Organization generally.

The review committee reported to the Executive in June 1981. The committee's report noted the excellent work of the Division since its last review in 1972, and the strength of its mathematical research effort. The report proposed that changes should be made in the objectives and organization of the Division in order to meet the changing needs for mathematical and statistical skills throughout the Organization. These changes would focus the Division's research on a small number of research areas of potential general applicability to the work of other CSIRO Divisions, improve the Division's interaction with other Divisions, encourage other Divisions to perform for themselves more of the straightforward statistical analyses, and give greater emphasis to the internal and external monitoring and evaluation of its projects.

The Executive, in September 1981, accepted this proposed new direction for the Division. The Division's new objective is to apply statistics and other appropriate mathematics in support of research throughout CSIRO and to conduct research related to such application. In pursuing these objectives, the staff of the Division will collaborate in research projects with other Divisions, pursue appropriate statistical and mathematical research, and provide consultative services.

A reorientation of effort and reorganization has been necessary to achieve this objective. In future, research will be more closely connected with the Division's consultative role. Also, the Division's computational and applied mathematics activities are to be strengthened.

Division of Textile Industry

A review of the Division of Textile Industry was conducted in late 1981 prior to the end of the term of appointment of the Chief of the Division in February 1982, and Executive decisions were made in April 1982.

The Executive endorsed the review committee's principal recommendations that the Division should continue in its present form with its main objective being to improve wool's position as a textile fibre on the world market for the benefit of the wool-producing industry. The Executive also approved the overall research strategy of the Division and the relative priorities of its programs. A broadening of the Division's objectives, to encompass the use of other fibres in conjunction with wool and to encourage further stages of wool processing in Australia, was referred for investigation to the Director of the Institute of Industrial Technology. The existing Chief of the Division was reappointed by the Executive for a further seven-year term.

Wheat Research Unit

In May 1981 the Executive commissioned a review of the Wheat Research Unit in anticipation of the retirement of the Officer-in-Charge in February 1983. Following the review, the Executive

concluded that the Unit was making an important contribution to Australia's research effort on wheat quality. The Executive agreed with the main recommendations of the review committee, which were that the Unit should:

- continue to undertake research directed at providing more definitive information on the relationship between grain composition and quality, for the benefit of the Australian industry and the users of Australian wheat and other cereals;
- extend its work where appropriate to other food grains;
- discontinue work on the biology of the developing and mature cereal grain and on the wet milling of wheat grain;
- continue as an independent Unit within the Institute of Animal and Food Sciences; and
- continue its close association with the Bread Research Institute.

The Executive decided that on the retirement of the Officer-in-Charge of the Unit, who is also Director of the Bread Research Institute, CSIRO should appoint an Officer-in-Charge of the Wheat Research Unit with clear terms of reference and for an initial period of seven years. The Executive also agreed in principle with the concept put forward in the review of a Research Advisory Committee and asked the Director of the Institute of Animal and Food Sciences to explore this concept with the Bread Research Institute.

Divisional Reviews in Progress

Division of Animal Health

In view of the impending retirement of the Chief of the Division of Animal Health, a review of the Division commenced in April 1982. In addition to its examination of the Division's research programs, the review committee is considering especially:

- the management of ANAHL, its inclusion within the Division, and its research program and activities which were endorsed in principle by the Executive in September 1980, with particular reference to the need to import live exotic animal disease viruses into the Laboratory; and
- with due regard to the responsibilities and activities of other groups in CSIRO and other organizations within Australia and overseas, the future direction and appropriate institutional arrangements for those activities for which a continuing need is identified; this may include comment on the continued existence of the Division, and the assessment and, if necessary, redefinition of the Division's role in contributing to the research needs of relevant industry sectors or community interests appropriate to CSIRO.

The scope of the review includes the activities of the Long Pocket Laboratories, previously in the Division of Animal Health but now in the new Division of Tropical Animal Science.

Division of Fossil Fuels

A review of the Division of Fossil Fuels is being undertaken prior to the end of the seven-year term appointment of the Chief in August 1982.

In particular, the review committee is examining:

- the objectives and relative priorities that should be set for fossil fuels research programs; and
- appropriate institutional and management arrangements for carrying on fossil fuels research programs.

Division of Materials Science

Divisions are generally reviewed at about seven-year intervals. As the Division of Materials Science was last reviewed in 1975 the Executive has commissioned a review.

In particular, the review committee will:

- advise on the extent to which the present objectives of the Division are being achieved;
- comment on the relations with other CSIRO Divisions, industry, academia, and those elements served by the Division; and
- advise on the future role of the Division and its relationships with industry, universities, research organizations, and other outside bodies.

Division of Protein Chemistry and the Molecular and Cellular Biology Unit

Arrangements have been made to jointly review the Division of Protein Chemistry and the Molecular and Cellular Biology Unit prior to the completion of the terms of office of the Chief and Officer-in-Charge respectively. A joint review is to be conducted because of interrelated activities of the Division and the Unit. The review is due to commence in September 1982.

The review committee will examine, in particular:

- the extent to which the objectives and programs of the Division of Protein Chemistry and of the Molecular and Cellular Biology Unit accord with relevant national needs and reflect current or emerging scientific opportunities, with particular reference to those needs or opportunities to which CSIRO should respond and to priorities for future research;
- the relationship of the fields of science, objectives and activities of the Division and the Unit, both with each other and with other groups in the Organization, particularly in the Institutes of Industrial Technology and Animal and Food Sciences; and
- future organizational and management arrangements for the Division and Unit.

Division of Textile Physics

A review of the Division of Textile Physics is being undertaken preparatory to the retirement of the Chief of the Division early in 1984.

In particular, the review committee will examine:

- the extent to which the objectives and work of the Division complement or overlap those of the Divisions of Textile Industry and Protein Chemistry;

- ways in which the work of these three Divisions is coordinated with other national and international wool research and textile research generally; and
- the likely future needs for research in this general area of applied physics.

Completed Subject Area Reviews

Biotechnology

The review of biotechnology is presented in Chapter 4.

Forest and Forest Products Problems

Reference was made in the 1978/79 annual report to the ad hoc review committee established by the Executive to advise on the nature and relative importance of the various problems of Australian forests and of the forest products industries. The committee was requested to consider both wood and non-wood uses of forests in relation to their economic and social significance to the nation, and to give particular attention to those problems likely to benefit from scientific research.

Consequent upon the wide-ranging nature of the review, the recommendations made by the committee were pertinent to several Divisions involved in forest-related research and these were subsequently reviewed. The committee's recommendations were then taken into consideration in the Executive's decisions that followed the reviews of the Division of Forest Research (reported in the 1979/80 annual report), of Wood Science and the Division of Chemical Technology (reported in the 1980/81 annual report), and of the Division of Building Research (reported earlier in this chapter).

The only recommendation yet to be decided upon by the Executive concerns a proposal to provide development and consultative services for the forest conversion industries. While the Executive recognizes the importance of these services to the forest harvesting, sawmilling and further processing operations, further examination is needed of the most effective way of providing such services. This examination is being made as part of a wider consideration of CSIRO's role in the processing and manufacturing industries.

Action on the outcome of this examination will complete CSIRO's response to the review committee's recommendations. These were aimed at strengthening the Organization's role in providing a scientific basis for the balanced management of Australia's forests and for the provision and utilization of wood and related products.

This is an important task in view of Australia's limited resource of natural forest, the increasing demand being placed upon this resource for wood production, recreation and conservation, and the significant changes that are occurring in the nature and location of the resource. The changes include an increasing proportion of softwood production compared with hardwood, and

a continuing increase in the proportion of timber used in forms reconstituted from fragments compared with sawn timber.

A planning review, now in progress, will provide the basis for the Executive to formulate an overall policy on research priorities for forestry and related industries.

Organizational Arrangements for Research in Western Australia

In May 1981, following consideration of the reviews of the Divisions of Land Resources Management and Land Use Research, a committee was established to enquire into, and advise on, future organizational arrangements for these Divisions and for CSIRO's activities in Western Australia, particularly priorities for water research (see p.45 of the CSIRO Annual Report 1980/81). The investigation also included an examination of the possibility of building-up CSIRO's research effort in Western Australia, particularly research into crops and pastures, soils, forests and animal production.

The recommendations made by the committee were endorsed by the Executive in May 1982, subject to some minor amendments. The Executive's decisions include:

- The dissolution of the Division of Land Resources Management and the establishment of a Division of Groundwater Research (see the chapter on 'Water'). The Chief of the previous Division of Land Resources Management, will be the Chief of the new Division, which will have its headquarters at Floreat Park, Perth.
- The attachment of the research staff of the previous Division of Land Resources Management (other than those transferred to the new Division of Groundwater Research or engaged in arid and semi-arid lands research) to the Divisions of Forest Research, Animal Production and Plant Industry, according to their research expertise.
- The establishment of a CSIRO Laboratory for Rural Research (Perth), which will be concerned with a range of research programs. The Laboratory will also provide facilities for Divisional research teams, the scientific direction of which will be the responsibility of the respective Chiefs of the Divisions. The Laboratory will be managed by a committee of the Laboratory's senior research scientists, whose Chairman will have overall responsibility and will report direct to the Director of the Institute of Biological Resources.

  Consideration is being given to the establishment in Perth of a branch of the Division of Soils. The possible involvement of the Division of Wildlife Research in the Laboratory's program is also being discussed.
- Arid and semi-arid zone research undertaken by the previous Division of Land Resources Management will continue at Alice Springs and Deniliquin pending the outcome of the review of arid and semi-arid zone research and its location (see below).
- A further examination will be made of the agricultural research needs of the Mediterranean climate regions of Australia,

particularly Western Australia, with a view to determining what expansion of such research by CSIRO may be desirable and feasible (see the chapter on 'Agriculture').

Overseas Scientific Liaison

Following reference to overseas scientific liaison in several recent reports to Government, the Executive, in June 1980, commissioned a review of this activity for which CSIRO had been responsible since the establishment of offices in Washington and London in 1942. Offices were established in Tokyo in 1971 and in Moscow in 1975. Although in April 1981 the Government decided that, following a recommendation of the Committee of Review of Commonwealth functions (RCF), the liaison offices in London and Washington should be closed, it was decided that the review should be completed.

The review report was published in July 1981. The committee concluded that:

- there was continuing need for permanent Australian scientific representation in London, Washington, Tokyo and, when operative, Moscow;
- the emphasis of CSIRO Divisional needs was on administrative assistance, e.g. recruitment, visitors and a base for overseas studies, while Departments and agencies demonstrated a need for policy and operational services and advice on trends in science and particularly technology;
- the offices suffered from a lack of policy direction, shortage of staff and too wide a range of functions and interests;
- minimum staffing in London, Washington and Tokyo should be one Australia-based scientist, one locally-engaged graduate assistant and a locally-engaged secretary: staffing in Moscow should be considered when scientific contact with the USSR was resumed;
- links should be established with Australian Missions having no scientific representation;
- the question of responsibility for overseas scientific liaison should be re-examined. It was subsequently agreed that the function should be transferred to the department of Science and Technology; and
- liaison officers should be scientists.

The remaining post in Tokyo continues to be staffed by CSIRO, pending the outcome of a review by the Public Service Board of staffing at several Australian overseas missions.

Water Resources Research

The Executive's decision on the review of water resources research are reported in the chapter on 'Water'.

Subject Area Reviews in Progress

Agricultural Engineering

It was noted in the 1980/81 annual report that an investigation would be made of research requirements and opportunities in the

field of agricultural engineering. An internal review was undertaken on agricultural engineering in Australia for the purpose of identifying uniquely Australian problems that present strategic research opportunities suitable for CSIRO, and which could be considered in conjunction with the report of the former Commonwealth Council for Rural Research and Extension on agricultural engineering R & D in Australia.

The review committee's terms of reference were:

- to examine the state of agricultural engineering in Australia with a view to identifying uniquely Australian problems;
- to identify which of these problems present strategic research opportunities suitable for CSIRO; and
- in the light of the preceding term of reference, to advise the Exeuctive on the future of agricultural engineering research and development within CSIRO.

The review report has now been received and is under consideration by the Executive.

Arid and Semi-arid Lands Research

CSIRO's research into arid and semi-arid lands is conducted at the Rangelands Research Centre, Deniliquin, New South Wales, and the Central Australian Laboratory at Alice Springs. It formed part of the work of the previous Division of Land Resources Management which was reviewed in 1981. The committee which reviewed the Division made a number of comments about the arid and semi-arid lands research, particularly the need for the relocation of the Deniliquin, NSW, group to a more appropriate site at which the work could be done more effectively. A decision was deferred by the Executive pending the outcome of other related reviews.

It was agreed, however, that a working group of staff from the Deniliquin Centre and the Alice Springs Laboratory should advise on the objectives and priorities for arid lands research and to propose appropriate organizational options. The working group's report was submitted to the Chief of the then Division of Land Resources Management in March 1982, and passed to the Executive with his comments and those of a number of State/Territory and University experts who were invited to review the report.

Executive consideration is proceeding and, as indicated above, under 'Review of Organizational Arrangements for Research in Western Australia', arid and semi-arid zone research is continuing in its present form pending a decision.

Atmospheric Sciences

In view of the interactions between the work of the Division of Cloud Physics and other atmospheric science research in CSIRO, a decision on the future of the Division was deferred pending a wide-ranging review of atmospheric science in CSIRO (see also the item above on the review of the Division of Cloud Physics). The review commenced in late 1981, and had the following terms of reference:

- to examine the objectives, research, management and organization of the Division of Atmospheric Physics and its relations with other bodies;
- to advise the Executive on the appropriate research role for CSIRO in atmospheric sciences, taking into account the activities of other bodies;
- to advise the Executive on the optimal disposition of resources devoted to CSIRO's atmospheric research, and on appropriate organizational arrangements, including the question of continuation of the Division of Atmospheric Physics as an autonomous unit.

Commercial Activities

The Executive has commissioned a review of the Organization's commercial activities. The review committee will examine:

- CSIRO's policies, procedures and administrative arrangements for its technology transfer function in relation to the results of its own research and, in particular, the use of collaborative arrangements, property rights and corporation powers for this purpose.

International Activities

A review of CSIRO's international relations activities, which was associated with the impending retirement of the Officer-in-Charge of the Centre for International Research Cooperation, was commissioned late in 1981 and conducted in early 1982. The report of the review committee was submitted in May 1982 and is awaiting consideration by the Executive.

The terms of reference of the review are to examine the scope and nature of the international relations activities in which CSIRO is involved at present, or is likely to become involved in during the next five years, and to report on appropriate administrative and organizational arrangements for undertaking those activities.

Plant Pathology

During 1981, the field of plant pathology was designated by the Executive as having high priority for expansion. A review of plant pathology was commissioned by the Executive to provide advice on priorities for plant pathology research in the Organization.

For the purposes of the review, plant pathology research has been defined as studies concerned with micro-organisms such as fungi, nematodes, bacteria, mycoplasmas, viruses and viroids causing deleterious effects in plants, and with the alleviation or prevention of these effects. The breeding and selection of plants showing tolerance or resistance to diseases have been included in the scope of the review. Other disorders of plants, such as those due to moisture and heat stress or to nutrient imbalance, are not included.

The review committee has been asked to examine:

- the scope of existing plant pathology research in Australia;
- the present involvement of CSIRO in plant pathology research, and the quality and appropriateness of this work;

- specific areas of plant pathology research which should be undertaken or strengthened and which would be appropriate for attention in Australia and by CSIRO in particular;
- the priorities which should be allocated to these areas and to existing areas of plant pathology research in CSIRO;
- the ability of existing research groups in CSIRO to undertake the additional plant pathology research indicated above and the possibilities for redeployment of existing skills into this field;
- the additional resources required to meet each of these new or expanded research tasks; and
- means of maintaining adequate liaison and initiating cooperative research programs between CSIRO groups and those in other organizations in the light of the responsibilities of these bodies.

11. Organization

On 30 June 1982, CSIRO had a total staff of 7426 in more than 100 locations throughout Australia. About one-third of the staff are professional scientists, with the others providing technical, administrative or other support. An organization chart appears overleaf. A map showing the geographical distribution of CSIRO's locations and study sites is enclosed at the back of this report.

Executive

CSIRO is governed by an Executive comprising three full-time members, one of whom is Chairman, and five part-time members. The Chairman is the chief executive of the Organization and 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.

Research Institutes

The research work of the Organization is carried out in five Institutes, each headed by a Director. Institutes are groupings of Divisions and Units with related research interests. The latter are headed by Chiefs and Officers-in-Charge respectively. Divisions and Units are each responsible for a coherent set of research programs, with Units generally being responsible for narrower fields of research and having fewer staff than Divisions.

Directors are responsible to the Executive for the management of their Institutes, with particular emphasis on priorities and objectives for research programs and on organizational arrangements. Chiefs and Officers-in-Charge are responsible to their respective Directors for the management of their Divisions and Units, with particular emphasis on scientific leadership and the day-to-day allocation of resources to achieve approved objectives. In addition, all Directors, Chiefs and Officers-in-Charge participate through committees and reviews in organizational decision-making beyond the confines of their immediate responsibilities.

Support Services

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

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

Policy and administrative support services are provided to members of the Executive and Directors by the Organization's central administration as follows:

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

The Executive is supported by an Executive Committee comprising the three full-time members of the Executive and the Directors of the Institutes, assisted by the heads of the three arms of the Organization's central administration.

Objectives, Fields of Research and Functions

The broad objectives and fields of research or functions of the various CSIRO Institutes and their component Divisions and Units, the Bureau of Scientific Services and the Planning and Evaluation Advisory Unit are given later in this chapter. A more detailed account of the objectives of current CSIRO research may be found in the publication 'Directory of CSIRO Research Programs 1982'.

Organizational Changes

Energy Research

Reference was made in the 1980/81 CSIRO Annual Report to the Government's decision, taken in the context of its Review of Commonwealth Functions, to reorganize and intensify energy research by transferring to CSIRO resources from the research establishment operated by the Australian Atomic Energy Commission (AAEC) at Lucas Heights, Sydney.

The Government decided that the AAEC should concentrate on nuclear research and that staff and resources surplus to this requirement should be transferred to CSIRO. It was also decided that CSIRO would establish an Institute of Energy and Earth Resources, largely committed to energy research, and that elements transferred to CSIRO would be co-located at Lucas Heights with the modified AAEC research establishment, and that the Ministers

for National Development and Energy and Science and Technology would share responsibility for the overall nature and direction of CSIRO's energy research.

The Ministers are advised on their joint responsibilities by a policy committee comprising the Permanent Head of the Department of National Development and Energy and the Chairman of CSIRO. This policy committee is supported by an Energy Liaison Group comprising representatives of the Department of National Development and Energy and CSIRO, with representation from the AAEC as required.

In March 1982 the Ministers approved a broad plan of action, agreed between CSIRO and the AAEC, for the transfer of resources and arrangements for co-location. It was agreed that 333 positions, including 77 research professionals, were surplus to requirements for nuclear research. These positions will come to CSIRO, either as staff actually transferred to the Organization or as equivalent man-years of effort. Arrangements have been made to transfer funds from the AAEC to CSIRO and for the utilization of buildings and services on the site itself. A joint management board, comprising the Director, AAEC Research Establishment, and the Director, Institute of Energy and Earth Resources, will be responsible to the Commission and to CSIRO for the day-to-day operational aspects of co-location. The Lucas Heights site is now known as the Lucas Heights Research Laboratories.

In addition CSIRO has:

- established an Institute of Energy and Earth Resources, comprising the bulk of the former Institute of Earth Resources and the majority of the resources transferred from the AAEC;
- established a Division of Energy Chemistry at Lucas Heights;
- augmented the Division of Mineral Physics;
- established a Division of Energy Technology with headquarters in Melbourne, comprising a portion of the former Division of Mechanical Engineering and a small number of ex-AAEC staff located at Lucas Heights; and
- augmented the Division of Chemical Physics by a small group working at Lucas Heights.

The objectives of the new Divisions are listed later in this chapter.

Other Organizational Changes

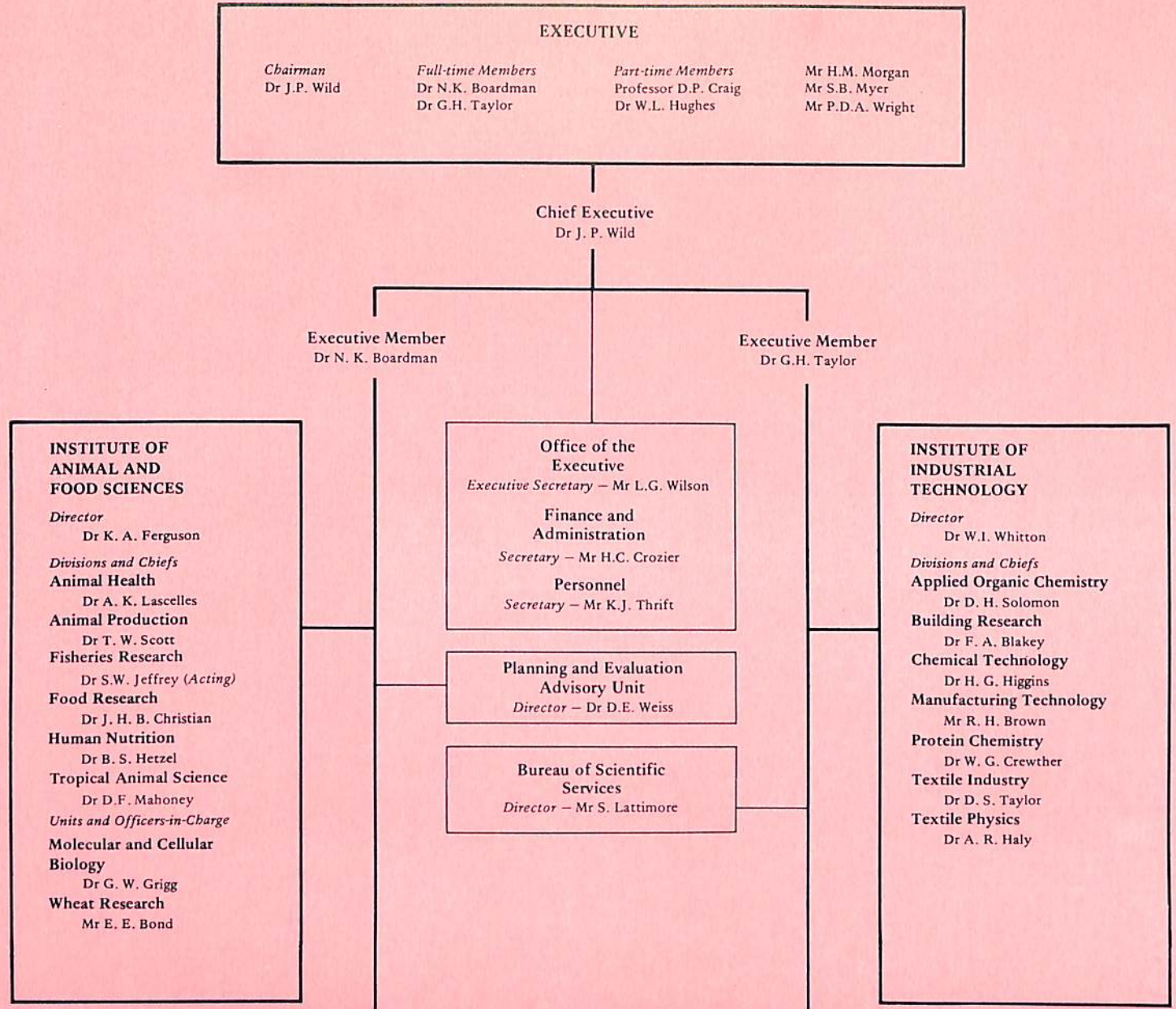
The following Divisional changes occurred this financial year:

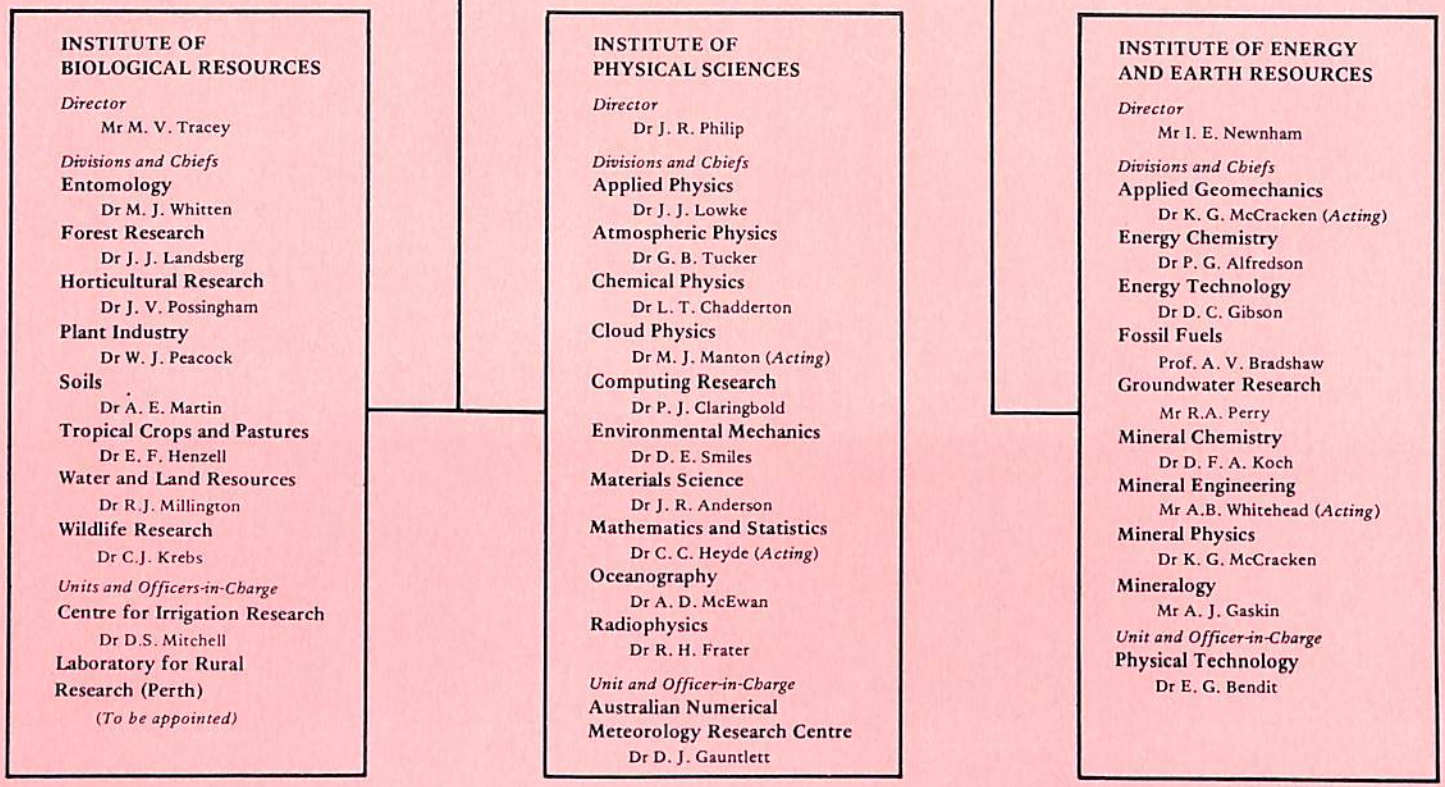
- Division of Mechanical Engineering—closed 31 August 1981
- Division of Energy Chemistry—formed 1 September 1981
- Division of Energy Technology—formed 1 September 1981
- Division of Tropical Animal Science—formed 1 March 1982
- Division of Land Use Research—closed 11 June 1982
- Division of Land Resources Management—closed 11 June 1982

- Division of Irrigation Research—closed 11 June 1982
- Division of Groundwater Research—formed 11 June 1982
- Division of Water and Land Resources—formed 11 June 1982
- Centre for Irrigation Research—formed 11 June 1982
- CSIRO Laboratory for Rural Research—formed 11 June 1982.

Details of these changes are reported in the chapters on 'Water', and 'Reviews', and the aims of the new Divisions, Centre and Laboratory are outlined in the following pages.

As mentioned in the 1980/81 annual report, the former Institute of Earth Resources was restructured to form the Institute of Energy and Earth Resources.


EXECUTIVE
Chairman
Dr J.P. Wild
Full-time Members
Dr N.K. Boardman
Dr G.H. Taylor
Part-time Members
Professor D.P. Craig
Dr W.L. Hughes
Mr H.M. Morgan
Mr S.B. Myer
Mr P.D.A. Wright
Chief Executive
Dr J. P. Wild
Executive Member
Dr N. K. Boardman
Executive Member
Dr G.H. Taylor
INSTITUTE OF ANIMAL AND FOOD SCIENCES
Director
Dr K. A. Ferguson
Divisions and Chiefs
Animal Health
Dr A. K. Lascelles
Animal Production
Dr T. W. Scott
Fisheries Research
Dr S.W. Jeffrey (Acting)
Food Research
Dr J. H. B. Christian
Human Nutrition
Dr B. S. Hetzel
Tropical Animal Science
Dr D.F. Mahoney
Units and Officers-in-Charge
Molecular and Cellular Biology
Dr G. W. Grigg
Wheat Research
Mr E. E. Bond
Office of the Executive
Executive Secretary — Mr L.G. Wilson
Finance and Administration
Secretary — Mr H.C. Crozier
Personnel
Secretary — Mr K.J. Thrift
Planning and Evaluation Advisory Unit
Director — Dr D.E. Weiss
Bureau of Scientific Services
Director — Mr S. Lattimore
INSTITUTE OF INDUSTRIAL TECHNOLOGY
Director
Dr W.I. Whitton
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
Protein Chemistry
Dr W. G. Crewther
Textile Industry
Dr D. S. Taylor
Textile Physics
Dr A. R. Haly



Organization Chart

The chart shows the structure of CSIRO as at 30 June 1982.

Institute of Animal and Food Sciences

The Institute comprises the following Divisions and Units:

Division of Animal Health
Division of Animal Production
Division of Fisheries Research
Division of Food Research
Division of Human Nutrition
Division of Tropical Animal Science
Molecular and Cellular Biology Unit
Wheat Research Unit.

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

The Institute's activities include research on:

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

Division of Animal Health

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

Division of Animal Production

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

Division of Fisheries Research

The Division undertakes strategic and resource-oriented research on marine biology and ecology, ocean productivity, and the population dynamics of commercial and potentially commercial species.

Division of Food Research	The Division's research is related to maintenance of the quality of meat, fish, dairy, fruit and vegetable foods throughout the chain of events from production to consumption. Microbiological safety, nutritional value, flavour and appearance are among the aspects of quality involved. Processing and storage methods are examined with a view not only to improving final quality, but also to avoiding or utilizing wastes and reducing the energy and labour costs of processing and handling.
Division of Human Nutrition	The Division studies nutritional processes with a view to identifying the existence and health consequences of nutritive imbalances and deficiencies in Australian diets. Its research includes experimental studies in developmental biology and in metabolism and digestion, and epidemiological and behavioural studies with emphasis on the relations between nutrition, lifestyle and human health.
Division of Tropical Animal Science	The Division carries out research to help the animal industries of northern Australia, particularly the extensive beef cattle industry, to improve their productivity. Its research is mainly in the fields of genetics, health, nutrition and reproduction.
Molecular and Cellular Biology Unit	The Unit's research is concerned with 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 man and animals.
Wheat Research Unit	The Unit's primary objective is to improve understanding of grain quality, with particular reference to wheat. It is also studying the chemical modification of wheat proteins for new industrial uses.

Institute of Biological Resources

The Institute comprises the following Divisions and Groups:

Division of Entomology
Division of Forest Research
Division of Horticultural Research
Division of Plant Industry
Division of Soils
Division of Tropical Crops and Pastures
Division of Water and Land Resources
Division of Wildlife Research
Centre for Irrigation Research
CSIRO Laboratory for Rural Research (Perth).

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

The Institute's activities include research on:

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

Division of Entomology

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

Division of Forest Research

The Division's research programs on forest resource characterization, forest management, forest ecology, tree breeding and genetics, and harvesting are designed to supply a scientific basis for the balanced

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

Division of Horticultural Research

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

Division of Plant Industry

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

Division of Soils

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

Division of Tropical Crops and Pastures

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

Division of Water and Land Resources

The Division has the broad aim of promoting better use of water and land resources in Australia. Its water research is particularly concerned with catchment hydrology, and with salinity and other aspects of water quality, with a view to improving conservation and management practices. The Division provides Commonwealth, State and local authorities responsible for water and land use decisions with improved methods of gathering, processing and using information on resources. To this end, the work is concerned with techniques for managing and surveying natural resources, for evaluating them for a range of possible uses, and for making decisions about the use of resources.

Division of Wildlife Research	The main objective of the Division is to understand the biology of vertebrates, both native and introduced, in relation to wildlife management and pest control. The general objects of the research are to study the status and basic biology of species and their interactions with their environments, to provide information about fundamental principles of animal ecology, behaviour and physiology, and to show how this knowledge may be applied to the management of wildlife populations.
Centre for Irrigation Research	The Centre is concerned with improving productivity of irrigated crops and the efficiency of water use management. Its main research programs are concentrated on physical, chemical and biological processes in the soil/water/root zone system in irrigated, fine-textured soils, and on management of the water resources. Other research is concerned with energy-conserving methods for greenhouse crop production and with oilseed breeding.
CSIRO Laboratory for Rural Research (Perth)	The Laboratory includes Perth-based staff of the Division of Forest Research (Institute of Biological Resources) and the Division of Animal Production (Institute of Animal and Food Sciences).

Institute of Energy and Earth Resources

The Institute comprises the following Divisions and Units:

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

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

The Institute's activities include research on:

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

Division of Applied Geomechanics

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

Division of Energy Chemistry

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

Division of Energy Technology

The Division undertakes engineering research directed towards the balanced use of Australia's energy resources; its activities cover industrial thermodynamics, fluids engineering, transportation research, and numerical modelling systems.

Division of Fossil Fuels

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

Division of Groundwater Research

The Division investigates the physical and chemical processes affecting the quality and quantity of groundwater, including natural interactions between surface water, groundwater, soils and rocks, and responses to man-made factors such as mining, waste disposal, agriculture, artificial recharge and pumpage.

Division of Mineral Chemistry	The Division's expertise is in physical and inorganic chemistry and extractive metallurgy. Its research is aimed at identifying and solving problems in the mineral industry and various other problems—related to energy, for example—that affect the community as a whole.
Division of Mineral Engineering	The Division conducts theoretical and practical studies aimed at developing methods for improving and controlling industrial processes. Particular emphasis is placed on processes used for the treatment and handling of ores and mineral products.
Division of Mineral Physics	The Division applies fundamental principles of physics, engineering, mathematics and geology to the identification and solution of problems in the mineral industry.
Division of Mineralogy	The Division develops its expertise in the geological sciences—particularly in geochemistry, mineralogy and petrology—with the aim of solving problems encountered, or expected, in exploration for ore bodies and economic minerals
Physical Technology Unit	The Unit's research is aimed at solving specific problems associated with the recovery and utilization of coals, the processing of minerals, and the transport in inland waters of trace metals arising from mining activities.

Institute of Industrial Technology

The Institute comprises the following Divisions:

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

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

The Institute's activities include research on:

- purification of water, waste-water and sewage;
- substitute liquid fuels;
- industrial microbiology;
- specialty polymers and resins;
- biologically-active chemicals;
- building materials;
- building and design of urban communities;
- safety and comfort in domestic and industrial environments;
- new and improved technology in metals fabrication;
- automated production technology;
- utilization of forest and other lignocellulose resources;
- preservation and properties of wood;
- properties, processing and use of wool and leather;
- agricultural engineering.

Division of Applied Organic Chemistry

The Division's particular expertise is in organic chemistry, physical chemistry and polymer science. Its activities are directed to developing alternative sources of energy, to studying 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 plastics materials with special structures for specific end-uses in industry and commerce.

Division of Building Research

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

Division of Chemical Technology

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

preservation; fibre separation and pulping; development of pulpwood resources; cellulose-based composite materials; the use of chemical and biological systems for converting ligno-cellulose to animal feed, chemicals and energy, particularly liquid fuels; the development of agro-industrial systems; and technologies for purifying and recycling water.

Division of Manufacturing Technology

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

Division of Protein Chemistry

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

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 relationship 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.

Division of Textile Physics

The principal task in the Division of Textile Physics is research and development for the Australian wool industry; major efforts are directed towards (i) research on the measurement, specification and handling of raw wool to achieve economies in packaging, transport, marketing and processing and (ii) improvements in processing and end-use arising from new techniques and studies of the physical properties of textile fibres, yarns and fabrics. Non-wool work is confined at present to the use of textiles for filtration, especially of industrial particulates from air and flue gases.

Institute of Physical Sciences

The Institute comprises the following Divisions and Units:

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

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

The Institute's activities include research on:

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

Division of Applied Physics

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

Division of Atmospheric Physics

The Division's principal object is to determine the characteristics of and the processes within the atmosphere and its interactions with land and sea surfaces in order to provide an improved understanding

of weather, climate and atmospheric phenomena generally that may provide a scientific basis for better predictions of weather and climate and for more efficient control of pollution.

Division of Chemical Physics

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

Division of Cloud Physics

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

Division of Computing Research

The Division provides advanced scientific and technical computing services for CSIRO Divisions, government departments and some universities through the CSIRONET computing network. This links the central computers in Canberra with smaller computers in all State capitals and other centres in various parts of Australia. The Division also conducts research concerned with the development and application of advanced computer operating systems, picture processing and graphics, simulation languages and simulation techniques, data-base management systems, and the design of Very Large Scale Integrated (VLSI) circuits.

Division of Environmental Mechanics

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

Division of Materials Science

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

Division of Mathematics and Statistics

The Division develops mathematical models and statistical methods for the solution of 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 Oceanography

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

Division of Radiophysics

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

Australian Numerical Meteorology Research Centre

The Centre is a joint unit of CSIRO and the Department of Science and Technology. It develops numerical models 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.

Bureau of Scientific Services

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

The Bureau consists of the following four units:

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

The Bureau's activities include:

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

Central Information, Library and Editorial Section (CILES)

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

Centre for International Research Cooperation (CIRC)

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

Commercial Group

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

the use of CSIRO's corporate powers.

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

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

Science Communication Unit

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

Planning and Evaluation Advisory Unit

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

The functions of the Unit are to:

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

12. Consultative Council and personnel policies

Consultative Council

The CSIRO Consultative Council was established by section 56 of the Science and Industry Research Act 1949. The Council's functions are 'to consider, and to report to the Executive on, any matter affecting, or of general interest to, the officers of the Organization, including any such matter that is referred to the Council by the Executive'.

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

The Council's fifth meeting was held on 14 October 1981, and the sixth was held on 21 April 1982. The venue for both meetings was Canberra. Mr E.P. Wright, Assistant Federal Secretary of the Australian Public Service Association (Fourth Division Officers), was Deputy Chairman of the Council for these meetings.

The Council's sub-committee on Flexible Working Hours completed its final report in October 1981. The Council had established the sub-committee in 1978 'to examine, and report to Council on, the Organization's experiments with flexible working hours and make recommendations as to whether, and if so in what form, flexible working hours should be adopted within the Organization by the Executive'.

Experiments with revised patterns of attendance were first introduced in CSIRO in 1973. Following the evaluation of the original trials in 1975, the Executive agreed to further trials throughout the Organization, based on a ten-day fortnight. These trials were reviewed by the sub-committee in 1981.

Following recommendations from the Council, the Executive approved the formal adoption of a common flexible working hours scheme to operate throughout the Organization. The new scheme incorporates the main characteristics that had applied satisfactorily to 80% of CSIRO staff during the trial phase. It is designed to ensure that satisfactory levels of work, communications and services are maintained at all times during standard hours. Special conditions apply at some remote stations and tropical locations in northern Australia.

The Council has been concerned for some time with new initiatives in relation to staff counselling and personal counselling. Further progress occurred during the year in establishing a sound basis to ensure that the Organization's staff counselling scheme achieves a high standard of effectiveness. A continuing series of seminars for supervisory staff in specific counselling skills has been conducted at various CSIRO locations during the year. In keeping with one of Council's earlier recommendations, a personal counselling service was established for a trial period of twelve months. A part-time senior personal counsellor was appointed in Canberra in March 1982. By 30 June 1982, part-time personal counsellors had also been appointed in Melbourne and Sydney.

Other Council activities are progressing, with the sub-committees on staff amenities, the employment of women, and technological change likely to complete their work in 1982/83. Other items that the Council is considering include:

- the Organization's retirement policies;
- changes in Institute and Divisional structures;
- the Executive's approach to managing the Organization's resources, including the ratio of support to professional staff; and
- disciplinary procedures.

Personnel Policies

A number of selected areas of personnel management are reported on briefly in this section.

Staff Grievances

In September 1981 the Executive introduced a new formal procedure for resolving staff grievances. CSIRO officers had long had the right to raise with the Chairman grievances about their employment. However, in the light of the work of the Royal Commission on Australian Government Administration, the Executive accepted the views of staff associations that it was desirable that the machinery for resolving grievances be formalized and action be taken to give staff a wider understanding of their right of access to grievance procedures.

The new grievance procedure is intended to:

- facilitate the resolution of grievances at the workplace, where this is possible;
- ensure that grievances are properly channelled and investigated;
- provide for the thorough investigation of complaints with the object of resolving them as speedily as is practicable;
- complement other mangement processes of supervision, staff counselling and staff development; and
- be simple and easily understood by officers.

Where grievances are not resolved at the workplace, they are referred to the Chairman of the Organization for central review. An

independent part-time position of Staff Mediator has been created to assist the Chairman in resolving complex grievances. The Staff Mediator acts as an intermediary, providing advice and assistance to staff and management alike. The mediator plays the role of conciliator and, where practicable, devises mutually satisfactory solutions to problems. The Executive, however, remains the ultimate arbiter on staff grievances. The new procedure is to be reviewed after twelve months' operation.

Staff Training and Development

The Organization's approach to staff training and development was described in Chapter 8 of the CSIRO Annual Report 1978/79. Key features include:

- emphasis on retraining and broadening staff job skills and interests;
- a decentralized approach to identifying and meeting training and development needs; and
- monitoring the success of the staff training and development programs.

The Executive concluded that a more fundamental review of CSIRO's staff training and development needs, and the extent to which these needs are being met, is warranted. A senior university expert was commissioned to conduct the review. He is being assisted by a senior staff development executive from a large technology-based private company and by a group of senior CSIRO managers who together form a steering committee; this committee is chaired by Dr N.K. Boardman, a full-time Member of the Executive.

The terms of reference for the review are:

1. to identify and describe CSIRO's present and likely future staff training and development needs;
2. to assess the extent to which present needs are being met and the extent to which likely future needs will be met by the Organization's staff training and development program as currently proposed;
3. to assess the cost effectiveness of the Organization's staff training and development activities; and
4. to recommend changes necessary to the Organization's staff training and development activities in the light of 1 to 3 above.

Substantial progress has been made with the review which commenced in January 1982. The Committee's report is expected to be completed early in 1982/83, when the Executive will decide the future course of the Organization's staff training and development activities.

Occupational Safety and Health

The importance of occupational safety and health procedures in research institutions is well recognised. CSIRO has long been committed to pursuing an occupational safety and health policy aimed at providing safety standards and practices which afford the highest practicable degree of protection to all staff.

The policy is kept under continual review and new ways are

constantly being sought for improving the Organization's safety performance. Within the Organization's central administration, a full-time professional safety officer works to coordinate these activities. In addition, part-time qualified safety officers are selected from among the staff at each location to act as local safety coordinators.

The Organization's safety and health program is primarily based on education and promotion of safety awareness. To this end, information is regularly distributed throughout the Organization through a series of circulars devoted to safety and health matters. Also, various training courses and meetings are arranged throughout the year, in which the regional and State training committees play an active role.

All staff are encouraged to contribute to the occupational safety and health program. Safety committees exist at most locations, with committee membership comprising a representative cross-section of the staff. Rotation of members gives the opportunity for as many staff as possible to be involved actively in working towards improving safety performance and increasing safety awareness.

These opportunities for consultation on safety and health matters have been enhanced by the establishment of a CSIRO Occupational Safety and Health Policy Committee. The Committee is chaired by Dr K.A. Ferguson, Director of the Institute of Animal and Food Sciences, and comprises representatives of the major staff associations, CSIRO Institutes and the Personnel Branch. It is able to provide policy advice to the Executive by considering and monitoring the Organization's safety and health policies and programs.

Since the Committee first met in 1980, it has examined a wide range of topics. These have included first aid facilities and training, safety education, policies on smoking at work, alcohol and drug abuse, the operation of visual display units, the disposal of hazardous wastes, work-related allergies, and overall occupational safety and health policies.

The wide scope of the Organization's research activities, and the nature of safety-performance statistics, makes comparisons with other institutions difficult. However, it is believed that the Organization's safety and health practices are effective in protecting the welfare of staff.

Retirement Policy

The new Commonwealth superannuation scheme introduced in 1976 made it possible for retirement benefits to be calculated for various ages prior to age 60 years. This opened the way for changes in retirement provisions applicable to Commonwealth employees. One new measure enacted was the Commonwealth Employees (Redeployment and Retirement) Act 1979 (the CE(RR) Act) which, by February 1981, had been brought into operation in the Australian Public Service. In July 1981 the Executive was advised of the way in which this Act would operate in relation to

statutory authorities which agreed that the legislation be applied to them.

After a careful examination of the legislation and consultation with staff associations through the Consultative Council, the Executive decided that, for the time being, CSIRO should not become a party to the CE(RR) Act. The Executive concluded that the policies available under the existing CSIRO terms and conditions of service are sufficient to enable the retirement of inefficient or redundant staff of any age. These terms and conditions also allow any officer to retire voluntarily upon attaining age 60 years. Moreover, the Executive is entitled to retire an officer at or after that age; this significant prerogative is not available under the CE(RR) Act. However, the eventual introduction of voluntary early retirement at age 55 years remains an objective of the Executive.

Retirement policy has a definite impact on the Organization's research output. The Executive endeavours to pursue personnel policies that promote flexibility and an infusion of new ideas among CSIRO officers. To achieve this, it is necessary to have an adequate turnover of staff, particularly professional scientific staff. One way of ensuring this is to use term appointments (see Chapter 8 of the CSIRO Annual Report 1978/79); another is to have a retirement policy that assists staff to leave the Organization when their effective contribution to its research has been concluded. The Executive considers that 60 years is the optimal retirement age for most scientists. Moreover, it believes that all staff should be encouraged to consider retirement before the maximum retirement age of 65 years.

Following the decision that the Organization should not at present adopt the provisions of the CE(RR) Act, the Executive arranged for the Organization's procedures for age and inefficiency retirement to be revised with a view to ensuring that these procedures operate in the most equitable and effective manner possible. Consultation with staff associations on these procedures is being arranged through the Consultative Council.

Research Scientist Salaries

With the abandonment of wage indexation by the Conciliation and Arbitration Commission in July 1981, the Organization received claims for increased rates of pay for most categories of staff on the ground of 'fair comparability'. The claims made on behalf of research staff sought to correct compression of salary relativities which had developed since April 1975. Comparison with the salaries of comparable employment categories outside the Commonwealth sector was used to substantiate these claims. In addition, comparisons were made between research scientist salaries and those of academic staff in universities.

The recruitment and retention of research scientists of the highest calibre is crucial to the success of CSIRO and consequently the competitiveness of their pay and conditions of service is particularly important. Salary increases for the classifications of

Research Scientist to Senior Principal Research Scientist have tended to be based on movements in the salaries of professional engineers. This relationship was established in the mid 1960s and has been observed since, including the increase of 10.9% to 12.5% which took effect from 28 January 1982. The salaries of Chief Research Scientists and Chiefs of Divisions have mainly moved in consonance with those of the Second Division of the Australian Public Service. Salary increases for these staff of 12.5% to 14.8% also took effect from 28 January 1982. As is customary, these salary increases were negotiated and adopted according to the processes of the Public Service Arbitrator's jurisdiction.

Traditionally, movements in the salaries of university lecturers are not accepted in themselves as sufficient basis to justify salary increases for research scientists. A full bench of the Conciliation and Arbitration Commission ruled in 1970 that 'rates for academics and research scientists should only have a general relationship'. The full bench had regard to comments made by Mr Justice Eggleston in 1970 in which he reiterated the caution given in his 1964 report 'against assuming that any particular range of any other occupation should be treated as a guide for the movement in academic salaries, with the exception of the commencing salary of a research scientist in CSIRO'.

In some respects, research scientists and university lecturers have much in common. The basic formal qualification for appointment to both positions is a PhD degree and both engage in research work. However, there are significant differences. Research scientists work virtually full time on their research programs while university lecturers have teaching and associated responsibilities which CSIRO research scientists do not have. Nevertheless, the relationship between the commencing salaries of research scientist and lecturer is important because CSIRO and the engineering and science faculties of universities tend to compete for new recruits from the same pool of graduates and comparable salaries ensure that the competition is on equal terms. The table opposite shows that the salaries of research scientists and lecturers have increased comparably since Mr Justice Campbell's report in 1973.

For many reasons it is important that there should be strong links between CSIRO and the universities. Staff interchange and mobility is encouraged by CSIRO and the universities as an effective means of fostering these links. It is therefore desirable that the salaries and employment conditions for research scientists and lecturing staff at all levels be comparable, although this does not mean that there should be fixed salary relationships. In 1973 Mr Justice Campbell accepted that movements in CSIRO salaries at appropriate levels must be considered relevant to the comparative wage justice aspects of his inquiry into academic salaries but he rejected arguments for additional salary links between research scientists and lecturing staff.

While in general the salaries have been in accord over the years, the fact that the processes for fixing salaries and conditions

TABLE 8

Comparison of Salaries of Research Scientist and Lecturer 1973-1982

Date 30 June of the year	Research Scientist		Lecturer	
	Annual salary min.–max. $ per annum	Percentage *min.–max.	Annual salary min.–max. $ per annum	Percentage *min.–max.
1973	8489–10 703	100–100	8698–11 982	100–100
1974	9698–12 194	114.2–113.9	9002–12 352	103.5–103.1
1975	11 653–14 446	137.3–135.0	11 655–15 644	134.0–130.6
1976	13 031–16 107	153.5–150.5	13 033–17 426	149.8–145.4
1977	14 012–17 204	165.1–160.7	14 345–18 884	164.9–157.6
1978	14 829–18 177	174.7–169.8	15 179–19 940	174.5–166.4
1979	15 422–18 904	181.7–176.6	15 786–20 738	181.5–173.1
1980	16 632–20 387	195.9–190.5	17 024–22 365	195.7–186.7
1981	19 662–24 100	231.6–225.2	20 963–27 539	241.0–229.8
1982	21 810–26 910	256.9–251.4	22 430–29 467**	257.9–245.9

* 1973 Salary = 100

** These salaries include the 7% increase from 10 August 1982 determined by the Academic Salaries Tribunal.

in CSIRO and the universities are not synchronized has resulted in adverse comparisons at various times. Academic salaries are now reviewed by the Academic Salaries Tribunal; they have always been fixed by a separate process to those of CSIRO staff to whom the Public Service Arbitration Act 1920 applies. It has been recognized by all tribunals that, in relation to salary fixation, the universities do not set the trend.

The temporary imbalances between CSIRO and university salaries, which can occur from time to time because of the separate nature of the pay fixation processes, do not reflect a lack of consideration on the part of the Organization for the interests of research staff. The Executive accepts the existing processes for fixing CSIRO salaries. Where imbalances are seen, CSIRO salaries are reassessed by means of these processes, with due regard to the prevailing principles of pay fixation.

Interaction with Universities

Relationships between CSIRO and the Australian universities were examined in detail in the mid 1960s by a committee established by the CSIRO Advisory Council. Since then, the need for closer

co-operation has been mentioned in a number of reports, including the report of the Independent Inquiry into CSIRO which recommended the establishment of a joint committee comprising representatives of CSIRO and the Australian Vice-Chancellors' Committee to investigate ways of developing CSIRO/university relationships.

In 1979, following Government endorsement of this recommendation, a joint committee was established which meets on a regular basis. Several initiatives aimed at forging closer links between universities and CSIRO have been examined, including exchanges and secondments of staff, opportunities for CSIRO staff to lecture at universities and the engagement of CSIRO staff as consultants to universities and vice-versa. More particularly, the committee's deliberations have indicated scope for greater rationalization of resources through collaborative work, including the sharing of facilities.

Collaborative Projects

Collaborative projects are considered an important means of interaction. They encourage new perspectives, stimulate new ideas and promote the rationalization of available resources through the sharing of expertise, equipment and facilities.

The benefits to the participants include the opportunity to expand the scope of their research by joining forces with scientists with complementary interests, and the opportunity to assess their suitability for other roles without the risks inherent in relinquishing one job for another. The benefits to the employing institutions include the broadening of their staffs' experience and interests, and the consequent enrichment of their teaching or research roles, and a better understanding of the organizations concerned.

Collaborative Projects Fund

To encourage collaboration, CSIRO and the Australian National University have established a joint fund on a dollar-for-dollar basis. An initial sum of $100 000 has been allocated; this sum is to be reviewed in subsequent years. A committee of CSIRO and Australian National University representatives has selected the collaborative projects which will receive support from the fund. The money will be used to cover items such as salaries for short-term research workers and support staff, and travel. In order to maintain flexibility in the early years of the fund, a high proportion of the initial allocations has been limited to one year. Longer-term projects will be reviewed and funded annually.

Similar arrangements may be entered into with other universities in due course.

13. People and activities

Executive and Staff Changes

Executive Changes

Dr W.J.McG. Tegart, FTS, resigned in December 1981 upon being appointed as Secretary to the Department of Science and Technology. Dr Tegart had served as a Member of the Executive since February 1979.

Professor Emeritus H.W. Worner, AO, FTS, was appointed to replace Dr Tegart as a full-time Member of the Executive from 25 December 1981 until 30 April 1982, when he reached retirement age. Professor Worner had been Foundation Director of the Institute of Industrial Technology since December 1978. He had earlier served as a Member of the Executive from 1976 until 1978.

Mr R.K.R. Morris, a part-time Member of the Executive, retired following the completion of his three-year term. Mr Morris, who is a partner in the firm of Price Waterhouse and Company, Chartered Accountants, was one of the five part-time Members of the Executive appointed to the reconstituted Executive on 14 December 1978.

Professor G.H. Taylor, FTS, a distinguished Australian scientist with a background in energy resources and industry, was appointed a full-time Member of the Executive for a period of seven years from 1 May 1982, to replace Professor Worner. Professor Taylor, Professor and Director of the Centre for Resource and Environmental Studies at the Australian National University, was formerly Officer-in-Charge of the CSIRO Fuel Geoscience Unit. He is a former member of the Australian Research Grants Committee and is currently a member of the National Energy Research, Development and Demonstration Council. Professor Taylor is a leading petrologist, and his research interests include fossil fuels, uranium and the assessment and use of energy resources.

Dr W.L. Hughes, CBE, and Mr H.M. Morgan were reappointed as part-time Members of the Executive with effect from 14 December 1981. Mr Morgan's appointment is for a period of three years and Dr Hughes's appointment will continue until 8 September 1982 when he will retire from the Executive.

Mr S.B. Myer was appointed a part-time Member of the Executive on 14 December 1981 for a period of three years, following the retirement of Mr Morris. Mr Myer is the Chairman of the Myer Emporium Limited, and his background in commerce, tertiary industry and management complements the experience and interests of the other seven members of the Executive. Mr Myer is a

director of a range of national companies in the food, life assurance and banking areas and serves on committees of management in the arts, science and international relations areas. His chairmanship of the Commonwealth Research Centre of Excellence Committee has also brought him into contact with scientific research in Australia.

Senior Staff Changes

Dr W.I. Whitton, FTS, Research and Technology Director of ICI Australia Ltd, was appointed Director of the Institute of Industrial Technology for a term of five years. He succeeded Dr Worner. Dr D.S. Taylor, FTS, Chief, Division of Textile Industry, acted as Director of the Institute of Industrial Technology until Dr Whitton took up his appointment on 1 March 1982.

Dr B.S. Hetzel, FTS, was reappointed Chief, Division of Human Nutrition for a further term until 30 June 1984.

Two new Divisions concentrating on energy research came into being on 1 September 1981. Dr P.G. Alfredson was appointed Foundation Chief of the Division of Energy Chemistry for a term of five years. Dr D.C. Gibson was appointed Acting Chief of the Division of Energy Technology and was appointed Foundation Chief from 7 June 1982 for a term of seven years.

Dr R.J. Millington, FTS, was reappointed Chief, Division of Land Use Research, for a further term of five years from 3 October 1981. The Division was re-established as the Division of Water and Land Resources on 11 June 1982, and Dr Millington was appointed Chief of the new Division.

Mr R.A. Perry, FTS, was reappointed Chief, Division of Land Resources Management, for a further term of five years from 3 October 1981. This Division was dissolved on 11 June 1982, and Mr Perry was appointed Chief of the new Division of Groundwater Research on that date.

The Division of Irrigation Research, located at Griffith, NSW, was dissolved on 11 June 1982, and the facilities renamed the CSIRO Centre for Irrigation Research. Dr D.S. Mitchell was appointed Officer-in-Charge of the Centre for a period of three years.

Dr B.D. Stacy, who was Acting Chief, Division of Fisheries Research, resumed his duties as Assistant Chief, Division of Animal Production on 26 October 1981. Dr S.W. Jeffery of the Division of Fisheries Research was appointed Acting Chief of the Division from 26 October 1981 until a new Chief is appointed.

Dr A.E. Martin was reappointed Chief, Division of Soils, for a further term until 31 December 1982.

Professor C.J. Krebs, FRAC, Professor of Zoology, Institute of Animal Resource Ecology, University of British Columbia, Vancouver, Canada, was appointed Chief, Division of Wildlife Research for a term of seven years from 17 May 1982. Dr C.H. Tyndale-Biscoe completed his term as Acting Chief of the Division on 13 November 1981 and Dr A.E. Newsome was then appointed Acting Chief of the Division until Dr Krebs took up duty.

Dr T.W. Scott was reappointed Chief, Division of Animal Production for a further term of seven years from 11 February 1982.

A new Division of Tropical Animal Science was created on 1 March 1982. Dr D.F. Mahoney was appointed Foundation Chief of the Division for a period of six years from 1 March 1982.

The death occurred on 15 April 1982 of Dr D.F. Kelsall, FTS. Dr Kelsall was Chief, Division of Mineral Engineering, and previously had concurrently held the position of Chief, Division of Applied Geomechanics. Mr A.B. Whitehead is acting as Chief of the Division of Mineral Engineering.

Dr B. Rawlings, Chief of the former Division of Mechanical Engineering, left the Organization on 1 February 1982 to work as a consultant in industry.

Dr R.H. Wharton, OBE, completed his term as Officer-in-Charge, Project for Animal Research and Development (PARD), Bogor, Indonesia, on 27 November 1981. Under a new Inter-Governmental Agreement, the Project then entered a new phase with PARD having an Indonesian Director and a CSIRO Project Manager to direct the Australian contribution. Dr B.D. Purser was appointed Project Manager from 27 November 1981 until 29 January 1982, when Dr J.L. Wheeler was appointed Project Manager for a two-year term.

Dr T.D. Grace returned to Australia from his posting as Counsellor (Scientific), Tokyo, on 20 February 1982. Dr R.D. Brock, formerly the Counsellor (Scientific), Washington, was appointed to the Tokyo position on a short-term basis and took up duties on 15 February 1982.

Mr I.D. Whiting was appointed Deputy Secretary (Personnel) from 22 October 1981.

CSIRO Submissions to Parliamentary and Official Inquiries

CSIRO made submissions during 1981/82 to a number of Parliamentary and other official inquiries with implications for the Organization's activities in scientific or industrial research. Details of these submissions are given below.

Examination of Annual Reports (Senate Standing Committee on Science and the Environment)

At the request of the Senate Standing Committee on Science and the Environment, CSIRO prepared a submission on the following topics:

(i) effects of the recent reorganization of CSIRO, particularly on the research effort;

(ii) effects of staff and financial restraints on CSIRO's capacity to perform its statutory functions;

(iii) new CSIRO initiatives and high priority programs; and

(iv) the likelihood of a build up of carbon dioxide and sulphur dioxide in the Australian environment.

In the course of its investigation, the Committee visited selected laboratories in Adelaide and Melbourne to observe the Organization's initiatives in manufacturing technology. Details were also provided of CSIRO programs where the research effort was either being terminated or reduced.

Inquiry into Environmental Implications of the Use of Coal (House of Representatives Standing Committee on Environment and Conservation)

The Organization's submission summarized environmental aspects of CSIRO's activities associated with coal recovery, transport and preparation, and coal combustion and liquefaction. Particular mention was made of coal transport by pipeline, fluidized bed combustion (including its potential application to lower grade coal, thereby producing lesser volumes of waste) and alleviating the contribution of coal combustion to atmospheric pollution. Examples were provided of the application of this knowledge to some local and regional problems.

Inquiry into the Commonwealth's Role in Rural Research and Extension Services, and the Contribution of those Services to the Development of the Rural Sector and the Australian Economy (Senate Standing Committee on National Resources)

The CSIRO submission summarized the Organization's role and activities in rural research and provided details of cooperation with State Departments and other rural research groups. The paper also outlined CSIRO's information dissemination services, and recent developments and future opportunities in rural research.

Inquiry into the Australian Export Coal Industry (Senate Standing Committee on Trade and Commerce)

The CSIRO submission addressed those aspects of the Organization's research with implications for the Australian export coal industry. These include studies on trace elements in Australian coals, fly ash production, coal pipelining, and the application of fluidized bed combustion techniques to the disposal of coal washery wastes and to the utilization of low grade coal for local power generation purposes.

Inquiry into the Management of Chemicals Potentially Hazardous to Health and the Environment (House of Representatives Standing Committee on Environment and Conservation)

The CSIRO submission discussed the Organization's advisory role on technical aspects of the management of hazardous chemicals and outlined the Organization's internal procedures for ensuring

that such chemicals are handled with due emphasis on staff safety. The submission also drew attention to the work carried out by CSIRO that is directed towards finding acceptable alternatives to hazardous chemicals currently in use.

Inquiry into Land Use Policy (Senate Standing Committee on Science and the Environment)

The CSIRO submission outlined the factors affecting land use in Australia, and discussed the potential contribution of research to the resolution of present and future problems. The document also described how the Organization complements and assists the work of relevant State authorities by conducting long-term strategic research and studying national problems in land use that transcend State boundaries.

Inquiry by Senate Select Committee on South-west Tasmania

The CSIRO submission discussed the unique value of south-western Tasmania for the purposes of Australian and world biological science. Consideration was also given to the scientific research needed to provide a basis for the conservation and proper management of the region.

Australia's Participation in International Environmental Organizations (Senate Standing Committee on Environment and Conservation)

In a joint submission with the Department of Science and Technology, details were provided of recent CSIRO interactions with international environmental organizations including participation in international programs, consultancy arrangements, conferences, training programs and workshops.

The submission summarizes the Organization's initial inputs to specific Parliamentary inquiries during 1981/82. However, it is customary for such Committees of Inquiry to arrange public hearings for the purpose of examining the statements made in the submissions that they receive. Consequent upon the appearance of a CSIRO delegation at such public hearings, CSIRO may be requested to provide additional information in writing on specific matters or to lodge a supplementary submission with the Committee as may be appropriate.

The Tenure of Employment of Academic Staff in Australian Universities and Colleges of Advanced Education (Senate Standing Committee on Education and the Arts)

The Organization's submission presented information about CSIRO's policies on the tenure of research scientists, Chiefs of Divisions and Directors of Institutes for comparison with other submissions concerning existing and proposed tenure policies in universities. The submission also focused on other measures for improving staff turnover and institutional flexibility, including policies which encourage early retirement.

In addition to specific Inquiries by Parliamentary Standing and Ad Hoc Committees, CSIRO assists in the work of other official inquiries. Examples during 1981/82 were as follows:

Inquiry into the Long-term Future of Christmas Island

This Inquiry was conducted by the Minister for Home Affairs and Environment with the object of identifying alternative industry proposals for Christmas Island. In this regard, the CSIRO submission discussed the development of plantation agriculture and horticultural products for export, pig breeding to meet local needs and export, tourism, and the beneficiation of low grade rock phosphate.

Policy Discussion Paper on Agriculture

The Minister for Primary Industry has convened a Working Group to prepare a discussion paper on agriculture. CSIRO has contributed to research aspects by participating in discussions with the Working Group and submitting written responses to specific queries.

CSIRO Calendar of Events

During the reporting year, CSIRO was concerned with a wide range of community, industry and international matters. Many seminars and open days were conducted, aimed at clarifying some of the issues involved in current research programs, and interested members of the community were invited to attend. CSIRO was also concerned with promoting more effective relations with industry. Some of the following events have been selected as examples of these activities.

July 1981

- The Minister for Science and Technology, the Hon. David Thomson, MC MP, visited the Molecular and Cellular Biology Unit in Sydney. The Unit had signed a collaborative agreement with Bioclone Australia Pty Ltd for the research, development and marketing of a range of monoclonal antibodies used for diagnosing human and animal diseases.

August 1981

- Executive members visited the Division of Animal Production in Sydney and attended an Executive Seminar at the Minerals Research Laboratory, North Ryde (Sydney), entitled 'Assisting the Minerals Industry—Present and Future'.

September 1981

- Executive members met with CSIRO Directors and Chiefs in Canberra to discuss research program priorities.
- The Senate Standing Committee on Science and the Environment visited the CSIRO Divisions of Horticultural Research and Human Nutrition in Adelaide, and the Divisions of Chemical

Physics, Mineral Engineering, and Manufacturing Technology in Melbourne, as part of the Committee's examination of the CSIRO Annual Report 1980/81.

- Dr J.P. Wild represented Australia at a meeting of the Anglo-Australian Telescope Board which was held in Australia.
- Dr J.P. Wild addressed the National Science Forum on the topic, 'Priorities for the 80s'.
- Dr W.J. McG. Tegart represented the Australian Academy of Technological Sciences at the 3rd Convocation of Engineering and Like Academies, held in Mexico.
- Open days were held at the National Measurement Laboratory, Division of Applied Physics, Lindfield (Sydney).

October 1981

- An Executive Seminar was held at the Australian National Animal Health Laboratory (ANAHL), Geelong, Vic., on 'The Role of ANAHL'.
- Dr J.P. Wild addressed the Australian Academy of Technological Sciences on 'Interaction between CSIRO and Industry'.
- SIRACTAC Ltd, a non-profit computer-based crop management program for the Australian cotton industry was launched by the Minister for Science and Technology at Narrabri, NSW.

November 1981

- Dr N.K. Boardman visited Bogor, Indonesia, as the CSIRO Executive's representative at a ceremony to mark the signing of an agreement to transfer the operation of the Centre for Animal Research and Development to Indonesia.
- Open days were held at the Division of Radiophysics at Epping (Sydney). The displays were officially opened by Dr H.R. Edwards, MP, Chairman of the Government Members' Committee on Industry, Business and Science.

December 1981

- The Executive members visited the Divisions of Energy Technology and Building Research, the Dairy Research Laboratory and the Agricultural Engineering Group, in Melbourne.
- An Executive Seminar on Information Technology was held at CILES in Melbourne.
- On behalf of UNESCO, Mr L.G. Wilson attended a planning meeting for a conference of Ministers responsible for the Application of Science and Technology to development and for economic planning in Asia and the Pacific (Castasia II). The conference was held in Bangkok.

February 1982

- At the invitation of the French Government, Dr N.K. Boardman visited France for discussions on French/Australian science and technology cooperation.

March 1982

- Executive members visited the Divisions of Computing Research and Entomology in Canberra.

- The Minister for Science and Technology officially opened the Melbourne laboratory of the Division of Manufacturing Technology. The laboratory will provide a focus for the technological research needs of manufacturing industry.
- As a member of the Australian delegation, Mr L.G. Wilson attended the Castasia meeting held in Manila.
- The Governor-General, Sir Zelman Cowen, presented the inaugural BHP Science Prize to the young Australian scientist who submitted the most outstanding piece of original research. The Prize was organized by the Australian Science Teachers' Association, BHP and CSIRO. Mr S. Lattimore chaired the selection panel.
- Open days for the food industry were held at the Division of Food Research, North Ryde (Sydney).

April 1982

- An Executive seminar on 'Plant Genetics and Plant Improvement' was held in Canberra.
- Dr J.P. Wild represented Australia at the Anglo-Australian Telescope Board meeting held in Australia.
- Dr Wild and other senior members of staff addressed a CSIRO and Manufacturing Industry symposium in Sydney which was directed towards assistance to manufacturing industry.

May 1982

- An Executive Seminar on 'The Atmosphere and the Oceans' was held in Melbourne.
- Dr N.K. Boardman visited the United States and Canada for discussions in the United States with the US Department of Agriculture on research programs appropriate for CSIRO/USDA collaboration, and in Canada with the Canadian Ministry of Science and Technology, National Research Council, Agriculture Canada and Environment Canada.
- The Minister for Science and Technology officially opened the D.F. Waterhouse Laboratory of Insect Taxonomy, Division of Entomology, Canberra.

14. Finance and works

Commencing with the 1981/82 financial year, the approach to determining CSIRO's budget has changed. In fixing the level of funding to be appropriated to CSIRO in any one year, the Government now takes into account the total funds from all sources available to the Organization or available to other Departments for expenditure on behalf of CSIRO. This is called a global approach. The global budget takes into account the Annual and Capital Funds directly appropriated to CSIRO, funds appropriated to the Departments of Transport and Construction and Administrative Services for expenditure on behalf of CSIRO, and funds received by CSIRO from non-Appropriation sources such as rural industry and other external funds.

The concept of global budgeting needs to be seen against the background of the Report of the Independent Inquiry into CSIRO. This Report, which was accepted by the Government, recommended that CSIRO should remain primarily a budget-dependent statutory authority and that research of general interest to the Commonwealth Government should be funded as far as possible through a specific budgetary appropriation direct to CSIRO. Further, the Government decided that CSIRO 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. Thus with global budgeting the Government approves a total level of activity for the Organization and the Executive is free to allocate resources to objectives within that level. This approach is consistent with the finance philosophy recommended by the Independent Inquiry.

While the principle of global budgeting has been implemented, a number of issues still need to be resolved. These include:

- Setting the level of the initial global amount.
- Means of indexing it in future years.
- Adjusting to variations in Government budgetary policy.
- Coping with changes in priorities.
- Contending with major unforeseen expenditures. For instance, should an amount be built in for reserves each year which could be accumulated if unspent, or should there be provision for seeking additional funds from the Government as required? Unforeseen expenditures of considerable magnitude may occur from workers and other compensation awards against the Organization, accident or storm damage to property, and major retrenchments when CSIRO is not the originating party.
- Planning for the resource requirements for buildings and associated activities which involve a lead-time of several years

in planning and developing proposals. In the absence of some guaranteed level of capital funds within a global budget, such planning is very difficult.

Employer Contributions to Superannuation

The Superannuation Act 1976 requires statutory authorities to meet the employer's share of superannuation contributions. The Minister for Finance directed CSIRO to meet the cost of the employer's contribution to superannuation in respect of its staff from 1 July 1981. This contribution is made at the rate of 20% of salary of eligible staff. In 1981/82, the Government provided some $26 million of additional funds to CSIRO to meet this commitment in respect of all staff, irrespective of the source of salary funding. From 1982/83, it is intended that sufficient funds will be made available to CSIRO to cover the employer's contribution to superannuation only in respect of employees whose salaries are met from CSIRO's direct appropriation. The contributions in respect of employees whose salaries are met from funds provided by external bodies, will have to be met by those bodies. A one-year moratorium in 1981/82 in passing these costs on to external contributors was arranged so that these bodies and, in particular, the Rural Industry Research Funds, could plan how best to meet this liability and to minimize any deleterious effects to externally-funded research projects.

Appropriation Resources

In 1981/82, CSIRO's expenditure from all sources of funds directly available to the Organization totalled $267.1 million. Excluding superannuation costs, this represented an increase of 14.3% over the 1980/81 level. Direct appropriations by the Government funded approximately 85.0% ($227 025 902) of CSIRO's expenditure. A further 3.9% ($10 373 029) was funded from revenue earned by the Organization.

The table opposite summarizes the source of funds directly under the control of CSIRO for 1981/82 and the categories of expenditure.

Expenditure from CSIRO's direct Appropriation and revenue, excluding employer contributions to superannuation, amounted to $211 345 590 in 1981/82, an increase of $26 422 676 (14.3%) over the 1980/81 period. By excluding an amount of $5 013 000 provided to cover an additional pay period which fell within the 1981/82 financial year, the increase over 1980/81 expenditure reduces to 11.6%. The Government provided $2 960 000 to meet increased costs associated with the provision of laboratory equipment, supplies and services. This sum, representing an increase of 6.0% over 1980/81 operating funds, was

TABLE 9

Source of funds	Salaries and general running expenses ($)	Contributions ($)	Capital works and services and major items of equipment ($)	Total ($)
Appropriation including Revenue	231 965 543	788 912	4 644 476	237 398 931
Wool Research Trust Fund	8 289 754	–	418 271	8 708 025
Meat Research Trust Account	3 455 245	–	11 300	3, 466 545
Wheat Research Trust Account	629 081	–	–	629 081
Dairying Research Trust Account	285 188	–	–	285 188
Fishing Industry Research Trust Account	257 295	–	–	257 295
Oilseeds Research Trust Account	94 481	–	–	94 481
Dried Fruits Research Trust Account	38 861	–	–	38 861
Poultry Industry Trust Fund	84 757	–	–	84 757
Chicken Meat Research Trust Account	85 193	–	–	85 193
Pig Industry Research Trust Account	80 745	–	–	80 745
NERDDC–Coal Research Trust Account	1 827 667	–	–	1 827 667
NERDDC–Appropriation Fund	1 503 694	–	–	1 503 694
Rural Credits Development Fund	309 868	–	–	309 868
Other contributors	12 067 710	–	212 104	12 279 814
Total	**260 975 082**	**788 912**	**5 286 151**	**267 050 145**

insufficient to cover cost rises due to inflation, and strict economy measures continued to be necessary. Additional Appropriation funds were made available to meet specific Government commitments ($1 142 000), including the continued development of the Australian National Animal Health Laboratory (ANAHL), and to meet inescapable salary increases ($14 384 000).

During 1981/82 the funds and the responsibility for payment of grants to Research Associations were transferred to the Department of Science and Technology. As a result of this change of functions, there was a reduction of $831 000 in funds provided to CSIRO.

The staffing level of CSIRO's existing Appropriation-funded

programs was reduced by a further 2.16% (132 staff) during the year, while additional staff ceiling cover was provided for staff currently transferred to CSIRO from the Australian Atomic Energy Commission (153 staff), and to accommodate the increased staffing requirements of ANAHL (30 staff).

Effect of Restricted Resources

The setting of the first global amount and the way in which it is indexed in future years are critical if adequate resources are to be maintained for support of CSIRO's research programs. The level of additional funding appropriated to CSIRO in recent years to meet the increased cost of goods and services has been insufficient to keep pace with inflation. While CSIRO Appropriation operating funds have increased by approximately 50% since 1976/77, the increase includes resources associated with changed funding arrangements and with responsibilities transferred to CSIRO which have frequently required the infusion of other resources. If, since 1976/77, CSIRO had been granted annual increments for increased costs of goods and services which were in keeping with the increases in the consumer price index (CPI), the Organization would have had appropriated to it an additional $9.4 million for operating funds in 1981/82. However, the financial position is more critical than this figure indicates because the impact of inflation on the type of goods and services acquired by CSIRO is calculated to run at about 2% above the annual CPI rate.

In 1979/80 the Executive, recognizing both the impact of successive restricted budgets on the operating resources of the Organization and the need to maintain an efficient level of operation in ongoing programs, transferred some 2% of total Appropriation funds from salaries to the operating area. This was reported in the Organization's annual report for that year. A primary aim of successive CSIRO budget strategies has been to maintain a balance between salaries and operating funds.

In its report on the examination of CSIRO's annual report for 1980/81, the Senate Standing Committee on Science and the Environment expressed its dissatisfaction at the level of resources appropriated to CSIRO in recent years and reported its concern that the Organization 'is being forced by resource restrictions to reduce and abandon significant areas of research'.[1]

External Funding of CSIRO's Research

Over the last few years, CSIRO's policies for attracting resources from external bodies for the funding of research have been

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1 'Senate Standing Committee on Science and the Environment Examination of Annual Reports', May 1982, p. 19.

examined. The Executive is concerned at the possibility of distorting the Organization's research priorities through the diversion of effort into research areas most likely to be capable of attracting external funding.

It was noted earlier that, following consideration of the Report of the Independent Inquiry into CSIRO, the Government had decided that CSIRO should remain primarily a budget dependent authority, funded as far as possible through a specific budget appropriation direct to CSIRO.

However, the Report also noted the advantages of receiving external funding in creating an 'enhanced level of work' and in bringing to the consideration of research scientists the directions and priorities of research as seen by important prospective beneficiaries of that research.

Explicit guidelines for accepting external funding were developed in 1981/82. The primary purpose of such funding should be to:

- enhance the capability of core research programs funded from CSIRO's Appropriation;
- improve the interaction with outside bodies, particularly industry; and
- improve the transfer of technology to industry.

The Executive also decided that, to maintain a balance between the level of Appropriation and external funds, external salary funding should not normally exceed one-third of a Division's total salary funds.

In 1981/82, funding from external sources totalled $29 651 214. This represented 11.1% of the total funds directly available to the Organization during the year.

Resources for National Facilities

Proposals in recent years for expensive research facilities have led to consideration of making such facilities available to as wide a group of interested scientists as possible. Their designation as national research facilities raises questions regarding their location and management and the manner in which they are financed.

A national facility, such as an oceanographic vessel or a major astronomical telescope, is usually given to an established institution to manage, and guidelines for its operation will depend on the kind of research it is designed to carry out. The Commonwealth will normally provide all of the funds necessary to establish and operate the facility, but the rules for recovering some of these costs from users are yet to be resolved. ASTEC recommended that users of national facilities be charged at 'practical and reasonable' rates. In the case of some facilities, however, it may be desirable to conform with accepted international practice. In the case of astronomy, for instance, it is the world-wide custom to allocate telescope time on the basis of scientific merit and to charge users

no more than the costs of accommodation and consumable items needed for their particular projects.

Oceanographic Research Vessel

Plans for acquiring an oceanographic research vessel have been reported in the two previous annual reports. In July 1981, the Government decided that tenders for the construction of the vessel should be re-invited.

The CSIRO tender called for the design and construction of an oceanographic research vessel of approximately 50 metres in length, with a beam of about 10 metres and a maximum draft of about 5 metres. The ship will be required to provide an all-weather, year-round, working platform for deep sea oceanographic research, in areas ranging from tropical to sub-temperate zones.

Tenders closed in April 1982, with ten tenders being received, seven from Australian companies, including two based on ships to be built overseas, and three from overseas. A 'short list' is now being developed, with the assistance of interested government departments, and it is hoped that the successful tenderer will be nominated in the second half of 1982.

F27 Aircraft Facility

The Division of Cloud Physics review committee, in its report to the Executive in May 1982, recognized the importance of the Fokker F27 Friendship aircraft to the Division as a means of conducting worthwhile scientific experiments. The committee also saw that the aircraft was of considerable potential use to other Divisions and should therefore be treated as a CSIRO facility.

In November 1981, the Executive decided that the F27 aircraft should be retained for three years and operated as an Organization-wide facility. Agreement has been reached on charges for Divisions and approved outside users. An operations committee, headed by the Director, Institute of Physical Sciences, has been established and is responsible for determining scheduling procedures and research priorities, and recommending the annual operating budget. After eighteen months of operation, the usage and cost effectiveness of the aircraft will be evaluated and the future of the F27 considered further.

The aircraft has already attracted users from the Divisions of Atmospheric Physics, Fisheries Research, Fossil Fuels, Mineral Physics and Oceanography, and is also being used for infrared scanning of bushfires (Project Aquarius). Demand for flying time is expected to increase as more scientists become aware of the aircraft's capabilities.

Capital Works and Property

The Independent Inquiry into CSIRO recommended that funds from the Commonwealth Budget for erection of buildings and for undertaking works, repairs and maintenance, and for acquisition of sites and buildings should be appropriated directly to CSIRO. Cabinet decided that this matter should be referred for further consideration to the Minister responsible for CSIRO, in consultation with other relevant Ministers. The matter has been the subject of considerable discussion over the past two years and the Executive recently agreed in principle to these funds being directly appropriated to CSIRO, commencing with the 1983/84 financial year. This decision is consistent with the global approach now being adopted in determining CSIRO's budget.

During 1981/82, a number of Government initiatives arose which will have a bearing on CSIRO's future building programs. Following acceptance by the Government of the recommendations flowing from the Review of Commonwealth Functions and the decision to commission the Department of Administrative Services to review Commonwealth landholdings, CSIRO initiated a review of its existing property and accommodation holdings.

Rationalization will be undertaken where appropriate and disposal action initiated where assets cannot be utilized economically or effectively. Recommendations following reviews in Queensland and Western Australia are at present before the Executive. Similar reviews in Victoria and New South Wales will be undertaken during 1982/83.

The Government also announced its decision to establish a Commonwealth Inquiry into Laboratory Facilities and Services and a number of CSIRO building proposals have been delayed pending the completion of this review.

Resources totalling $55 million were provided in 1981/82 to fund buildings already under construction, the commencement of construction of the CSIRO Marine Laboratories in Hobart, Tasmania, and a number of smaller capital works projects. Details of progress with major buildings are provided at the end of this chapter.

Funds provided in 1981/82 for repairs and maintenance were less than the expenditure incurred during the previous financial year, resulting in CSIRO buildings and plant continuing to be maintained at a less than desirable level. This situation will increase the requirement for capital outlays in future years to replace items which cannot be maintained properly.

Details of Progress with Major Buildings

Australian National Animal Health Laboratory

Satisfactory progress has continued to be made with the construction of the Australian National Animal Health Laboratory at Geelong, Vic. Expenditure in 1981/82 was $40 million and, at

June 1982 prices, the project has an estimated cost of $145 million. The building structure is now totally covered and is in the finishing and fit-out stages. Most services have been completed and some commissioning has commenced. It is expected that building work will be completed in March 1983, concurrently with the completion of the commissioning phase. The laboratory will be then 'set to work', that is, the overall microbiological security system will be tested, with the aim of achieving full operational status by the middle of 1984.

Chemical Technology Laboratories

The Chemical Technology laboratory complex has been under construction at Clayton, Vic., throughout the 1981/82 financial year, and progress during this period has been excellent. The laboratories are now 80% complete and are scheduled for completion by October 1982 at a total cost of approximately $14 million. The project represents a further progress in achieving the Organization's objective of establishing at Clayton, adjacent to Monash University, a major CSIRO chemical research campus.

Materials Science and Applied Organic Chemistry Laboratories

Following the recommendations arising from the Review of Commonwealth Functions, approval for the construction of new laboratories at Clayton, Vic., for the Divisions of Materials Science and Applied Organic Chemistry was deferred for inclusion in the Government's 1981/82 Civil Works Program. CSIRO has again sought Government approval for the construction of the laboratories in 1982/83.

Crop Adaptation Laboratory

The Crop Adaptation Laboratory for the Division of Plant Industry at Black Mountain, ACT, is approximately 60% complete and should be completed by mid 1983. The current estimated cost is $3 million.

CSIRO Marine Laboratories

In 1981, Parliament approved recommendations of the Parliamentary Standing Committee on Public Works that new laboratories and support facilities for the Divisions of Fisheries Research and Oceanography be constructed in Hobart. The estimated cost of this work is $11.84 million at April 1982 prices.

The Department of Transport and Construction has let a contract to the firm of Hansen and Yuncken (Tasmania) Pty Ltd to manage the construction. Arrangements have been completed for the construction of stage 1 which is estimated to cost $1.7 million and covers the provision of workshops, fluid dynamics laboratories, marine equipment stores and other ancillary functions in the existing warehouse at Castray Wharf. Documentation for the remainder of the project, including three laboratory blocks and an administration building, is well advanced and it is anticipated that this work will commence late in 1982. Stages 1 and 2 are scheduled for completion in mid 1983 and late 1984 respectively. Work has already commenced on demolition of existing facilities to clear the site for the proposed buildings.

As part of the new initiatives in Marine Science, it is intended

that, commencing early 1983, the Division of Oceanography will be progressively relocated to Hobart. The Division will be housed in temporary accommodation until the new buildings are completed.

Projects costing more than $250 000 which were completed during 1981/82 are listed below, with their authorized costs:

Institute of Animal and Food Sciences	**Animal Production**, Prospect, NSW—animal genetics laboratory—$1 272 650.
Institute of Energy and Earth Resources	**Minerals Research Laboratories**, North Ryde, NSW—general purpose laboratory No. 1—$1 146,711. **Minerals Research Laboratories**, North Ryde, NSW—upgrading of water supply services—$648 414.

Projects costing more than $40·000 which were committed during 1981/82 are listed below, with their program authorization:

Institute of Animal and Food Sciences	**Animal Health**, Seymour, Vic—construction of house—$55 800. **Animal Health**, Maribyrnong, Vic—upgrading of steam generators—$69 379. **Food Research**, Cannon Hill, Qld—provision of emergency generator—$144 499. **Animal Production**, Prospect, NSW—upgrading of small animal colony—$150 000. **Animal Production**, Armidale, NSW—construction of library and upgrading of site services—$450 000. **Tropical Animal Science**, Indooroopilly, Qld—upgrading of main laboratory roof—$95 000.
Institute of Biological Resources	**Horticultural Research**, Glen Osmond, SA—erection of glasshouse for salinity research—$145 000. **Water and Land Resources**, Black Mountain, ACT—provision of conference facilities—$74 670.
Institute of Energy and Earth Resources	**Mineral Chemistry**, Port Melbourne, Vic—erection of laboratory—$391 840.
Institute of Industrial Technology	**Textile Industry**, Geelong, Vic—construction of mechanical development building—$618 000.
Institute of Physical Sciences	**Radiophysics**, Epping, NSW—construction of test equipment building for aerial range—$169 000.
Bureau of Scientific Services	**Science Communication Unit**, East Melbourne, Vic—alterations to film unit accommodation—$60 000.
Other	**Headquarters**, Campbell, ACT—construction of office block—$1 804 103. **Site Services**, Black Mountain, ACT—modifications to heating system—$278 590.

Site Services, Black Mountain, ACT—conversion of oil fired equipment to natural gas stage 2—$87 302.

Marine Laboratories, Hobart, Tas—erection of laboratory complex —$11 840 000.

OFFICE OF THE
AUDITOR GENERAL

Canberra House, Marcus Clarke St.,
Canberra City, A.C.T. 2601
Telephone 48 4711

F82/110

17 November 1982

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

Dear Sir

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

In compliance with sub-section 57(3) of the Science and Industry Research Act 1949, the Commonwealth Scientific and Industrial Research Organization has submitted for my report its financial statements for the year ended 30 June 1982. These comprise:

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

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

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

- the statements are based on proper accounts and records, and
- the receipt, expenditure and investment of moneys, and the acquisition and disposal of assets, by the Organization during the year have been in accordance with the Act except that moneys were expended from the General Research Account prior to formal Ministerial approval of the estimates of expenditure on 21 September 1981 under sub-section 49(2) of the Act.

Yours faithfully,

(Sgd.) D.J. HILL
Acting Auditor-General

D.J. Hill
Acting Auditor-General

Summary of Receipts and Payments for the Year ended 30 June 1982

(Figures in brackets refer to 1980/81 financial year)

	Funds held 1 July 1981 ($)	Receipts ($)	Total funds available ($)	Payments ($)	Funds held 30 June 1982 ($)
General Research Account	948 466 (1 202 892)	241 439 397* (184 668 488)	242 387 863 (185 871 380)	237 398 931 (184 922 914)	4 988 932 (948 466)
Specific Research Account	4 564 924 (4 861 409)	29 433 415 (25 699 203)	33 998 339 (30 560 612)	29 651 214 (25 995 688)	4 347 125 (4 564 924)
Other Trust Moneys**	216 020 (88 046)	3 931 519 (2 726 086)	4 147 539 (2 814 132)	3 811 747 (2 598 112)	335 792 (216 020)
Total	**5 729 410** (6 152 347)	**274 804 331** (213 093 777)	**280 533 741** (219 246 124)	**270 861 892**† (213 516 714)	**9 671 849**†† (5 729 410)

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

J.P. Wild
(*Chairman*)

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

Consolidated Statement of Payments for the Year ended 30 June 1982

1980/81 ($)		1981/82 ($)
	Headquarters (including Regional Administrative Offices)	
7 466 473	Salaries and allowances	10 270 109
447 621	Travelling and subsistence	409 118
642 614	Postage, telegrams and telephone	627 383
2 863 905	Incidental and other expenditure	3 149 066
186 368	Advisory Council	210 912
50 487	State Committees	47 408
11 657 468		14 713 996
	Research Programs	
	Institute of Animal and Food Sciences	
178 965	Institute Headquarters	258 793
7 973 769	Animal Health	9 976 823
10 142 320	Animal Production	12 235 050
– *	Fisheries Research	7 373 983
8 474 947	Food Research	11 105 710
2 223 782	Human Nutrition	2 916 576
1 531 565	Molecular and Cellular Biology	2 188 176
2 400 648	Project for Animal Research and Development**	2 212 822
–	Tropical Animal Science	56 373†
468 852	Wheat Research	622 521
33 394 848		48 946 827
	Institute of Biological Resources	
208 991	Institute Headquarters	275 274
9 307 339	Entomology	11 801 918
8 747 555	Fisheries and Oceanography	– ††
5 410 102	Forest Research	7 054 832
2 010 342	Horticultural Research	2 468 234
1 825 908	Irrigation Research	2 310 638
4 781 057	Land Resources Management+	5 810 938
3 939 572	Land Use Research+	5 033 582
10 006 542	Plant Industry	12 542 139
5 348 361	Soils+	6 892 219
7 311 719	Tropical Crops and Pastures	8 924 198
3 586 092	Wildlife Research	4 504 213
62 483 580		67 618 185

* In 1980/81 expenditure for Fisheries Research was integrated with Fisheries and Oceanography (Institute of Biological Resources).

** Formerly known as Centre for Animal Research and Development.

† Tropical Animal Science was a newly created Division during 1981/82.

†† In 1981/82 expenditure is recorded separately under Fisheries Research (Institute of Animal and Food Sciences) and Oceanography (Institute of Physical Sciences).

\+ In 1980/81 Land Resources Management, Land Use Research and Soils were part of the Institute of Energy and Earth Resources.

1980/81 ($)		1981/82 ($)
	Institute of Energy and Earth Resources	
183 822	Institute Headquarters	280 956
3 173 662	Applied Geomechanics	3 504 410
–	Energy Chemistry	1 530 769*
– **	Energy Technology	2 766 579
16 995 098	Mining, Minerals and Energy	21 654 392
567 833	Physical Technology	798 624
20 920 415		30 535 730
	Institute of Industrial Technology	
200 190	Institute Headquarters	333 711
– †	Agricultural Engineering	619 417
3 271 911	Applied Organic Chemistry	3 972 968
6 190 310	Building Research	6 405 047
3 453 899	Chemical Technology	5 969 577
2 059 168	Manufacturing Technology	3 602 670
2 940 763	Mechanical Engineering	– ††
3 650 360	Protein Chemistry	4 468 962
5 016 539	Textile Industry	6 429 387
3 008 632	Textile Physics	3 724 392
29 791 772		35 526 131
	Institute of Physical Sciences	
223 152	Institute Headquarters	255 666
10 049 338	Applied Physics	13 460 622
2 790 135	Atmospheric Physics	3 389 572
561 519	Australian Numerical Meteorology Research Centre	623 536
3 184 139	Chemical Physics	4 091 599
2 012 659	Cloud Physics	2 118 960
4 291 428	Computing Research	7 952 079+
839 596	Environmental Mechanics	1 027 031
2 356 741	Materials Science	3 107 782
3 106 246	Mathematics and Statistics	3 854 915
– ++	Oceanography	3 534 571
5 384 953	Radiophysics	6 497 867
34 799 906		49 914 200

* Energy Chemistry was previously a part of the Australian Atomic Energy Commission. Expenditure recorded is that incurred since 1 April 1982.

** In 1980/81 expenditure for Energy Technology was integrated with Mechanical Engineering (Institute of Industrial Technology).

† In 1980/81 expenditure for Agricultural Engineering was integrated with Mechanical Engineering (Institute of Industrial Technology).

†† In 1981/82 expenditure is recorded separately under Energy Technology (Institute of Energy and Earth Resources) and Agricultural Engineering (Institute of Industrial Technology).

\+ Expenditure for Computing Research excludes $3 316 819, which is the value of CSIRONET services provided to CSIRO users. (See Note 6.)

++ In 1980/81 expenditure for Oceanography was integrated with Fisheries and Oceanography (Institute of Biological Resources).

1980/81 ($)		1981/82 ($)
	Bureau of Scientific Services	
222 988	Bureau Headquarters	333 427
4 409 092	Central Information, Library and Editorial Section	5 530 145
286 628	Centre for International Research Cooperation	400 381
1 550 521	Commercial Group	1 683 139
1 274 963	Science Communication Unit	1 584 375
7 744 192		9 531 467
2 908 642	Miscellaneous	4 188 546
192 043 355	Total Research Programs	246 261 086
	Contributions	
877 400	Research Associations	*
705 567	Other Contributions	788 912
1 582 967		788 912
	Capital Works and Services	
1 140 701	Buildings, works, plant and developmental expenditure	1 567 279
4 449 277	Major items of laboratory equipment	3 655 154
44 834	Construction of research vessel	63 718
5 634 812		5 286 151
	Other Trust Moneys	
334 376	Remittance of revenue from investigations financed from Industry Trust Accounts	663 126
2 263 736	Other miscellaneous remittances	3 148 621
2 598 112		3 811 747
213 516 714**	**Total Expenditure**	**270 861 892**

J.P. Wild
(*Chairman*)

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

* The Department of Science and Technology has assumed responsibility for payments to Research Associations from 1 July 1981.

** Dissection details of 1980/81 expenditure have been adjusted, where necessary, to allow comparison with 1981/82 figures.

Statement of Payments—General Research Account for the Year ended 30 June 1982

1980/81 ($)		1981/82 ($)
	Headquarters (including Regional Administrative Offices)	
7 466 473	Salaries and allowances	10 270 109
446 478	Travelling and subsistence	406 772
642 614	Postage, telegrams & telephone	627 383
2 863 905	Incidental and other expenditure	3 149 066
186 368	Advisory Council	210 912
50 487	State Committees	47 408
11 656 325		14 711 650
	Research Programs	
	Institute of Animal and Food Sciences	
175 441	Institute Headquarters	258 793
7 092 060	Animal Health	9 029 742
6 919 972	Animal Production	8 793 289
– *	Fisheries Research	6 983 550
6 865 785	Food Research	8 942 092
2 189 099	Human Nutrition	2 771 822
1 519 624	Molecular and Cellular Biology	2 041 511
–	Project for Animal Research and Development**	123 155†
–	Tropical Animal Science	56 373††
233 796	Wheat Research	359 149
24 995 777		39 359 476
	Institute of Biological Resources	
208 991	Institute Headquarters	275 274
7 101 015	Entomology	9 133 953
8 368 159	Fisheries and Oceanography	– +
5 305 687	Forest Research	6 904 272
1 941 835	Horticultural Research	2 388 315
1 685 168	Irrigation Research	2 103 114
4 550 255	Land Resources Management++	5 496 879
3 467 689	Land Use Research++	4 387 591
9 424 098	Plant Industry	11 776 253
5 040 479	Soils++	6 516 446
6 673 229	Tropical Crops and Pastures	8 186 628
3 274 293	Wildlife Research	4 146 204
57 040 898		61 314 929

* In 1980/81 expenditure for Fisheries Research was integrated with Fisheries and Oceanography (Institute of Biological Resources).

** Formerly known as Centre for Animal Research and Development.

† Expenditure, represents Employer's Share of Superannuation which was funded from CSIRO Appropriation in 1981/82.

†† Tropical Animal Science was a newly created Division during 1981/82.

\+ In 1981/82 Expenditure is recorded separately under Fisheries Research (Institute of Animal and Food Sciences) and Oceanography (Institute of Physical Sciences).

++ In 1980/81 Land Resources Management, Land Use Research and Soils were part of the Institute of Energy and Earth Resources.

1980/81 ($)		1981/82 ($)
	Institute of Energy and Earth Resources	
182 965	Institute Headquarters	280 956
1 919 931	Applied Geomechanics	2 324 238
–	Energy Chemistry	1 528 009*
– **	Energy Technology	2 442 011
13 846 855	Mining, Minerals and Energy	17 571 547
539 363	Physical Technology	702 516
16 489 114		24 849 277
	Institute of Industrial Technology	
200 190	Institute Headquarters	333 711
– †	Agricultural Engineering	437 268
3 073 095	Applied Organic Chemistry	3 858 214
6 045 486	Building Research	6 232 776
3 123 079	Chemical Technology	5 511 590
2 029 987	Manufacturing Technology	3 509 510
2 357 297	Mechanical Engineering	– ††
3 649 228	Protein Chemistry	4 457 186
2 098 676	Textile Industry	3 059 248
1 829 529	Textile Physics	2 434 921
24 406 567		29 834 424
	Institute of Physical Sciences	
223 152	Institute Headquarters	255 666
9 966 566	Applied Physics	13 382 772
2 642 075	Atmospheric Physics	3 256 516
532 006	Australian Numerical Meteorology Research Centre	613 307
3 181 180	Chemical Physics	4 091 599
1 861 895	Cloud Physics	2 061 313
4 050 083	Computing Research	7 738 394+
834 196	Environmental Mechanics	1 014 980
2 264 536	Materials Science	2 812 622
3 079 434	Mathematics and Statistics	3 837 129
– ++	Oceanography	3 516 995
5 115 780	Radiophysics	6 157 549
33 750 903		48 738 842

* Energy Chemistry was previously a part of the Australian Atomic Energy Commission. Expenditure recorded is that incurred since 1 April 1982.

** In 1980/81 expenditure for Energy Technology was integrated with Mechanical Engineering (Institute of Industrial Technology).

† In 1980/81 expenditure for Agricultural Engineering was integrated with Mechanical Engineering (Institute of Industrial Technology).

†† In 1981/82 expenditure is recorded separately under Energy Technology (Institute of Energy and Earth Resources) and Agricultural Engineering (Institute of Industrial Technology).

\+ Expenditure for Computing Research excludes $3 316 819 which is the value of CSIRONET services provided to CSIRO users. (See Note 6.)

++ In 1980/81 expenditure for Oceanography was integrated with Fisheries and Oceanography (Institute of Biological Resources).

1980/81 ($)		1981/82 ($)
	Bureau of Scientific Services	
222 988	Bureau Headquarters	333 427
4 268 410	Central Information, Library and Editorial Section	5 298 772
269 167	Centre for International Research Cooperation	348 128
1 550 521	Commercial Group	1 683 139
1 196 483	Science Communication Unit	1 528 582
7 507 569		9 192 048
2 901 385	Miscellaneous	3 964 897
167 092 213	Total Research Programs	217 253 893
	Contributions	
877 400	Research Associations	– *
705 567	Other contributions	788 912
1 582 967		788 912
	Capital Works and Services	
904 896	Buildings, works, plant and developmental expenditure	1 404 038
3 641 679	Major items of laboratory equipment	3 176 720
44 834	Construction of research vessel	63 718
4 591 409		4 644 476
184 922 914**	**Total Expenditure**	**237 398 931**

J.P. Wild
(*Chairman*)

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

* The Department of Science and Technology has assumed responsibility for payments to Research Associations from 1 July 1981.

** Dissection details of 1980/81 expenditure have been adjusted, where necessary, to allow comparison with 1981/82 figures.

Statement of Payments—Specific Research Account for the Year ended 30 June 1982

1980/81 ($)		1981/82 ($)
	Headquarters (including Regional Administrative Offices)	
1 143	Travelling and Subsistence	2 346
1 143		2 346
	Research Programs	
	Institute of Animal and Food Sciences	
3 524	Institute Headquarters	–
881 709	Animal Health	947 081
3 222 348	Animal Production	3 441 761
– *	Fisheries Research	390 433
1 609 162	Food Research	2 163 618
34 683	Human Nutrition	144 754
11 941	Molecular and Cellular Biology	146 665
2 400 648	Project for Animal Research and Development **	2 089 667
235 056	Wheat Research	263 372
8 399 071		9 587 351
	Institute of Biological Resources	
2 206 324	Entomology	2 667 965
379 396	Fisheries and Oceanography	– †
104 415	Forest Research	150 560
68 507	Horticultural Research	79 919
140 740	Irrigation Research	207 524
230 802	Land Resources Management ††	314 059
471 883	Land Use Research ††	645 991
582 444	Plant Industry	765 886
307 882	Soils ††	375 773
638 490	Tropical Crops and Pastures	737 570
311 799	Wildlife Research	358 009
5 442 682		6 303 256

* In 1980/81 expenditure for Fisheries Research was integrated with Fisheries and Oceanography (Institute of Biological Resources).

** Formerly known as Centre for Animal Research and Development.

† In 1981/82 expenditure is recorded separately under Fisheries Research (Institute of Animal and Food Sciences) and Oceanography (Institute of Physical Sciences).

†† In 1980/81 Land Resources Management, Land Use Research and Soils were part of the Institute of Energy and Earth Resources.

1980/81 ($)		1981/82 ($)
	Institute of Energy and Earth Resources	
857	Institute Headquarters	–
1 253 731	Applied Geomechanics	1 180 172
–	Energy Chemistry	2 760*
– **	Energy Technology	324 568
3 148 243	Mining, Minerals and Energy	4 082 845
28 470	Physical Technology	96 108
4 431 301		5 686 453
	Institute of Industrial Technology	
– †	Agricultural Engineering	182 149
198 816	Applied Organic Chemistry	114 754
144 824	Building Research	172 271
330 820	Chemical Technology	457 987
29 181	Manufacturing Technology	93 160
583 466	Mechanical Engineering	††
1 132	Protein Chemistry	11 776
2 917 863	Textile Industry	3 370 139
1 179 103	Textile Physics	1 289 471
5 385 205		5 691 707
	Institute of Physical Sciences	
82 772	Applied Physics	77 850
148 060	Atmospheric Physics	133 056
29 513	Australian Numerical Meteorology Research Centre	10 229
2 959	Chemical Physics	–
150 764	Cloud Physics	57 647
241 345	Computing Research	213 685
5 400	Environmental Mechanics	12 051
92 205	Materials Science	295 160
26 812	Mathematics and Statistics	17 786
– +	Oceanography	17 576
269 173	Radiophysics	340 318
1 049 003		1 175 358

* Energy Chemistry was previously a part of the Australian Atomic Energy Commission. Expenditure recorded is that incurred since 1 April 1982.

** In 1980/81 expenditure for Energy Technology was integrated with Mechanical Engineering (Institute of Industrial Technology).

† In 1980/81 expenditure for Agricultural Engineering was integrated with Mechanical Engineering (Institute of Industrial Technology).

†† In 1981/82 expenditure is recorded separately under Energy Technology (Institute of Energy and Earth Resources) and Agricultural Engineering (Institute of Industrial Technology).

\+ In 1980/81 expenditure for Oceanography was integrated with Fisheries and Oceanography (Institute of Biological Resources).

1980/81 ($)		1981/82 ($)
	Bureau of Scientific Services	
140 682	Central Information, Library and Editorial Section	231 373
17 461	Centre for International Research Cooperation	52 253
78 480	Science Communication Unit	55 793
236 623		339 419
7 257	Miscellaneous	223 649
24 951 142	Total Research Programs	29 007 193
	Capital Works and Services	
235 805	Buildings, works, plant and developmental expenditure	163 241
807 598	Major items of laboratory equipment	478 434
1 043 403		641 675
25 995 688*	**Total Expenditure**	**29 651 214**

J.P. Wild
(Chairman)

R. Nairn
(Assistant Secretary, Management Services)

* Dissection details of 1980/81 expenditure have been adjusted, where necessary, to allow comparison with 1981/82 figures.

Notes to and forming part of the Accounts for the Year ended 30 June 1982

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:

	1980/81 $	1981/82 $
Appropriations—Consolidated Revenue Fund		
Operational	174 594 000	223 067 000
Capital	4 000 000	8 500 000
	178 594 000	231 567 000
Revenue and other Receipts		
General Operations		
Sale of publications	444 756	505 374
Receipts in respect of expenditure in former years	386 763	563 547
Sale of produce, including livestock	380 319	429 733
Royalties from patents	150 217	61 622
Fees for tests and other services	223 446	230 277
Interest on investments	150 781	408 699
Miscellaneous receipts	297 074	425 523
	2 033 356	2 624 775
CSIRONET Operations		
Computing service charges	4 025 268	7 085 438
Receipts in respect of expenditure in former years	14 278	142 354
Miscellaneous receipts	1 586	19 830
	4 041 132	7 247 622
	6 074 488	9 872 397
Total Receipts	184 668 488	241 439 397

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

4. Total expenditure comprises:

	1980/81 $	1981/82 $
Salaries	142 383 507	194 313 962*
Travel	7 290 974	7 798 764
Equipment	12 518 775	11 427 022
Maintenance	45 662 686	52 022 012
Capital	5 660 772	5 300 132
	213 516 714	270 861 892

* As from 1 July 1981 CSIRO assumed responsibility for the Employer's Share of Superannuation. In 1981/82 CSIRO incurred expenditure of $26,053,128 on the Employer's Share of Superannuation.

5. Funds held at 30 June 1982 included investments totalling $6 658 200. The comparative investments figure at 30 June 1981 was $2 158 200. Of the total investments $4 304 000 represents funds which had been appropriated to CSIRO but could not be expended in 1981/82 as a result of Federal Budget restraints.

Investments (at cost) held as at 30 June 1982:

	$
Trust Funds	
Commonwealth Inscribed Stock	50 000
State Electricity Commission of Victoria	18 200
Melbourne & Metropolitan Board of Works	12 000
National Bank Term Deposit	78 000
	158 200
Other Investments	
Reserve Bank of Australia Interest Bearing Deposits	6 500 000
TOTAL	6 658 200

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

	1980/81 $	1981/82 $
Receipts		
CSIRO users	3 416 175	3 316 819
Other users	4 025 268	7 085 438
Receipts in respect of expenditure in former years	14 278	142 354
Miscellaneous receipts	1 586	19 830
	7 457 307	10 564 441
Payments		
Operational expenditure	7 466 258	11 055 213*
Capital expenditure	636 617	685 574
	8 102 875	11 740 787

* Of the operational expenditure recorded for CSIRONET the Division of Computing Research research activities were funded by CSIRO Appropriation to the Division of $1,287,200.

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

	1980/81 $	1981/82 $
Department of Transport and Construction:		
Repairs and maintenance	4 851 476	4 380 727
Buildings and works	44 722 507	54 930 242
	49 573 983	59 310 969
Department of Administrative Services:		
Acquisition of sites and buildings	215 377	2 615 440

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

   On 30 June 1981 CSIRO exercised its option to purchase a one-third shareholding in Siromath Pty Limited. CSIRO purchased a $1 share in the Company and as at 30/6/82 CSIRO has subscribed a total of $34 000 to the working capital of Siromath Pty Limited.

9. Following the death in December 1980 of Miss T McMaster, the life interest left to her by her father, the late F D McMaster, fell to CSIRO. The interest is in the form of 60 601 shares (or 32.05% of the issued capital) in F D McMaster Pty Ltd. The principal asset of the company is a property at Cassilis NSW named 'Dalkeith'.

J.P. Wild
(Chairman)

R. Nairn
(Assistant Secretary, Management Services)

Advisory Council and State and Territory Committees

The Science and Industry Research Act 1949 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.

This section includes advice provided between 1 July 1981 and 30 June 1982, and comments on that advice. By agreement with Council, it also reports generally on the activities of Council, the six State Committees and the Northern Territory Committee for the same period.

15. Advisory Council and State and Territory Committees - advice and activities

In the year under review a number of re-appointments and new appointments to Council and to State Committees occurred, as terms of initial appointment to the reconstituted Council and State Committees ended. The changes in membership are reported later in this chapter and full lists of members are set out in Appendix II.

Council met four times during the year, and State Committees met regularly. A notable event this year was the establishment of the Northern Territory Committee. Its establishment was foreshadowed in the 1979/80 annual report, and resulted from a suggestion by the Chief Minister for the Northern Territory.

ADVISORY COUNCIL

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

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

Changes in Membership

Terms of appointment of all State Committee Chairmen, who are *ex officio* members of Council, expired on 31 August 1981.

Mr D. Horgan was appointed Chairman of the Western Australian State Committee; he succeeded Mr L.C. (now Sir Laurence) Brodie-Hall. Dr G.I. Alexander was appointed Chairman of the Queensland State Committee. Mr E.P.S. Roberts was Acting Chairman from the time of Mr K.E. Gibson's retirement in 1981 until Dr Alexander took up his appointment. Mr R.A. Footner succeeded Mr J.E. Harris, in South Australia. Mr K. Satchwell was appointed Chairman of the New South Wales State Committee following Mr A. Boden's retirement from Council. Mr G.A. Letts, already a member of Council, was appointed Chairman of the Northern Territory Committee. Professor P. Scott and Mr J.E. Kolm were re-appointed as Chairmen of the Tasmanian and Victorian State Committees respectively.

Dr J.L. Farrands, the former Secretary, Department of Science and Technology, retired in January 1982 and was succeeded by Dr W.J.McG. Tegart, the current Secretary of the Department.

The terms of appointment of Sir Ian McLennan and Mr J.A. Michael expired on 31 August 1981.

Mr A.J. Woods, Secretary, Department of National Development and Energy, was succeeded by Mr D. Ives, Deputy Secretary of the Department, and Mr N.S. (now Sir Neil) Currie, the then Secretary, Department of Industry and Commerce was succeeded by Mr F.N. Bennett, Deputy Secretary of the Department.

Mr J.H.S. Heussler and Dr B.W. Scott were re-appointed as members.

New appointments were: Dr S.C. Bambrick, Sub-Dean, Faculty of Economics, Australian National University; Mr R.K. Gosper, Chairman and Chief Executive Officer, Shell Company of Australia; Mr D. Hartley, Hartley Computer Applications Pty Ltd; and Mr M.S. Shanahan, member of the Australian Wheat Board.

Council has worked closely with the CSIRO Planning and Evaluation Advisory Unit in seeking advice from industry and other users of CSIRO research about the direction and level of current research in the Divisions. Council also works with individual members, Standing Committees and *ad hoc* committees, to CSIRO review committees examining research programs of particular Divisions, or programs related to subjects that extend over several Divisions.

In all these activities the State Committees play an important role and, together with Standing Committees of Council, provide a network which is developing into an extensive and, in many instances, highly specialized source of information, comment and advice to the Organization.

Standing Committees of Council

During the reporting year Council's Standing Committees have been re-organized by the addition of a fifth group, the Information and Social Impact Standing Committee. All Council members now serve on a Standing Committee. Some Standing Committee Chairmen have also co-opted non-Council members.

The titles of the Committees and their terms of reference are as follows:

. Manufacturing Industries Standing Committee
Chairman: Mr J.E. Kolm
Terms of reference: to advise Council on
(a) the needs of industries to which CSIRO research and development might make a contribution;
(b) the means by which cooperation between relevant industries and CSIRO may be established or strengthened; and
(c) CSIRO's research objectives and priorities.

- Rural Industries Standing Committee
  Chairman: Mr J.H.S. Heussler
  Terms of reference: to advise Council on
  (a) the needs of industries to which CSIRO research and development might make a contribution;
  (b) the general level of research effort required;
  (c) the relationships between CSIRO, other research institutions, extension organizations and funding bodies; and
  (d) CSIRO's research objectives and priorities.
- Natural Environment, Renewable Natural Resources and Public Health Standing Committee
  Chairman: Professor F.J. Fenner
  Terms of reference: to advise Council on
  (a) the needs in these areas to which CSIRO research and development might make a contribution; and
  (b) CSIRO's research objectives and priorities.
- Mineral, Energy and Water Resources Standing Committee
  Chairman: Professor L.M. Birt
  Terms of reference: to advise Council on
  (a) the needs of industries or Government authorities to which CSIRO research and development might make a contribution;
  (b) the means by which cooperation between relevant industries, Government authorities and CSIRO might be established or strengthened; and
  (c) CSIRO's research objectives and priorities.
- Information and Social Impact Standing Committee
  Chairman: Professor P. Scott
  Terms of reference:
  (a) to advise Council on matters of national interest which are relevant to
    (i) CSIRO's statutory functions set out in sections 9(b) to (j) of the Science and Industry Research Act 1949;
    (ii) related functions which might, in the national interest, be performed by CSIRO; and
  (b) to cooperate with other Standing Committees by providing an 'information and social impact' input to their deliberations.

Council Advice

The Science and Industry Research Act 1949 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.

During the year Council has provided formal advice to the Executive on CSIRO's biotechnology research, agricultural research policies and priorities, and water resources research. The Executive has responded with comments on the advice. The advice and comments are reported below in full.

Biotechnology

At its meeting in September 1981, Council considered the report of an *ad hoc* committee which it had established to examine a report entitled 'Biotechnology for Australia', which had been commissioned by the Executive. Council's subsequent advice, and the Executive's response to it, is set out below.

1. Council supported the selective expansion of CSIRO work in the biotechnology field. It stressed that this process of selection must rest on the need for:

(a) The acquisition of information about national and international markets for biotechnological products and processes. This information would help the Executive to assess the commercial implications of research projects in the light of resources of existing Australian industries and the potential for creating new industries, and on this basis to determine its priorities.

(b) Early concentration of CSIRO resources into defined target areas.

Response:

The effect of the Report's recommendations and the Executive's decisions on them will be to expand CSIRO's work in biotechnology selectively. The use of market intelligence will be considered in the forthcoming review of the Organization's commercial activities. Such information is always helpful in setting research priorities but its weighting would remain a matter for judgement in any particular instance.

2. Council considered that the greatest commercial potential lay in the pharmaceutical field, particularly human drugs, but made the following observations:

(a) The scope for biotechnology research by CSIRO could be limited by the Government's directive that research in human medicine should not be a direct objective of the Organization.

(b) The cost of commercial development, including toxicological screening, together with the vastly greater resources and research investment of the major overseas pharmaceutical manufacturers, and their patent domination and marketing strength, make it a difficult field in which to get a foothold.

Nevertheless, Council considered it likely that any fundamental discoveries in methodology which CSIRO might make could have relevance (possibly their greatest potential) in the pharmaceutical area. Developmental strategies, including patenting and licensing arrangements, should therefore take this possibility into account.

Response:

In terms of national benefit and world market, a greater potential may be in veterinary rather than medical pharmaceutical products. In either event, CSIRO, in accordance with its published policy, would not initiate programs in human medicine; where appropriate, however, the results of its research with relevance to human health would be drawn to the attention of the CSIRO Medical Research Liaison

Committee. This Committee could then consider the possible development of the discoveries, including collaboration between CSIRO and a recognized medical research organization. Discoveries with application in the pharmaceutical area would be examined on their merits in accordance with CSIRO's normal procedures for patenting and licensing but special attention would be given to the development of suitable strategies in the pharmaceutical area.

3. Council recognized that there are other less market-oriented and less competitive research areas in which it was appropriate for CSIRO to maintain a strong effort. These included:

(a) Research of particular significance to Australia which was unlikely to be initiated by Australian or overseas industries, e.g. genetic improvement of crops and pastures.

(b) 'Public interest' research, e.g. treatment of effluents.

(c) Broadly mission-oriented or basic research which might lead to breakthroughs in both techniques and applications.

Response:

The Executive recognizes the importance of these three areas. The present range of the Organization's research activities is consistent with these criteria.

4. Council noted evidence of public disquiet about possible hazards associated with experimentation in biotechnology. It felt that there was a need to inform the public about the social and economic implications of rapid developments in this field, and that CSIRO should accept a share of the responsibility. It recommended that the Executive develop a public-awareness strategy, linked, in terms of content and timing, to the announcement of significant CSIRO developments.

Response:

As a result of its consideration of the report 'Biotechnology for Australia', the Executive decided upon the prompt publication of an amended version which would incorporate a revised version of the earlier report on the use of recombinant DNA techniques with a comprehensive preface. The publication, entitled 'Biotechnology Research and Development', was published in November 1981.

While this represents an immediate response to this aspect of the Council's advice, it is also noted that the Commonwealth Government has instituted a Recombinant DNA Monitoring Committee which will draw up guidelines for the commercial scaling-up of genetic engineering techniques and act as a 'watchdog' on future developments. A senior CSIRO officer has been appointed in a personal capacity to both the Monitoring Committee and its Scientific Subcommittee.

5. Council noted that a current review of the Australian patenting system was being conducted by the Industrial Property Advisory Committee, and that plant varietal rights legislation was being considered by the Government at present. It considered that reciprocal international protection of products of genetic

engineering was critical to the exploitation of Australian discoveries, and should, therefore, be reflected in Australian law.

Consequently, it recommended that CSIRO provide a submission to the Committee supporting the patenting of genetically engineered substances, including organisms and processes, in order to protect its own interests and those of Australian industries developing CSIRO discoveries.

Response:

CSIRO has already made a submission to this review which did not, however, touch on this topic. The Executive has asked the Director of the Bureau of Scientific Services, in consultation with appropriate Institute Directors, to give consideration to the preparation of a supplementary submission addressing this proposal.

6. Council also asked that comments, prepared for or on behalf of the State Committees in Western Australia and New South Wales, be drawn to the Executive's attention.

Response:

The comments from the State Committees in Western Australia and New South Wales have been noted and, where appropriate, incorporated into the Organization's publication 'Biotechnology Research and Development'.

(A statement of the Executive's policies on biotechnology research is presented in the chapter on 'Biotechnology'.)

Agriculture

At its meeting in June 1982, Council considered the report of its Standing Committee on Rural Industries. Council's subsequent advice to the Executive on Agricultural Research: Statement of Policies and Priorities, and the Executive's response to this advice were as follows:

1. Council notes that the statement of policies and priorities follows an extensive planning review. Council commends both the structure of this review, which enabled research opportunities to be tested against market needs, and the wide consultation which has taken place during the process. The review represents significant progress in establishing policies and priorities for agricultural research.

Council notes that while the outcome of the extensive review sets a broad framework for research planning, continued close attention will be paid to further scientific advances or changes in economic factors. Council agrees that continuing Divisional and subject reviews in specific areas will be important inputs to this process. It supports the Executive's aim to maintain a flexible means of setting priorities while ensuring that the Organization's research effort is selective and concentrated in those areas of greatest promise and relevance. Council believes it will be necessary to assess continually the appropriateness of CSIRO's research policies and priorities against the changing structure of Australian agriculture and wishes to remind the Executive of its willingness to contribute to such assessments.

2. Council agrees:

(a) That the primary emphasis of CSIRO agricultural research should be directed to aspects of agricultural production of widespread significance which require mid- to long-term research. However CSIRO should not be inhibited from pursuing certain short-term research opportunities, as and when they arise, particularly where support from industry is available.

(b) That the present CSIRO agricultural research effort and the balance between basic, strategic and tactical research is appropriate to this role. In terms of CSIRO's current resources the overall level of agricultural research effort is appropriate, but minimal in terms of national requirements. Council notes references in recent surveys to the decrease in Commonwealth allocations to rural research and thus considers the need for a continuing review of how resources are allocated is especially important.

Response:

The Executive welcomes Council's endorsement of its planning review process and of the balance, level and primary thrust of CSIRO's agricultural research effort.

3. Council considers the priorities determined as a result of the review are appropriate, subject to the following important qualifications:

(a) That in view of present and projected industry productivity and market prospects, especially export markets, CSIRO should give more emphasis to plant research relative to animal research.

The last few years have seen a significant increase in world trade in grain crops and an increasing contribution of crops to agricultural production relative to livestock industries. Competition amongst developed countries for grain markets has been intense and in a number of countries has attracted increased resources to research to capitalize on the opportunities. Such research is required, especially in Australia, to address problems of static and, in some cases, declining yields in major crop species and problems associated with intensification of cropping, namely the increased pest and disease risk, lowered soil fertility and soil erosion.

It is noted that an enhancement of plant research which contributes to pasture improvement would reduce the exposure of Australia's animal production industries to price changes in world meat and fibre markets. Research on animal production inputs allows for greater flexibility than research on the animals themselves insofar as the same inputs can be used for different animals.

Council recognizes that there are divergent views on the relative emphasis to be given to plant as against animal research and commends the Executive's decision to carry out a more detailed analysis as part of the implementation of the research priorities. Such an analysis should take account of the potential for more competitive animal production as better pastures are developed,

particularly in northern Australia and marginal country, and as advances are made in immunology and tropical animal science.

(b) That in view of the indications that the world fibre market offers relatively stable prospects for wool and that the future for trading meat is not so clear, a shift in research emphasis from cattle to sheep may be appropriate. It is noted that this matter will be addressed by the Executive's detailed analysis mentioned in 3(a) above.

In this context, Council observes that, with the possible exception of research into tropical animal production, there are probably more opportunities for utilizing the results of overseas research on cattle, than there are on sheep.

Response:

The Executive notes Council's endorsement of its decision to carry out a further detailed examination of the balance between plant research and animal research, which will also include consideration of the balance between cattle and sheep research.

(c) That research into agricultural systems, that is, the understanding of interactions between soil, plants, animals and climatic factors with the aim of developing productive and sustainable agricultural systems, should be placed in the highest priority category.

Response:

The Executive accepts Council's views on the importance of agricultural systems research, and will take these into account in its planning review of the natural environment sub-sector which includes land research. The Executive also notes that some already identified agricultural research priority topics (e.g. improving efficiency of root function and management of soil-borne plant diseases) include elements of agricultural systems research.

(d) That a primary consideration in pest and disease research should be objective assessments of biological effects and economic losses.

Response:

The Executive agrees that long-term ecological effects require consideration in pest and disease research planning and that inclusion of assessments of economic losses is also important; it notes, however, that at the early stages of research planning the extent to which potential benefits of such research can be quantified is often limited.

(e) That biological control of insect parasites should be given highest priority in addition to research into the resistance of parasites of livestock to pesticides and anthelmintics.

Response:

The Executive accepts Council's views and has included in its highest priority category the topic 'biological control of insect parasites'.

4. Council notes comments by a number of members that CSIRO

receives insufficient feed-back from the industry about its needs, or the impact that CSIRO research might have, or was having, on productivity gains or lowering production costs. It feels that CSIRO itself could help to improve this situation by critically examining its relationships with State Departments of Agriculture and Primary Industries, taking account of the increased R & D resources in the States. All levels of the Organization should be involved in collaboration, co-operation and communication, as appropriate, with other agricultural R & D bodies and thus contribute to co-ordination of the national effort.

An Executive review of the effectiveness of the transfer of CSIRO results to the agricultural industry, with particular reference to the role of the State Departments in this process, is recommended.

Response:

The Executive notes Council's views on the importance of industry inputs and feed-back on the application of CSIRO research results and the role State Departments of Agriculture and Primary Industries can play in this regard. The Organization is in the process of developing closer links with State departments at the highest level and agrees on the importance of cooperation at all levels. The effectiveness of the transfer of CSIRO's agricultural research results will be subject to on-going scrutiny.

5. The difficulties of co-ordinating the national effort in agricultural research are noted. Council feels that the preparation of a compendium of agricultural research and development in Australia, similar to the compendium of Australian energy research, development and demonstration projects prepared by the Department of National Development and Energy, would be a useful first step towards a better co-ordinated effort. It recommends that the Executive give sympathetic attention to any requests for assistance in the preparation of such a document.

Response:

CSIRO will assist in the co-ordination of the national agricultural research effort. The Executive believes that the preparation of a compendium of agricultural research and development in Australia is important and that this should be a responsibility of the Commonwealth Department of Primary Industry. It will alert that Department to Council's views and will respond sympathetically to any subsequent request for assistance in preparation of a compendium.

(A statement of the Executive's policies on agricultural research is presented in the chapter on 'Agriculture'.)

Water Resources Research

At its meeting in June 1982 Council considered its earlier views and agreed that advice on water resources research in CSIRO should be given to the Executive. Council's advice was as follows:

Water is amongst Australia's most critical resources. The importance of security of supply and quality for the community in

general and agricultural purposes needs no emphasis. Many manufacturing activities and an increasing number of mining activities are also dependent on assured supplies. Council considers that too little is yet known of Australia's water resources and their management, and yet the results of an Australian Water Resources Council Study (AWRC Working Group on Water Research Policy January 1982) indicate that there has been a decline in water resources research in this country over the last few years.

In March 1982 Council received the report of an Executive Working Committee on CSIRO's water research opportunities and the Executive's proposals following this report. Council was advised that the level of Commonwealth support and arrangements for water resources research were under review by Government. It noted that the Government had recently initiated a study into national water resources perspectives to the year 2000. Pending the outcome of the Government's considerations Council wishes to provide the Executive with the following advice:

Research by CSIRO into water resources problems should be accorded very high priority.

Council supports the emphasis given by the Executive to research on:

. salinity and other water quality aspects
. management of groundwater resources
. catchment hydrology.

The Executive's response was as follows:

The Executive welcomes the Advisory Council's advice which endorses the high priority CSIRO is giving to water research and the particular research areas selected by the Executive for expansion.

(A statement of the Executive's policies on water research is presented in the chapter on 'Water'.)

STATE COMMITTEES

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

The names of the current members of the Committees and their affiliations are set out in Appendix II.

The functions of a 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 it received and the information so gained, and in particular, to furnish such advice with respect to any matter that is referred to it by the Advisory Council for advice.

Advice from a State Committee to the Advisory Council provides an important contribution towards the development of CSIRO's research policies.

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

New South Wales

The New South Wales State Committee met formally on four occasions during the year. The Committee has been involved in a number of activities both independently and in collaboration with the Advisory Council.

Members and co-opted members have been involved with the Manufacturing Industries Standing Committee, the Rural Industries Standing Committee and the Advisory Council's *ad hoc* committee on biotechnology. Members contributed towards the reviews of the Divisions of Textile Industry and Building Research and the Wheat Research Unit.

Submissions were made in respect of planning documents prepared by the CSIRO Planning and Evaluation Advisory Unit on agricultural research and manufacturing industry research.

The Minerals and Energy sub-committee has actively supported the further development of a project concerned with the use or disposal of coal washery wastes using fluidized bed techniques. Discussions have taken place with possible users in industry and with State authorities.

The major activity of the Committee during the year was the organization of a seminar, 'CSIRO and Manufacturing Industry'. The aim of the seminar was to promote discussion between executives of manufacturing companies and senior CSIRO staff about ways in which CSIRO could work to assist industry in developing industrial and product technology. Over 150 participants attended. The initial aims of the seminar were met and the Committee will be following up several recommendations which resulted from the seminar.

Representations were made in relation to upgrading facilities for Australia's use of the Landsat 'D' satellite program, the reconsideration of decisions made on some research at the Division of Irrigation Research, and the decision by Government to close the Scientific Liaison Offices in London and Washington.

Queensland

The Queensland State Committee met formally on five occasions during the year. Members contributed to the reviews of the Divisions of Atmospheric Physics, Building Research and Animal Health. Submissions to the CSIRO committee reviewing water resources research were also made. To ensure effective consideration of matters coming before the Committee, four Standing Committees involving all Committee members were formed. The

State Committee was represented when the Advisory Council Rural Industries Standing Committee met in May 1982 and participated in the discussions on 'CSIRO Agricultural Research: Policies and Priorities'.

During the year Sir Peter Derham, Chairman, CSIRO Advisory Council, addressed the Committee, and Mr L.G. Wilson, CSIRO Executive Secretary, presented a report on CSIRO's activities for the Committee's information. Also, Mr R. Brown, Chief, Division of Manufacturing Technology, addressed a joint meeting of members of the Institution of Engineers, Australia and the State Committee on interaction between CSIRO and Australian industry.

In March 1982, the Australian Scientific Industry Association held a two-day seminar in Brisbane with the major theme 'Scientific Instruments in Primary Production'. The Committee supported and assisted in the arrangements for this successful exchange of ideas.

The Committee has seen a need for greater understanding between CSIRO and industry and has given consideration to a seminar on 'CSIRO and the Engineering Profession' to be held at a later date.

South Australia

The South Australian State Committee held five business meetings during the year and was able to inspect work being carried out at the Divisions of Soils and Human Nutrition (Glenthorne Laboratory).

The policy of promoting CSIRO interests in South Australia was developed with a seminar held at Berri in the Riverland district in which the Organization's work was explained to an audience of community leaders. Similar activities are planned for other regions in the future.

The Committee has contributed to the development of CSIRO's policy on water research and has considered how best to deal with the Divisional and subject reviews periodically undertaken by the Organization. The need for the establishment of sub-committees to take advantage of these opportunities has been recognized.

Tasmania

The Tasmanian State Committee met on five occasions in 1981/82.

Communication with the public and industry has been an area of concern to the Committee, which saw a need for recognized but simple procedures so that both provision of technical information and the evaluation of problem areas for future consideration could be handled effectively.

New appointments to the State Committee have provided more emphasis to the area of manufacturing industry. A Manufacturing Industry sub-committee has been formed to evaluate local needs in relation to general policy developments.

The sub-committee formed to consider rural research needs is concerned about the decreasing involvement of CSIRO in agricul-

agricultural research in Tasmania. Ways of increasing the presence of CSIRO in the smaller States have been considered, including the possible need to develop a system of secondments to transfer expertise to State agencies if no independent research is maintained. The sub-committee responded to the CSIRO proposals on agricultural research policy and priorities.

The sub-committee considering marine science has identified the fishing industry as the main area for CSIRO attention. The possibility of co-operative work with other institutions in Tasmania directed to marine studies, with expansion into aspects never previously handled, such as shipping, has been discussed.

Victoria

The Victorian State Committee met on five occasions during the year and visited the Divisions of Protein Chemistry, Chemical Physics, and Materials Science. On each visit, the Committee was accompanied by a group of industry and community leaders chosen for their interest in the activities of the particular Division.

The Committee is maintaining a close interest in the Advisory Council's consideration of CSIRO's agricultural research policies and priorities. It has submitted a report 'Rural Research in Victoria—Suggested Research Objectives and Tentative Priority Rankings' as a Victorian input and has kept in contact with the Advisory Council's Rural Industries Standing Committee.

The State Committee has made submissions to the Committees responsible for the reviews of CSIRO's International Activities; Library and Information Services; the Divisions of Building Research, Applied Geomechanics, and Animal Health; and to the subject review of Biotechnology.

Western Australia

New appointments to the State Committee were not finalized until early 1982, which resulted in only three meetings being held in the current year.

The Committee responded to the review of CSIRO agricultural research and is investigating the prospect of increasing resources in agricultural research in Western Australia, particularly in the area of animal and plant relationships.

Submissions were made to the committees reviewing the Divisions of Animal Health and Building Research, and the Library and Information Services.

The Committee supported the transfer of the Surface Chemistry Section of the Division of Mineral Chemistry to Western Australia, and consulted with the Western Australian Government and private industry with a view to assisting with the transfer.

Research

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

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

16. Genetic control of helminth parasites

Losses in meat and wool production caused by helminth parasites, especially gastrointestinal worms, are a major concern of the grazing industry. The total cost of parasitism is difficult to assess, but farmers spend more than $30 million a year on anthelmintic drenches for the control of worms in sheep alone.

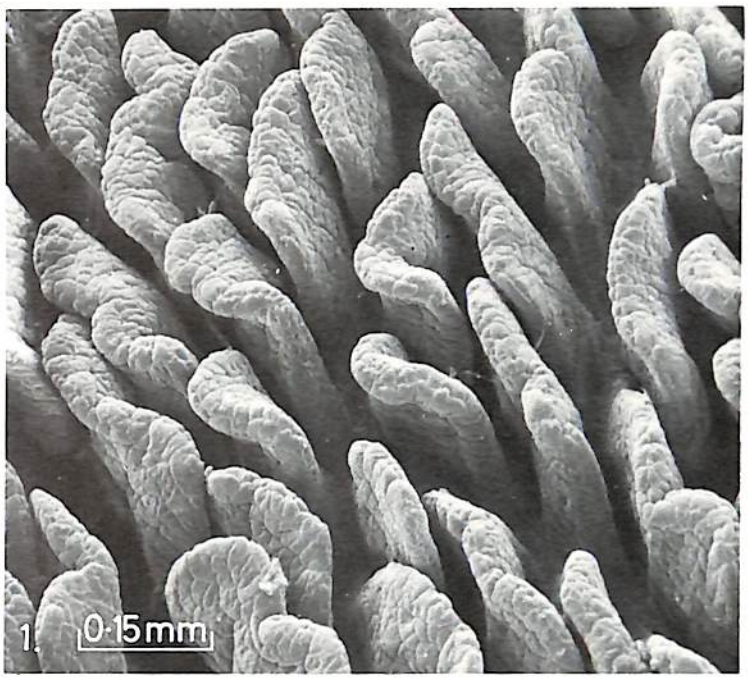
Current methods of control rely on the timely use of anthelmintics and the reduction of the rate of reinfection by grazing management. These procedures, however, do not eliminate the effects of parasitic infections. Because of the widespread use of anthelmintics, parasites of ruminant animals are becoming increasingly resistant to one or other of the modern broad-spectrum drugs. This resistance is likely to continue to increase in spite of recent, more enlightened, strategic use of the drugs. CSIRO is helping in the search for alternative methods of control by manipulating and exploiting the genetic make-up of both hosts and parasites.

Genetic Selection for Host Resistance

Resistance may refer either to the ability of an animal to tolerate the effects of infection or to its being able to prevent infection through its immune mechanisms. As animals are seldom completely tolerant to infection, prevention is better than cure. Research is focused therefore on the immunological responsiveness of animals.

Although the immunity acquired during natural infection in the field plays an important role in controlling parasites in grazing animals, natural selection ensures the survival of the parasite as well as the host. Thus the level of protection stimulated by field infection, while ensuring survival of the host, is not high enough to eliminate the parasite—nature makes no special provision for the economic considerations of the farmer. Attempts to improve on natural immunity by producing vaccines that give very high levels of protection against field infection have met with only limited success. An irradiated larval vaccine against bovine bronchitis caused by *Dictyocaulus viviparus* remains the sole commercial success.

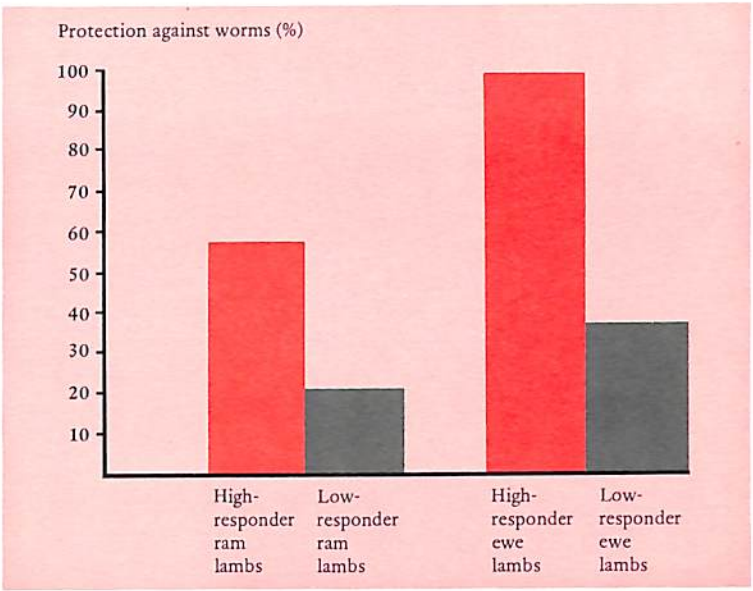
Studies have shown that the capacity of sheep to respond to vaccination against some intestinal worm parasites is determined genetically. It has long been recognised that young animals are less responsive to vaccination against helminth parasites than mature animals. However, while lambs respond poorly on average, in fact some 40 to 50 per cent respond quite vigorously and the remainder show little, if any, response. This division into high- and low-responders suggests that in lambs the variation of response is largely due to genetically-determined factors and lends weight



1. *Scanning electron microscopy of the surface of the small intestine of a normal animal, showing the projections or villi on the intestinal wall.*

2. *A male worm and the irregular, flattened villi of an animal heavily infested with parasites.*

Within high- and low-responder matings, ewe lambs respond better to vaccination than ram lambs.



to the view that the immunological control of parasites may be exploited by manipulation of the host. In sheep, differences in susceptibility to parasitic infections also occur between breeds and between sire progeny-groups within breeds of sheep.

The approach is to improve the resistance of young animals to gastrointestinal helminths by selective mating. This type of selection is particularly relevant to the grazing industry since the effects of parasitism are particularly severe in young animals. In addition, selected high-responder animals will probably react vigorously at an early age against a broad range of parasites rather than only against the particular organism that is used in the selection program. For example, research at the Tropical Cattle Research Centre at Rockhampton has shown that in yearling heifers at pasture, individuals resistant to one species also tend to be resistant to others.

Lambs were vaccinated by oral dosing with larvae of the black-scour worm (*Trichostrongylus colubriformis*) which had been treated with γ-rays; this limits infection and nearly eliminates the pathogenic effects of the live vaccine. Response to vaccination was assessed by examining faecal samples for worm eggs when the lambs were challenged with normal infective larvae. The lambs were then ranked for performance and subsequently assortively mated in both high- and low-responder categories. The performance of the first generation of offspring showed that acquired responsiveness of young animals against the parasite was highly heritable, and involved both paternal and maternal genes. About 60% of the variation in responses of lambs to vaccination and challenge was genetic in origin. The work has also shown that within high- and low-responder matings, ewe lambs respond better to vaccination than ram lambs.

The research is aimed at showing that gastrointestinal parasites in young animals can be controlled by genetic manipulation of the immune response without selecting against desirable characteristics like meat and wool production and fertility. Moreover, comparisons of high- and low-responders should increase the basic knowledge of the mechanism of resistance against these parasites.

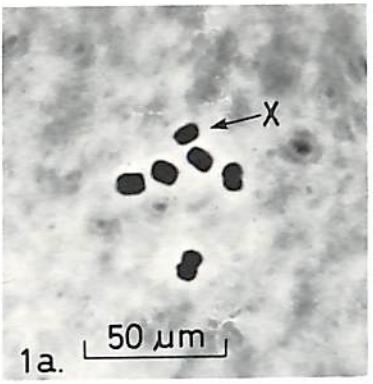
Extension of the genetic approach to immunological control of parasites into the field depends largely on finding a genetic marker for predicting resistance. Currently, some success is being achieved in seeking markers for detecting potential high- and low-responders. This work is based on medical research aimed at measuring the compatibility of the tissues of donors and recipients of skin, kidney and heart transplants by tissue typing. Particular tissue types have been associated with certain diseases in man and animals. Work is directed towards defining types of white blood cells (lymphocytes) in sheep, primarily for use as markers for potential high- and low-responders against parasitic infection. However, it may also be possible to use such markers in selecting for resistance to other infections and diseases and desirable production characteristics.

As the genetic program is directed towards modifying the immunological reactivity of lambs, it is necessary to determine the effect of selection on the animals' general immunological response. This is being done by monitoring the resistance of high- and low-responder animals against a range of parasites and other infective organisms following both natural field infection and artificially-induced infection in penned sheep. It is also important to check the effect of selection on the mechanisms of host resistance, and this is being done by analysing the components of blood that are involved in immune responses and resistance to infection.

Genetic Manipulation of Parasites

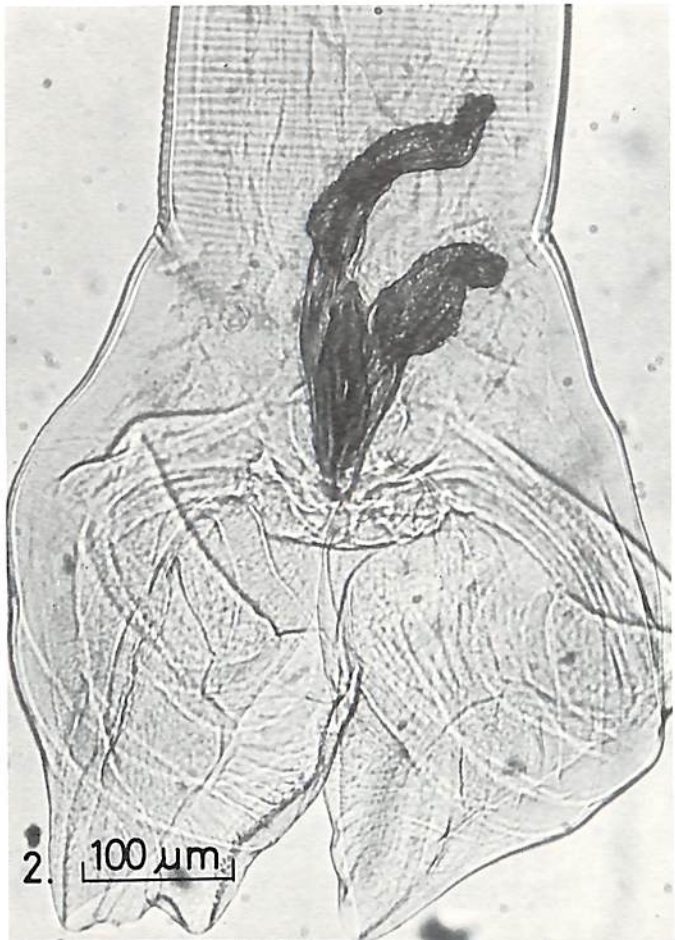
Haemonchus contortus is the most pathogenic species of roundworm infecting sheep in the summer rainfall zones of Australia. The disease haemonchosis causes severe anaemia and occurs mainly in young sheep from three to seven months of age during summer and autumn. Sheep losses of 30% or more have been recorded in a single outbreak of haemonchosis. Recently, this parasite has developed resistance to many of the drenches used to control it. As an alternative means of control, research workers are subjecting the parasite rather than the host to genetic manipulation. This approach requires sheep to be infected with a synthetic strain of parasite.

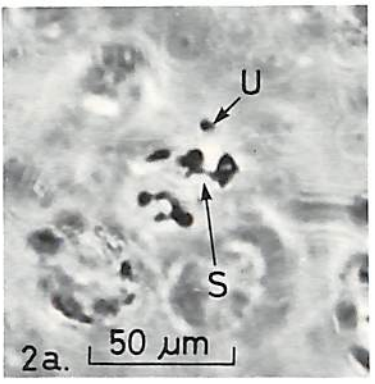
To produce a synthetic strain of *Haemonchus*, the closely related species, *H. placei*, a parasite of cattle, has been hybridized with *H. contortus*. These two species are very similar in appearance and can be identified accurately only by examining their chromo-



1. *Bursa and spicules of a normal* H. contortus *worm.*

1a. *During sperm formation in a normal male, duplicated members of each pair of chromosomes lie side by side. The X, or sex-determining chromosome, is represented by a single pair of chromosomes.*





2. *Spicules are deformed in a hybrid male and cannot be extended, rendering the male incapable of inseminating the female.*

2a. *In the hybrid male, chromosomes do not pair properly; some remain unpaired (U) while the others attempt to pair with several chromosomes, forming secondary associations (S). Chromosomes fail to divide and no sperm are produced.*

somes, the X chromosomes in *H. placei* being larger. Hybrids can be identified by a large *H. placei* and a small *H. contortus* X chromosome.

Crossing *H. contortus* and *H. placei* produces hybrid offspring with a characteristic pattern of abnormal chromosomes. This prevents the chromosomes from pairing correctly and results in male sterility. Sterility occurs in the first generation of males resulting from the mating of *H. contortus* males and *H. placei* females. These hybrids are called the HX_1 strain. In the reverse mating between *H. placei* males and *H. contortus* females, male sterility occurs in the second generation, referred to as the HX_2 strain. A high percentage of these sterile males also have deformed and non-functional spicules, or copulatory organs.

In these two hybrid strains, females are only semi-sterile and produce about 15 per cent viable eggs when backcrossed to wild type *Haemonchus* males. Offspring from hybrid females and wild type males consist of sterile males, the rare fertile male, and semi-sterile females. These latter females produce more sterile male and semi-sterile female offspring, perpetuating a low reproductive potential in the population. Backcrossed progeny, both male and female, often have an increased number of chromosomes consisting of fused *H. placei* and *H. contortus* chromosomes. These worms cannot produce offspring when backcrossed with the wild type.

In nature, however, the two *Haemonchus* species seldom interbreed. It has recently been discovered that if sheep are first infected with *H. placei* and then given *H. contortus*, the *H. contortus* larvae cause the *H. placei* to be rejected. Thus the two species are kept separate.

The genetic control program received a boost when a similar relationship was found between *H. contortus* and the sterile HX_2 strain. In this instance, though, the HX_2 strain is able to exclude or reject *H. contortus*. Experiments with penned sheep have shown that as few as 500 HX_2 parasites were able to exclude 90 per cent of the *H. contortus* which were given in weekly doses of larvae over six weeks. On the other hand, when sheep already infected with *H. contortus* were given weekly doses of HX_2 larvae for several weeks, the resulting infection was less than 500 worms per sheep, 95 per cent of which were HX_2. In both experiments the resulting infections produced no fertile eggs.

Research has also shown that both exclusion and rejection of *H. contortus* by HX_2 can be prevented by injecting the host with opticortenol (a drug with anti-inflammatory and immunosuppressive activities). From this, it appears that the HX_2 worms use an immune-type response to exclude *H. contortus*. This reaction is similar to that used by *H. contortus* to prevent its competitor, *H. placei*, from infecting sheep. The ability of HX_2 to use this reaction against *H. contortus* may be due to hybrid vigour enhancing a previously existing *Haemonchus* trait. An analogy can be made between HX_2 *Haemonchus* and mules; both are sterile but very strong.

The fact that the HX_2 strain uses either an immune or an inflammatory reaction to remove wild type *H. contortus* from sheep may confer another benefit as the sheep would become more resistant to further *H. contortus* following the treatment with HX_2.

The competitiveness of HX_2 must now be tested under field conditions with both large and small *H. contortus* populations on pasture. Also, the factors involved in the rejection of *H. contortus* are being investigated as a prelude to attempts to further improve competitiveness of HX_2.

The surviving *H. contortus* in the abomasum of the sheep will be outnumbered by the HX_2 strain and will mate more frequently with it than with other *H. contortus*. As the HX_2 males are sterile and the HX_2 females semi-sterile, most eggs will fail to hatch. Those backcrossed worms which do develop are characterized by sterile males and semi-sterile females. The population thus has a low reproductive potential. Further useful traits can be infused into the population by selection. Two traits which have already been incorporated into the HX_2 strain are low fertility and a requirement for a minimum temperature of 15°C for egg hatching. The 15°C minimum restricts the time in which eggs can hatch to a much shorter season than that of wild *H. contortus*. Another trait incorporated into HX_2 is susceptibility to the benzimidazole group of anthelmintic drugs. A release of HX_2 could thus reduce *Haemonchus* numbers and also make the subsequent generations susceptible to anthelmintics.

For the present, control of helminth parasites in grazing animals must continue to rely on anthelmintics and farm management. However, recent research has shown that the new initiatives which exploit the genetic variability of both host and parasite promise options for the future. Host and parasite by definition, and by deed, are involved in an intimate relationship; host involvement in premating exclusion of wild strains by sterile hybrids is an example of this association. Furthermore, it is likely that the natural exclusion of one species by another is mediated by an immune reaction in the host. So the two genetic approaches to parasite control outlined are complementary. In short, the exclusion barrier should function most effectively in animals which have been selected for a high level of resistance to worms. The development of drug resistance in parasites in the field has added a note of urgency to these research programs.

17. Improving plants for Australia

Virtually all of Australia's crop and pasture plants have been introduced from overseas. Apart from the development of the macadamia nut as a commercial crop and the beginnings of a domestic and international trade in floricultural species, the only major development of Australian native plant resources has been in the area of forestry.

The development of new agricultural and forest resources and continuing changes in agronomic practices, plant pests and diseases, and consumer attitudes, call for the development of plants with improved characteristics.

Plant Introduction

The introduction, evaluation and conservation of plant genetic resources has made and is continuing to make an essential contribution to plant improvement in Australia. The genetic resources of a species can be defined as all the genes in the wild and cultivated plants that comprise that species, including, sometimes, genes of close relatives of the species. The genetic resources of most of the pasture plants and forest trees that have been cultivated by man for only a short time consist largely of wild types of the species. On the other hand, some field and horticultural crops have been cultivated and selected for thousands of years and may scarcely resemble their wild ancestors. Their genetic resources may consist of an assortment of ancestral types, primitive cultivated varieties and modern improved varieties.

The limited amount of genetic material already introduced into Australia in many of our important crop and pasture species underlines the need to obtain new genetic material. CSIRO has recently completed an extensive two-year plant collecting expedition in Central America where wild types of pasture legume and grass species were gathered. On the other hand, the Organization may import varieties and breeding material from overseas sources as was the case some years ago when the novel technique of bringing in pollen rather than seed was used to speed up a sunflower improvement program.

Recognition of the need to conserve Australia's existing plant resources lay behind the proposal to establish a network of national germplasm centres, a concept supported by the Australian Agricultural Council. Australian collections of tropical pasture plants, annual medics, subterranean clover and *Pinus radiata* pine trees are the largest and most representative in the world for these species, and are only partly duplicated in other countries.

CSIRO holds a collection of some 9000 tropical legumes and 3500 grasses, and shares with the Centro Internacional de

Agricultura Tropical (CIAT) in Colombia world responsibility for the genetic resources of tropical pasture and forage species. The CSIRO collections of tropical pasture and forage plants were granted funding support in 1981/82 from the Australian Development Assistance Bureau (ADAB) in recognition of their value to overseas aid projects.

Priority is being given to assembling representative collections of indigenous Australian wild relatives of important crop species, including soybean, sorghum, rice, and cotton. CSIRO now has the largest collection of Australian native soybean-related species in the world, which are currently being assessed as potential genetic resources for use in improving and adapting soybeans to Australian conditions.

CSIRO also holds the most comprehensive collection of grapevine and grapevine relatives in Australia as part of its breeding work with this crop, and has large collections of citrus, avocados and tropical and subtropical fruits. Traditionally fruit varieties have been maintained either by grafting or by planting cuttings rather than by seed. In view of the difficulty of storing large quantities of vegetative material, tissue culture techniques are being investigated as an alternative means of storage. This work has been supported by the International Board for Plant Genetic Resources.

ADAB and the Food and Agriculture Organization (FAO) also give financial support to the Organization's work in the exploration, collection, distribution and conservation of genetic resources of native eucalypts, acacias and casuarinas. These trees are being used increasingly in forestry and fuelwood projects in developing countries, and for commercial forestry elsewhere.

In Australia, as in other countries, research workers are engaged in domesticating almost wild, unselected trees. Forest trees often have such a broad range of genetic material that an essential first step in any tree breeding program is to identify those natural populations that are sources of better seed than the ones in use at present. For example, in the widely distributed species river red gum, *Eucalyptus camaldulensis*, some populations have been found with superior growth rates and drought resistance. Other populations with a tolerance to high salt concentrations are being tested in field sites in Australia and Israel.

Plant Breeding

Many useful genes lie unused in genetic resource collections simply because they cannot be recognized, their effects are small, their significance is not understood, or their existence is not documented. There may often be a wealth of genetic variation available for the plant breeder; his task is to discover how to use it.

Plant breeding by CSIRO, State departments, universities and some private companies has paid big dividends in Australia. Much of CSIRO's research has been on plant genetics and physiology, aiming for a longer-term contribution to the improvement of a wide range of species. The Organization's breeding work includes the breeding of the long-lived species of plants used in horticulture

and forestry, the adaptation of new crops from overseas to Australian conditions, and the development of productive cultivars from pasture and crop species not previously used in agriculture. CSIRO's plant breeders have also been active in producing varieties that enable existing crops to be grown in new areas.

Much of the task of breeding pasture plant cultivars for eastern and northern Australia has been carried out by CSIRO. For example, the lucerne cultivars 'Siriver' and 'Sirotasman' and the phalaris cultivars 'Sirosa', 'Siro 1146' and 'Sirolan' were produced in the late1970s. Other successful productions include the legume 'Siratro' and cultivars such as 'Narok' setaria, 'Silk' forage sorghum and 'Cunningham' leucaena. The time-scale for breeding new varieties such as these can be as much as ten to fifteen years. However, it can be much shorter, as in the case of recently released lucerne varieties bred as a matter of urgency to meet the crisis brought on by the advent of lucerne aphids in 1977.

With tree breeding, the time-scale is much greater. For instance, twenty-five years of work was necessary to gain a reliable estimate of the degree of genetic improvement possible in radiata pine. Nevertheless, experiments have shown that in only one generation of selection on this species, it is possible to increase tree volume by 20 per cent.

Any advances that allow early selection of promising plants prior to field testing or shorten the assessment period, will greatly improve the rate of genetic improvement. Recently, controlled environment studies have shown a strong relationship between the growth rate of seedlings and the performance of adult trees. However, further research is needed to define the conditions under which early selection can be made. At present, methods are being developed for screening large numbers of grapevines for resistance to fungal diseases and tolerance of saline conditions using *in vitro* or tissue culture techniques. These techniques are also being used to propagate rapidly plants that merit further evaluation.

In the past, plant breeders have been seeking characteristics such as drought tolerance and resistance to stresses imposed by salinity, temperature or defoliation, without there being any clear understanding of the mechanisms involved in these adaptations or any clear definition of the anatomical and physiological characteristics of the plant associated with them. A present trend in basic plant breeding research in CSIRO is aimed at obtaining such an understanding in key crops including wheat, sorghum, oilseeds, rice, forages, grapevines, macadamias, avocados, citrus and other horticultural crops. The work includes studies of the inheritance of characteristics that confer tolerance to stress and will lead to the production of germplasm for use by State departments and other institutional and private breeders in their breeding projects.

For example, basic plant breeding research is in progress into the effects of the environment on flowering and fruit development in avocados. Further research, in collaboration with the University

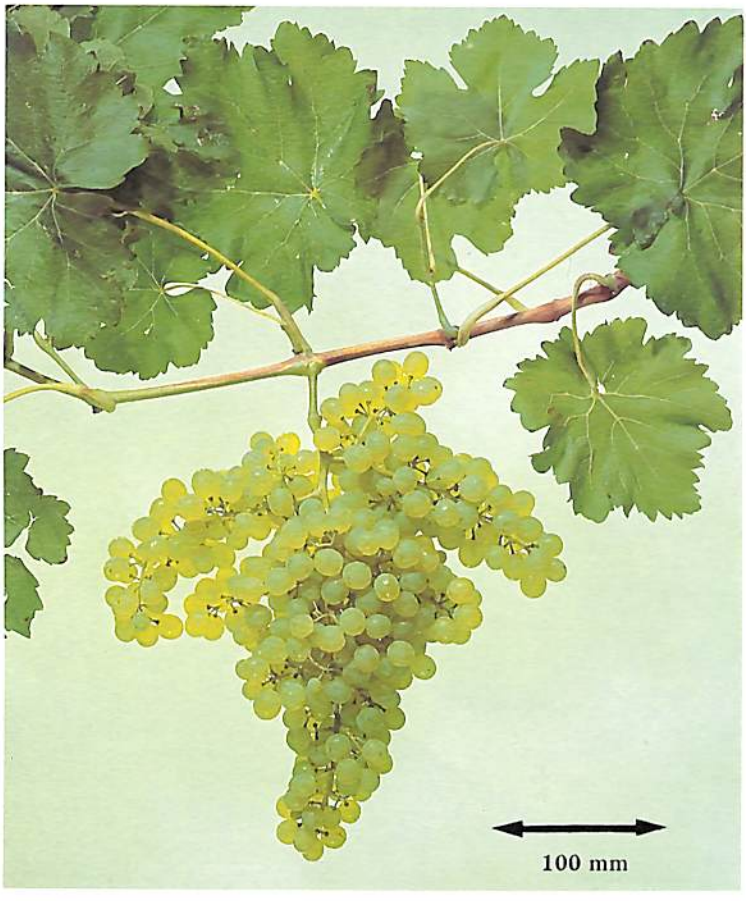
Glaucousness, the waxy covering imparting a bluish-green tinge to the left-hand wheat ear, is being tested for its potential in wheat-breeding programs. Glaucous lines have been found to use water more efficiently during the day and lose less at night.

of Adelaide, has resulted in a technique for rapidly detecting avocado sunblotch viroid. Studies of the physiological and biochemical effects of salinity on plant performance have been aimed at developing rapid methods for testing plants for tolerance to stress using biochemical markers. Also using tissue culture in combination with conventional heat therapy, grapevines completely free from all the major virus diseases that are present in Australia can now be produced—an important breakthrough for future selection work and for the wellbeing of Australia's viticultural industry.

Other research is directed towards understanding the physiological basis of tolerance to saline conditions, particularly in wheat, and has had some success in identifying wheat plants that may be more drought resistant by virtue of an anatomical feature

which restricts supply of water to the plant early in its life. Basic studies on drought and frost tolerance and on herbage quality are helping scientists to breed and select more persistent and nutritious tropical pasture species. In other recent studies, breeding lines of Indian mustard have been identified with oil free from erucic acid, which is regarded as undesirable for human consumption, and lines of sunflower with consistently high levels of linoleic acid which will make the crop a more reliable source of polyunsaturated oil. These lines also germinate much more rapidly under cold conditions than seed with low linoleic acid levels. This should allow farmers to sow sunflowers much earlier in the season, even in winter.

A number of other contributions to crop improvement have resulted from the Organization's plant breeding programs in recent years, including the development of disease-resistant lines of sunflower and safflower, the improved grape varieties 'Carina', 'Tarrango', 'Goyura', 'Tulillah' and 'Merbein Seedless', and the wet-season varieties of soybean 'Buchanan' and 'Durak'. Many of these have arisen from the recognition that certain genes already available in the existing pool of genetic resources would be useful if incorporated into existing well-adapted varieties.



Merbein Seedless, a newly released white seedless grape variety similar to Sultana, was bred primarily for drying but can also be used for wine-making or as a table grape. Compared with Sultana, it gives higher yields and is less easily damaged by rain and by the drying process.

Molecular Biology and Plant Breeding

In plant breeding programs, sometimes only two or three genes may be needed to develop an improved variety with resistance to certain pests or diseases, or adapted to environmental stress, or with better yield and quality. Once the sources of these genes have been identified, the plant breeder is then faced with isolating them from the many thousands of genes and gene combinations that are not wanted. A lengthy crossing program to achieve this can involve him in up to ten years of rigorous effort and field testing. Perennial species are even more of a problem since they rarely grow true to type from seed and the long period from seed to first flowering (from two to ten years) slows the process of evaluation and reduces the opportunity for assessment of the second or third generations.

Recent advances in recombinant DNA techniques ('genetic engineering') and cell and tissue culture research have given plant geneticists new insights into the structure and function of genes. These techniques have also increased the possibility of being able to remove the required genes from chromosomes with 'genetic scissors' and reintroduce them into existing well-adapted cultivars without disturbing the rest of the finely-balanced gene complement. Using the new technique, it should also be possible to modify the genes and improve their function, then return them to plants in the modified form. Both prospects would offer immediate advantages to plant breeders. Normal plant breeding would still be necessary, but in cases where genetic engineering could be employed, the lead time for new varieties of plants could be halved.

At the moment, the main use of these new technologies is to gain an understanding of how genes are structured and organized in plants, and what makes them work. Eventually, it is expected that they will be used to incorporate such features as pest or disease resistance into crop and pasture plants. Other more ambitious projects under review include improving the nutritive value of seed protein, incorporating drought resistance characteristics, and transferring to non-legume crops the ability to fix their own nitrogen.

Techniques for isolating and decoding specific fragments of DNA have developed rapidly over the past ten years, partly as a result of the discovery that certain enzymes found in bacteria cut DNA at particular points. These enzymes (the 'genetic scissors' referred to earlier), of which about 200 are currently available, can be used in different combinations to isolate particular portions of DNA. These portions, which may contain one or several genes, can be recombined with the DNA of another organism using enzymes that mend instead of cut the DNA strand.

For instance, portions of cut-off bacterial DNA can be mixed with fragments of plant DNA and made to recombine in the presence of another set of enzymes. The recombinant DNA molecules so formed can then be multiplied many millions of times using the bacteria as gene factories. A number of plant genes for certain enzymes and pea-storage proteins have been isolated and multiplied in this way.

The availability of a large number of exact copies of a gene for studying their structure and function, gene isolation and multiplication is also an essential first step in transferring specific genes between plants. Gene sequences will have to be introduced into plant cells in such a way that they function in a controlled manner. Several techniques are being investigated, including mixing DNA with cells from which the cell walls have been removed, injecting DNA into cells using microsyringes, or incorporating them into molecules such as certain plant viruses which can carry them into cells.

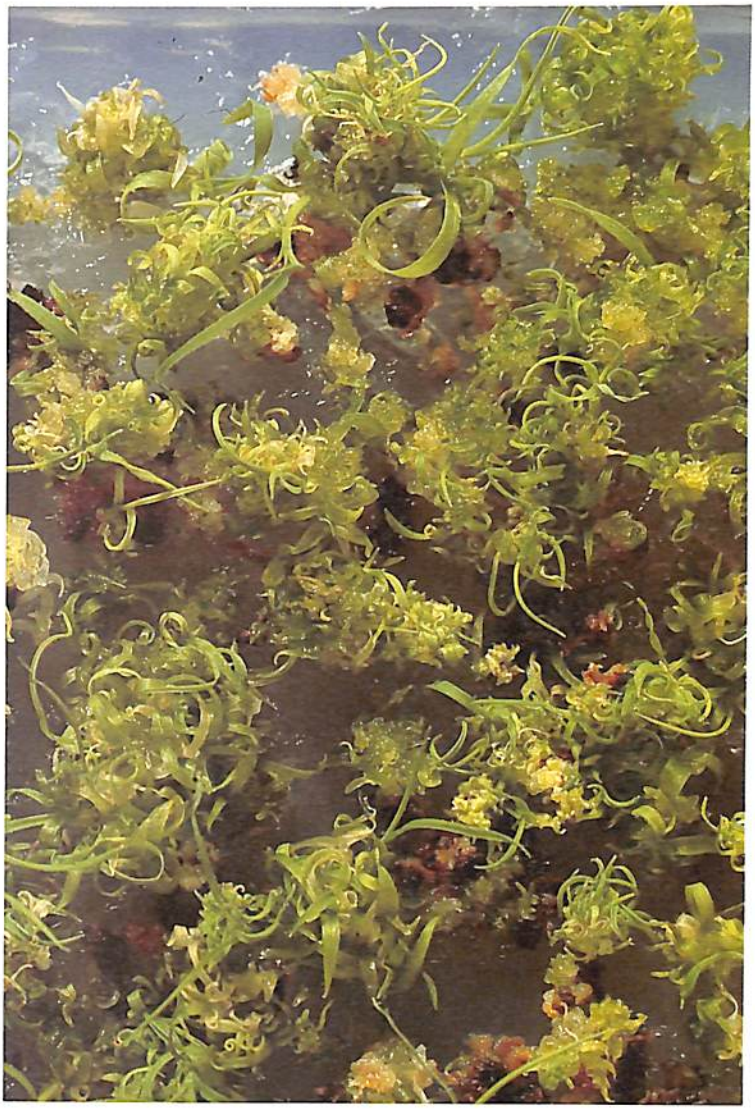
Once DNA has been introduced into a cell, it must be demonstrated that it has been successfully incorporated. Some genes have products which can be recognised immediately while others may have to be attached to other genes that can be switched on or off during propagation. At present, work is in progress on isolating the coding and switching sequences of the gene for the enzyme alcohol dehydrogenase which only expresses itself when oxygen is in short supply. It is possible that these genes could be used to transport other desired genes into plant cells.

Cell and Tissue Culture in Plant Breeding

The success of molecular plant breeding techniques will depend largely on recent advances in plant cell and tissue culture research. It is now possible to strip the cell walls off plant cells so that foreign DNA can be inserted. In some species, these naked cells can be induced to reform their cell walls, form colonies and then regenerate into fully mature, fertile plants. This allows a greatly increased rate of selection for biochemically recognizable plant characters, as millions of cells can be tested at one time in the laboratory.

Besides the possibility of being able to recognize the incorporation of specific genes into plant cells, the techniques can be used for selecting for desired characteristics identified within the range of genetic variation in a particular crop species. For example, a recently initiated research program is directed towards selecting for higher levels of certain dietary components in cereals, resistance to diseases in various crops, tolerance to saline conditions, and resistance to the herbicides used in modern agriculture. Research is also under way aimed at inducing genetic variation through exposure to agents that cause mutations.

Another approach is to explore the genetic variation that is known to occur in tissue culture. Until recently, it was generally accepted that all plants regenerated from cells of a single parent plant would be genetically identical. However, it has recently been discovered that on passing cells through a tissue culture cycle, genetic variation may occur. This phenomenon has been observed in sugarcane, potato, maize, oats, rice, lucerne, ryegrass and other species. Using this procedure, it has been possible to develop from a previously susceptible cultivar, a number of lines of sugarcane



Sugar cane plants regenerating from tissue culture. Using the genetic variation exposed during tissue culture cycles, a number of lines resistant to eyespot disease toxin have been developed from a previously susceptible cultivar.

that are highly resistant to eyespot disease toxin. Regenerated plants are now being tested under field conditions. Similar techniques are being applied to recover resistance to leaf scald and Fiji disease in sugarcane, and resistance to *Fusarium* and *Verticillium* wilt in cotton.

Thus plant cell and tissue culture research are already having an impact on crop improvement. Together with the further development of recombinant DNA techniques, it is expected that in five to ten years' time the new biotechnologies will be making significant contributions to other plant breeding programs.

18. Understanding the urban atmosphere

Atmospheric pollution is a product of man's activities which is detrimental to his way of life as well as his health. The pollutants are generally present at concentrations of less than one part per million but some need only be present at very low levels to have adverse effects. However, the rate of emission of these substances in any large city is such that if ventilation is poor, considerably higher levels of pollutants than those typically measured may be experienced over a large part of an urban area.

The atmospheric pollutants which cause concern for the public welfare include carbon monoxide, oxides of nitrogen, sulphur dioxide, non-methane hydrocarbons, ozone, polycyclic aromatic hydrocarbons, and particulates, particularly heavy metals such as lead. Some atmospheric pollutants also cause corrosion of stone and metals.

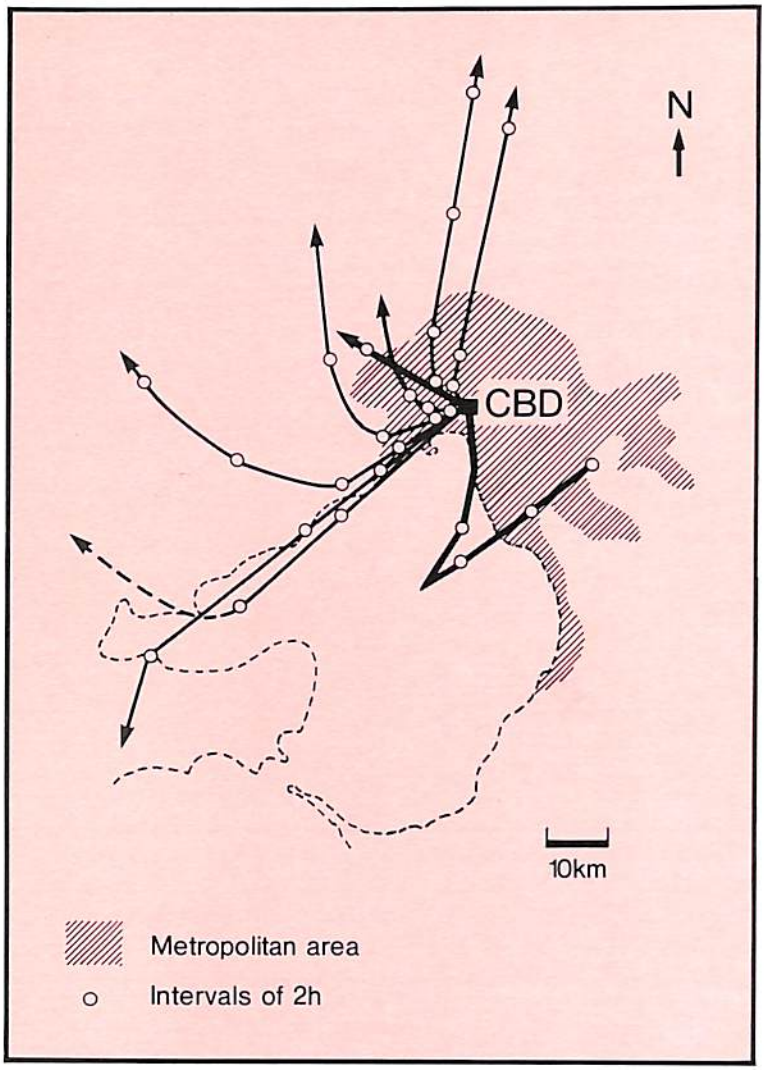
Urban pollution is largely due to combustion and can be classified into two types, primary and secondary. Primary pollutants are emitted directly into the atmosphere from a variety of sources. Examples of these are carbon monoxide, oxides of sulphur and nitrogen, and some of the small particles that contribute to urban haze. Secondary pollutants are formed from primary pollutants as a result of chemical transformations in the atmosphere. Photochemical smog, which results from interaction of hydrocarbons and nitrogen oxides in the presence of sunlight, is classed as a secondary pollutant. Another example in this category is aerosol sulphate, formed by the photochemical oxidation of sulphur dioxide.

The Organization's research in Melbourne and Sydney is designed to provide an adequate understanding of the nature and origin of urban pollution so that effective pollution control strategies can be devised. The corrosive nature of urban pollution is also being studied in projects investigating the acidity of rainfall and metallic corrosion.

Meteorological Aspects of Pollution

In any city, pollutants are being emitted into the atmosphere at about the same rate each day. However, pollution levels may vary considerably from one day to the next. This is because the prevailing meteorology is the major influence on pollution. In general, high levels of pollution are associated with the light winds and temperature inversions that accompany anticyclones. Local meteorological phenomena may exacerbate the situation by further reducing the volume of air into which pollutants are injected. The occurrence of photochemical smog in Melbourne and urban

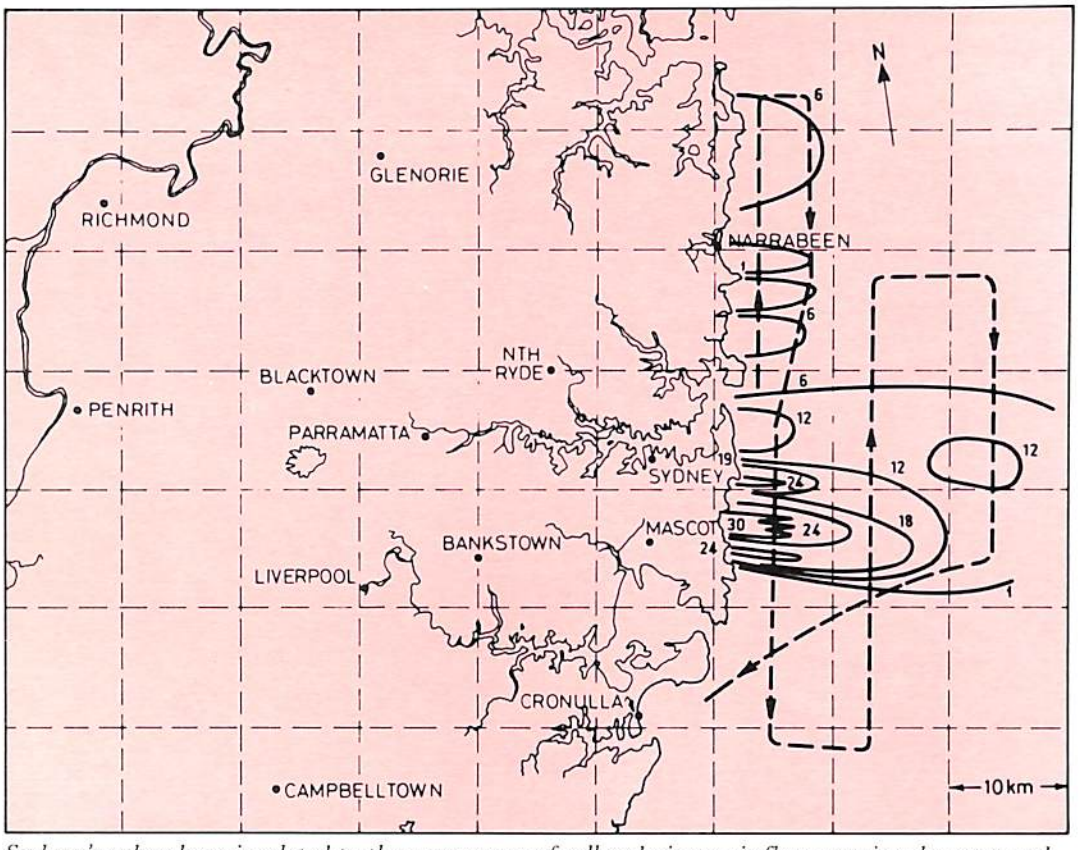
CSIRO has tracked the polluted air parcel from Melbourne's central business district (CBD) to the surrounding rural areas. Smog is produced by photochemical reactions occurring among precursor substances within this air parcel, and has its full impact a considerable distance from the city centre.



haze in Sydney is affected by local meteorological conditions and both are more intense and more frequent at certain times of the year.

Photochemical smog requires sunlight for its formation, so it is more intense during the summer months. Also, it takes a few hours for the photochemical reactions to proceed sufficiently to form ozone and other noxious compounds, so the smog is produced in the middle of the day in an atmosphere which is well mixed vertically. For high levels of ozone to be recorded in the urban area, either there must be very calm conditions, or there must be a mechanism for bringing the urban air parcel back over the city after a time lag of a few hours, such as a sea breeze.

Research has led to the identification of the meteorological conditions associated with photochemical smog in Melbourne. Generally, the pollution occurs on days when there is a warm north-east gradient wind which overlies a colder layer and carries



Sydney's urban haze is related to the occurrence of valley drainage air flow crossing the coast and moving out to sea. Measurements show a number of strong sources of haze between Sydney harbour and Botany, probably associated with heavy industry. The numbers attached to the contours indicate the extent of visibility impairment. The dotted line represents the flight path of the research aircraft while taking the measurements.

emissions over Port Phillip Bay. The onset of a sea breeze then brings the pollutants back to land. Recently, combined airborne and ground-based experiments have tracked the most polluted air parcel, which comes from the central business district. These experiments have demonstrated that, after moving over Port Phillip Bay, the air parcel usually turns north-west so that the full impact of any smog produced by photochemical reactions within the parcel of air is felt over rural areas. It has also been found that the high ozone levels measured in the central business district come from pollutants emitted in the suburbs rather than in the central business district itself. An important conclusion from this work is that emissions from the Newport D power station are usually not involved when high levels of ozone occur in the metropolitan area. Research workers are now developing ways of simulating in the laboratory the events leading to these high levels of ozone so that more detailed studies of photochemical smog can be made. From the results, it should be possible to make better predictions of the effects of changes which might be implemented in pollution control strategies.

Unlike photochemical smog, Sydney's urban haze is at its worst during the night and early morning on calm clear days in the colder half of the year. When the haze is at its worst and in the absence of fog, visibility can be reduced to about one kilometre. Its occurrence is related to the drainage of cold air from high ground across the Sydney Basin and out to sea, a phenomenon that is much more prevalent during the winter months. The layer of cold air, which is usually 100-200 metres thick, traps the pollutants within it. Research workers have mapped haze trapped within such valley drainage flow as it crosses the coast and moves out to sea. Strong sources of haze which are probably associated with heavy industry are evident between Sydney Harbour and Botany Bay. North of the harbour, the haze is more likely to have arisen from domestic and transport sources.

Photochemical Smog

Photochemical smog is the result of a complex series of chemical reactions between hydrocarbons and nitrogen oxides which produce high levels of ozone and oxidized organic compounds such as formaldehyde. The reactions are photochemical, that is, they only occur in the presence of sunlight. The usual way of controlling the smog is to reduce hydrocarbon emissions so that smaller amounts of hydrocarbons are available for photochemical reaction with the nitrogen oxides. Reducing emissions of nitrogen oxides is more difficult to achieve.

The formulation of an effective strategy for reducing hydrocarbon emissions to the atmosphere requires knowledge of the relative quantities emitted from the various sources. An understanding of the relative effectiveness of the various hydrocarbons in producing smog is also essential. Since 1975, CSIRO has been investigating the factors that influence the formation of photochemical smog, particularly as they apply to Sydney.

The objectives of the project are to:

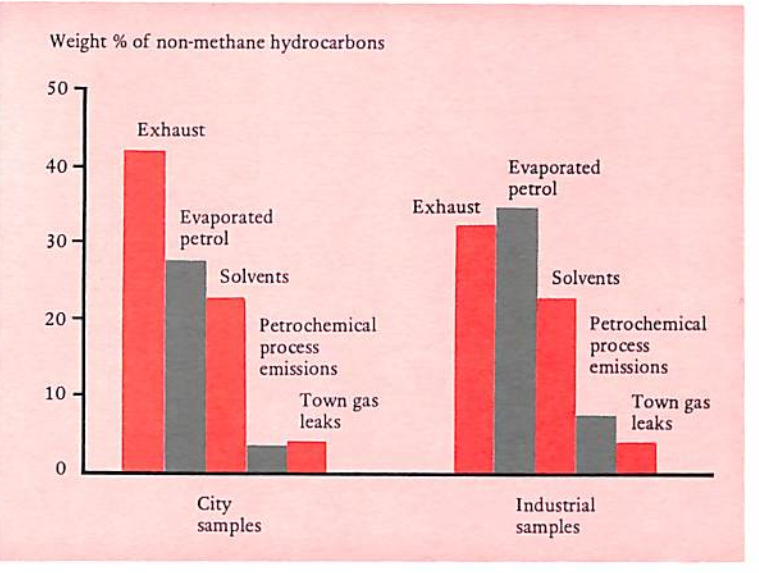
- identify the hydrocarbon sources present in the air in the Sydney area and determine their individual concentrations;
- determine the relative importance of the various sources of emissions of the identified hydrocarbons in the Sydney area; and
- establish the relative capacities of individual hydrocarbons and groups of hydrocarbons for producing smog under certain environmental conditions (for example, sunlight and temperature).

The first two objectives are being accomplished by an extensive field study, while the third is being pursued by experiments with a smog chamber installation.

Earlier research directed to the first objective established the presence of over 200 individual hydrocarbon species in Sydney's atmosphere. These were almost entirely man-made in origin, and the concentrations of the most prevalent species (about 30) were found to be comparable with those in large cities overseas.

Recent work is aimed at the last two objectives. CSIRO's approach to determining the relative strengths of the sources of hydrocarbons is based on the fact that the composition of the hydrocarbons in a sample of air is determined by the contributions from several different sources. The sources include motor vehicle exhausts and fuel systems, refinery and petrol station storage tanks, painted surfaces, printing factories, leaks in the reticulated gas grid, and petrochemical plant. Most of these sources emit common hydrocarbon species but in different proportions, and a few contain species peculiar to themselves.

The first task is to sample the air and determine the composition of the hydrocarbons in it. The compositions of the known sources, such as petrol, solvent and vehicle exhaust are also determined. The relative contributions of each of the sources to the sample are then found by using a statistical technique to calculate the appropriate proportions of the sources that would be



Average relative contributions of the various sources of non-methane hydrocarbons to the Sydney atmosphere for 1979/80.

required to reproduce the composition of the sample. Numerous air samples are required for this work, and special analytical techniques have been developed. The work was carried out with the support of the State Pollution Control Commission of New South Wales and the Petroleum Institute Environmental Conservation Executive.

Vehicle exhaust, petrol evaporation and solvent emissions have been established as the principal sources of atmospheric hydrocarbons in Sydney. As expected, somewhat different relative contributions of the various sources of hydrocarbons were found at different sites. For instance, there was a greater contribution from vehicle exhausts at a site downwind of the central business district.

There is little evidence from CSIRO's work to suggest that natural emissions from vegetation contribute significantly to the hydrocarbons in Sydney's atmosphere. However, a current study

Comparison of constituents of clear air and typical Sydney air

Constituent	Concentration of clean air (parts per million by volume)	Concentration of typical Sydney air (parts per million by volume)
Nitrogen	780800	780800
Oxygen	209500	209500
Argon	9340	9340
Carbon dioxide	340	345 400 (George St peak hour)
Oxides of nitrogen	0.002	0.08
Ozone	0.02	0.05 (daytime)
Sulphur dioxide	0.0002	0.01
Methane	1.5	1.5
Hydrocarbons excluding methane	0.0002	0.3
Carbon monoxide	0.08	2.0 25 (George St peak hour)
Particulates	10 units*	40 units*
Water vapour	variable	variable

*The unit is micrograms per cubic metre of air

is aimed at estimating more precisely the importance of natural hydrocarbons relative to man-made emissions in the Sydney Basin.

Hydrocarbons are destroyed in the atmosphere in the course of the smog-producing photochemical reactions, so their relative rates of destruction can be used to measure their relative activities in producing smog. This aspect is being studied using a smog chamber consisting of two chambers, each of which is ten cubic metres in volume. The walls of the chambers are made of Teflon film which is transparent to sunlight and chemically inert. Typically, a chamber is filled with purified air to which measured small amounts of known hydrocarbons and nitrogen oxides are added to simulate polluted urban air. The chamber is rolled out into the sunlight and the smog formation is followed by monitoring the disappearance of the hydrocarbons and the consequent production of ozone. The rates at which hydrocarbons disappear in the smog chambers have been measured under appropriate conditions, and the relative smog-forming capacities of the major sources of hydrocarbons in Sydney's air estimated.

The smog chambers have also been used to examine the effects on smog formation of using water-based instead of oil-based

paints in Sydney. The results indicate that, although there would be a reduction in amounts of hydrocarbons emitted into the atmosphere, there would not be an equivalent lessening of the incidence of smog. This is because the smaller amounts of hydrocarbons present in water-based paints are more effective smog-producers than those in oil-based paints.

Currently, two types of mathematical model of smog formation are being developed using the smog chamber data. One is a detailed chemical kinetic model while the other is an empirical model relating smog development to factors such as the concentration of primary pollutants, temperature and measured intensity of sunlight. The ultimate aim of these models is to be able to predict more precisely the conditions that will be conducive to smog formation.

Since 1975, the Organization has carried out basic studies of the kinetics of elementary atmospheric reactions. These investigations are based on advanced mass spectrometric and kinetic techniques. Recently, the determination of rates of reaction between alkylperoxyl radicals and nitric oxide has been achieved for the first time. These are the key reactions by which hydrocarbons and nitrogen oxides promote the formation of photochemical smog. It is only through such fundamental knowledge that there can be full confidence in the use and applicability of mathematical models.

Urban Haze

CSIRO's investigations into the formation of urban haze are based in Sydney and are aimed at identifying the visibility-reducing species and establishing where they come from. Again, work is carried out in collaboration with the State Pollution Control Commission of New South Wales.

Urban hazes may appear somewhat brown in colour, depending on the disposition of the haze and the observer with respect to the sun. This is because the deterioration in visibility is largely due to the scattering of light by numerous tiny particles whose sizes are similar to the wavelength of light. Blue light is scattered more readily than red light, so objects viewed through the haze will appear deficient in blue light.

Intensive field studies have been conducted by CSIRO over the past three years. The haze intensity has been measured and samples of the atmospheric particles have been collected simultaneously at different locations in Sydney. Analyses of the total suspended particulate matter have shown that the major constituents are carbon, sulphate, nitrate, chloride and sodium. Also, 70-80% of this matter consists of fine particles that are less than 1.5 millionths of a metre in diameter.

Particulate matter has been collected near possible sources, such as bushfires, incinerators and other combustion equipment, as well as from road tunnels. From analyses of the respective compositions, estimates have been made of the relative contributions from these sources to the total suspended particulate

matter. From optical measurements, their relative contributions to the haziness have also been estimated. Preliminary results show that the major contributors to the total suspended particulate matter are sea salt and motor vehicle and incinerator emissions. However, sea salt particles are larger than the wavelength of light and so cause little deterioration in visibility. This means that the haziness is mainly due to motor vehicle and incinerator emissions.

CSIRO is now continuing this work in order to determine the major sources of Sydney's urban haze in more detail, and the research is being extended to determine the nature of the haze's organic components, including polycyclic aromatic hydrocarbons.

Acid Rain

An observation concerning the nature of urban haze, pertinent to possible corrosion of materials, was that it is acidic, probably through oxidation of sulphur dioxide to sulphuric acid on the surface of carbon-containing particles. In addition, the nitrate present was thought to be associated with sea salt, where it had replaced the chloride in a reaction of the salt with nitric acid vapour. It seems therefore that acidity is present in the air both in the gaseous and condensed forms.

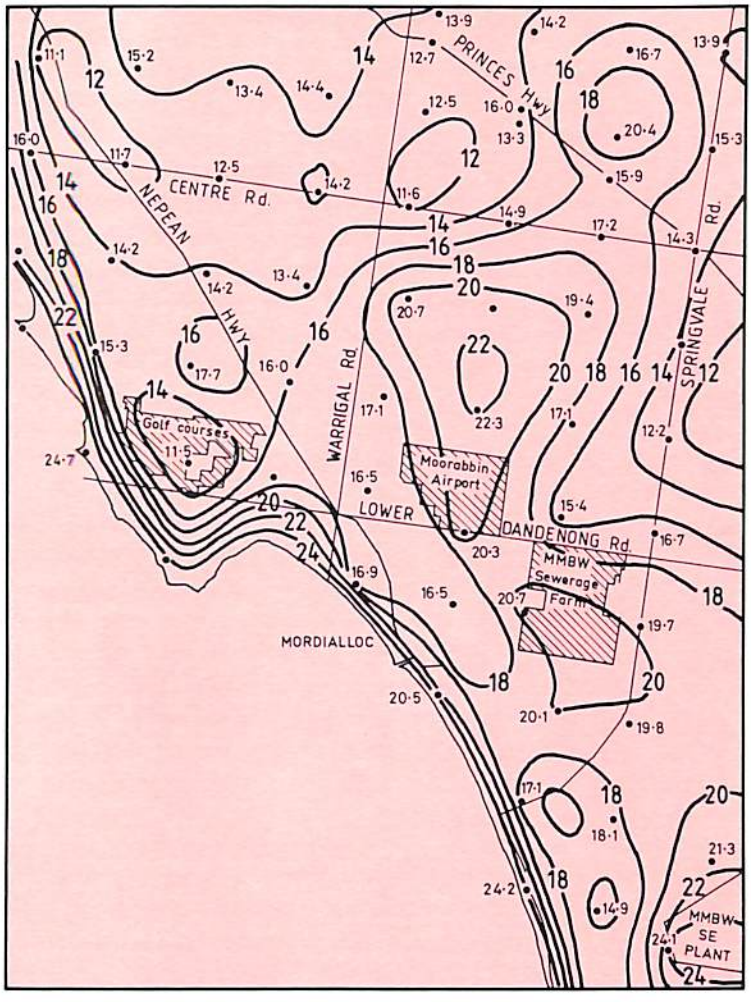
Support for these observations comes from preliminary measurements of the acidity of rainfall in the Sydney region. This study showed that the acidity of Sydney's rainfall was somewhat higher than the accepted value for rain in remote areas. The excess acidity appears to be almost entirely due to sulphuric and nitric acids.

These preliminary results indicate that Sydney's rain is not sufficiently acid to cause the city immediate problems. However, firm conclusions must await analysis of the eighteen months of data so far obtained. The ultimate aim is to further the understanding of the mechanisms of acid production in rain to the point where mathematical models can be used to predict expected levels of acidity. Then a means will be available for deciding what, if any, measures are needed to combat the formation of acid rain.

Corrosion of Metals

The most obvious damage caused by air pollutants is corrosion of metals. The corrosive action of air pollutants has been studied at a few sites in each of the major Australian cities. These studies have shown that both sulphur dioxide and sodium chloride are implicated, although the latter is only important when the sites are within about one kilometre from the sea. The corrosivity at sites of similar industrial activity was found to be higher in Sydney, Brisbane and Perth than in Adelaide, Melbourne, Hobart and Canberra. This difference could be due to temperature and factors such as rainfall, frost and evaporation. A novel means of measuring the time of wetness of a surface has been developed to explore the matter further.

Discrimination between the contributions of the many sources of pollution in a large city is difficult and continuous measurement of corrosive pollutants at many sites is too costly.



Corrosivity map of Melbourne which can guide the selection of metals for use in building. The numbers indicate corrosion rates for a low alloy steel in micrometres per year.

However, CSIRO has had success with another approach. Numerous metal specimens of known sensitivity to corrosive pollutants were placed throughout Melbourne on a two-kilometre grid. The rates at which individual specimens corroded were used to draw a corrosivity map. This map is the first of its kind in the world, and will be used as a guide to selecting metals for use in the building industry and specifying corrosion protection treatments for particular sites. In this way, it will help to conserve resources and reduce costs of corrosion protection.

The results for the Melbourne sites have confirmed the expected influence of Port Phillip Bay and the industrial zones. However, unexpected results were also obtained: zones of higher corrosivity were found to be associated with the airports and a sewage works, and lower than expected corrosivity zones were found around trees. These results are being explored further using a scanning electron microscope to analyse the corrosion products.

19. Solar energy

CSIRO started its solar energy research program in the early 1950s when the Division of Mechanical Engineering began studying domestic solar water heating systems. By the early 1960s, these systems were being produced commercially in South Australia, Western Australia and Queensland, and ten years later approximately 7000 square metres of collectors were being produced annually. The substantial increase in fuel prices in 1973 resulted in dramatic increases in the manufacture and use of domestic solar heating systems, with current sales of over $50 million a year.

CSIRO has continued to study new areas of solar technology, gradually shifting the emphasis from domestic to industrial uses and increasing the effort in strategic research as other organizations have started to take up tactical research and demonstration projects. This article looks at some of CSIRO's activities and progress in the field over the last five years.

Developing and Evaluating Solar Collectors

The efficiency of solar collectors depends on their ability to absorb as much solar radiation as possible. Their surfaces are usually coated with thin films of selectively absorbing materials, which are highly absorbing at wavelengths in the solar region but are poor emitters of thermal radiation at wavelengths corresponding to the temperature of the absorber panel. The development of these special surfaces is a research area to which CSIRO expertise is contributing in several ways.

Three different surfaces have been developed so far. One of these, AMCRO, is already being used commercially, while the other two, black chrome and nickel black, are in the process of being tested by industry. Work is now concentrated on developing surfaces that will help produce the higher temperatures needed for industry.

Since 1981, investigations have been under way on new ion-beam techniques for making durable surfaces for solar absorbers. Beams of charged particles are used to modify the structure and composition of vacuum-deposited thin films, precisely controlling their properties. This research is being funded under the National Energy Research, Development and Demonstration Program (NERDDP).

In 1979 a NERDDP-funded project was begun with the aim of designing a flat-plate solar collector that can operate at temperatures up to 150°C. Up till now, only the more expensive and complex evacuated tubular and concentrating collectors have been able to operate at this temperature.

In a well-constructed collector, the largest heat loss is due to natural convection from the absorber to the collector cover. This loss can be suppressed by inserting transparent barriers between the cover and absorber that transmit incoming solar radiation, but restrict the circulation of air by convection within the collector. Several designs of convection suppression devices have been studied and prototype collectors have been constructed for testing and evaluation. A new simple method for suppressing heat transfer by natural convection has emerged from this research, and a provisional patent has been lodged on the resulting device. While this research was under way, an information exchange program on advanced solar collectors was arranged with organizations in Japan, which has provided detailed insight into research and manufacturing in that country. In April 1982, details of the new collector design were released to the solar industry, which has shown interest in taking up the CSIRO work.

Up to 10 per cent of solar radiation can be lost by reflection from the glass collector covers that are used to insulate the absorbing surface. To counter this, a simple dip-coating technique has been developed for depositing thin films on cover plates, reducing losses due to reflection by up to 2.5 per cent per plate. Covers treated in this way gave an increased heat output of 5-12 per cent for single-glazed and 10-20 per cent for double-glazed collectors. This procedure is now being tested in industry.

In the late 1970s, efforts to improve the cost-effectiveness and aesthetics of solar collectors led to the development of roof-integrated units. These collectors have acrylic or glass covers that double as the roof sheeting, with the absorber panel, insulation and piping located out of sight under the roof line.

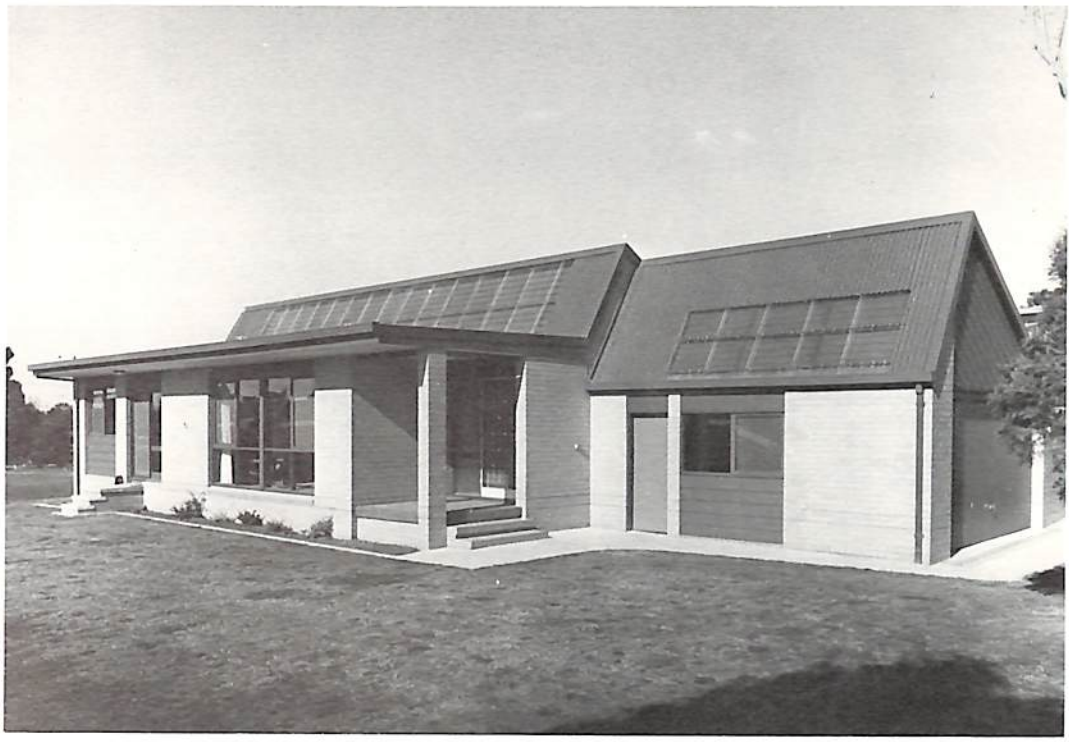
Several such collectors were designed by the Organization for both water and air heating. They were successfully demonstrated on the CSIRO low energy house, and similar designs have been incorporated into experimental solar greenhouses built at Griffith, NSW. Architects and the building industry have shown particular interest in the integrated air heater, which now seems certain to be used in future designs.

Low Energy Consumption House (LECH)

In 1978, the Organization combined with a leading home builder to design and construct a three-bedroomed house incorporating energy saving features, including two solar heating systems.

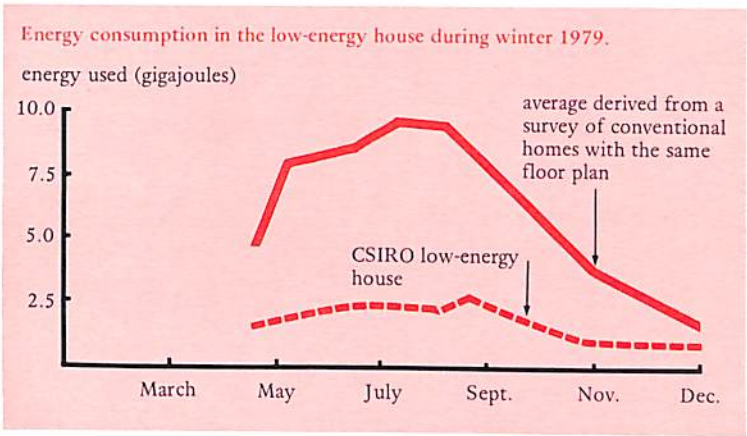
An air-based, closed-loop, space heating system draws warm air from a solar air heater located on the roof; this air is passed into an under-floor rockbed where heat is transferred to stones and the now cooler air returned to the collector. The concrete slab floor conducts heat from the rockbed and transfers it to the room by radiation and natural convection. The solar air heater is a low cost unit, designed by CSIRO, and constructed on site using conventional building materials.

During a two-year study, the house was completely automated and operated continuously under the control of a



The CSIRO low-energy house in Melbourne, designed to reduce energy consumption. Its special features include solar energy systems for heating and cooling, good insulation, and wide eaves to protect against summer sun but allow entry of winter sun.

micro-processor, programmed to simulate human occupancy. Comparisons made with a number of houses of similar size and floor plan indicate reductions of 75 per cent in the energy required during winter and of 70 per cent in the annual energy requirements. The design concept has been adopted by a Melbourne-based home builder who now offers the solar air heater as an option on a range of houses.



Energy consumption during winter 1979 in the low-energy house.

Although the solar heating system was successful, the initial construction costs of the storage rockbed were too high and research is continuing, supported by the Victorian Solar Energy Council, aimed at reducing costs.

Calculations have shown that a rockbed of only 150 millimetres depth would give adequate storage for two to three days' energy supply for a well-insulated house in Melbourne. The researchers are studying what happens when hot air passes horizontally through the rockbed. They are also examining temperature variations and the fall-off in temperature when the hot air is no longer circulating through the house.

Solar Industrial Demonstration and Technology Transfer Program

CSIRO's industrial demonstration program started in 1975 with a can-warming system at a Queanbeyan, NSW, soft drink factory and a beer pasteurizer at an Adelaide brewery. In both cases CSIRO was responsible for funding the solar systems while the companies concerned met the costs of integrating the solar installations with the process machinery. The systems were monitored and evaluated over a two-year period, after which the companies purchased the installations at a price related to the annual value of energy savings.

In 1978, CSIRO sought to involve State Government departments and instrumentalities in collaborative programs. The first collaborative program was arranged with the Solar Energy Research Institute of Western Australia, and involved an installation to provide approximately 50 per cent of the energy required for bottle washing in a Perth soft drink factory.

As the industrial demonstration program matured, it became clear that the designers of solar systems should be made aware of the unique problems and solutions that were being encountered in the projects. Consequently, a technology transfer program, funded by NERDDP and organized by CSIRO, was arranged for a limited number of consultants from different States. This involved familiarization with various computer design techniques, followed by analyses of actual installations. Each participant was required to undertake a feasibility study from a design brief prepared by CSIRO and design an installation.

The main findings of the demonstration program have been that there are no major operating problems in solar industrial heating systems of the type installed. For known operating conditions, the long term performance of the systems can be predicted to better than 10 per cent and the cost-effectiveness of the installations has increased.

Total Energy Systems in Industry

A total energy system is one in which electricity is generated at the place where it is to be used so that the lower temperature heat available from the cooling system of the generating equipment can also be used, instead of being discharged to the environment. An investigation is commencing aimed at identifying those Australian industries that have the best potential for using total energy systems, preferably with a major part of the primary energy input being derived from solar energy collected at high temperatures.

The most promising geographical locations for these industries will be selected by using data on solar radiation and climatic features collected by CSIRO and the Bureau of Meteorology. The Organization, at its National Radiation Centre at Aspendale, Vic., has had a long-standing project of measuring global, direct and diffuse solar radiation. More recently, it has assisted the Department of Science and Technology to make similar measurements at Cape Grim in north-western Tasmania. A satellite radiometer reception and processing facility is to be installed at Aspendale to enable further research to be undertaken into the effects of clouds and aerosols on the depletion of solar radiation at the earth's surface.

Assessments are also being made of renewable energy sources, including global solar radiation, on a continental scale, and of the use of satellites in the estimation of solar radiation. The continental long-term data are being augmented by measuring direct-beam solar radiation at specific sites in the Northern Territory, in cooperation with the Bureau of Meteorology. This is a continuation of earlier work done by the Australian Atomic Energy Commission (AAEC) during the Japan/Australia feasibility study of solar thermal electric power systems. These data will also be used to develop methods for estimating typical short-term (daily or hourly rather than monthly) variations, using conventional meteorological measurements.

Electricity from Solar Cells

Solar energy can be converted direct to electricity in photovoltaic devices, which consist of solar cells that absorb solar radiation. Photovoltaic devices could be particularly useful for providing small-to-medium scale electricity in remote areas.

The solar cells in use today are made from silicon with added elements such as phosphorus or arsenic. With support from NERDDP, the Organization is investigating a relatively cheap and efficient production method, which consists of implanting silicon with phosphorus or arsenic ions and using a pulsed laser to repair the radiation damage caused during implantation. This research was started in 1980 by the AAEC.

Simpler and cheaper alternatives to silicon cells are also being investigated. Two types of cell have been selected for study—cells formed from a thin layer of copper sulphide on cadmium sulphide, and CIS cells which consist of a transparent conducting oxide film (C) and a very thin insulating silica layer (I) on silicon (S). The former cell is produced using a simple sputtering technique, while the sputtering technique is being evaluated against a dip method for production of the latter cell. Development of the CIS cells is being supported under the NERDDP and by the Victorian Solar Energy Council.

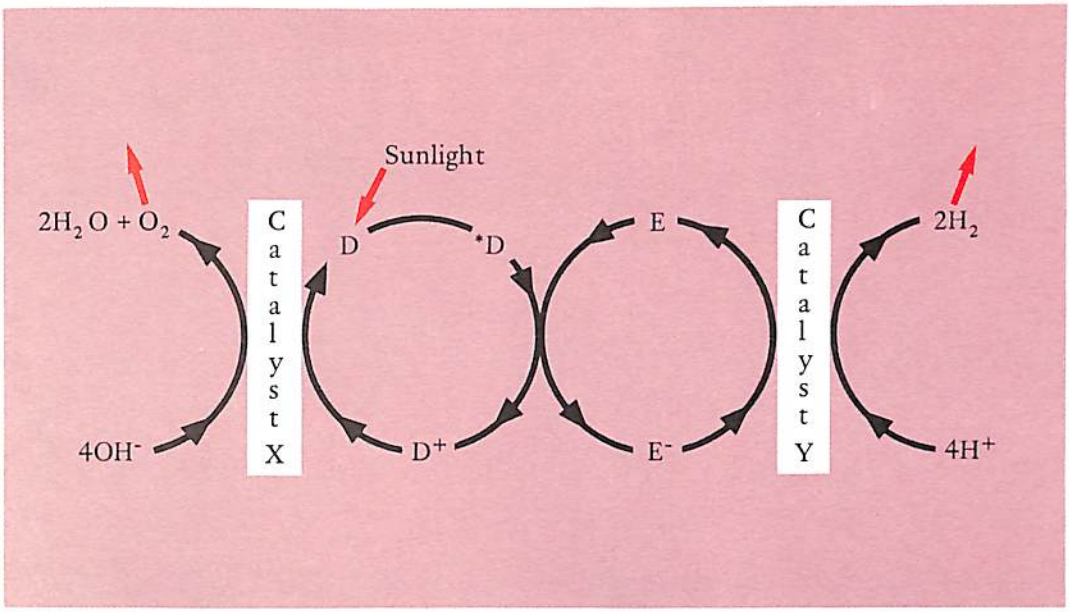
Hydrogen Production

Hydrogen, a key raw material in industry, is used in making conventional fuels and novel fuels such as methanol, in the conversion

A demonstration solar cell for producing hydrogen from water.

of coal to oil, and can also be used in internal combustion engines. In the search for cheap ways of generating hydrogen, the splitting of water into its constituent hydrogen and oxygen molecules is an attractive prospect. Commercial units that do this are already available but they use a non-renewable power source such as electricity.

CSIRO, together with other research bodies throughout the world, is investigating ways of obtaining hydrogen from water, using sunlight as the source of energy. One possible way of doing this is by using photoelectrochemical cells in which electrodes are used to split the water. The key to success in such cells lies in finding a suitable chemical oxide for the electrode that has the right stability and electrochemical properties, and reacts to solar radiation. Work so far has established that the chances of finding a suitable conventional oxide with this combination of properties, which is also efficient as an electrode, are very low. It appears that the structure of such oxides essentially precludes electrochemical



*The photochemical conversion of water (H_2O) into hydrogen (H_2) and oxygen (O_2) requires a dye (D) that absorbs energy when exposed to sunlight, becoming *D. *D can transfer an electron to the chemical E, forming E^- which is then able to react with hydrogen ions (H^+) to produce hydrogen gas. In transferring the electron to E, *D is changed to D^+ which is able to change hydroxyl ions (OH^-) into oxygen and water. D and E are reformed in these reactions so that, theoretically, the process is continuous. The reactions occurring are assisted by the chemical catalysts X and Y.*

and solar utilization properties from being favourable simultaneously. Hope for photoelectrochemical storage systems now appears to lie with more complex chemicals.

The Organization is continuing the NERDDP-funded research begun in the AAEC which aims to improve the efficiency of the solar decomposition of water by both photoelectrochemical and photochemical methods. Thin films of various semiconductors on metals are being evaluated as electrodes for photoelectrochemical cells. A titanium oxide film on metal has performed well as an electrode in a demonstration solar cell constructed at Lucas Heights, Sydney. Also, new metal alloys are being developed to act as storage units for the hydrogen.

The decomposition of water by photochemical means needs sunlight and small amounts of several chemicals that help split the water. This process is being examined together with the products formed when complex organic chemicals are used to assist the reaction.

In another program, work is directed towards developing longer lasting as well as more effective systems. Research has identified new combinations of chemicals that capture more sunlight and produce more hydrogen than the chemicals currently in use. Particular effort has been devoted to identifying and elimin-

ating unwanted processes that curtail the production of hydrogen when the reaction is run for a long time.

Further improvements are expected from work that uses techniques derived from studying photosynthesis in plants. A great deal of research and development will be required before such systems become economically viable but the technical feasibility has been improved.

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 and Overseas 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
G.H. Taylor, DSc, DrRerNat, FTS

Part-time Members

D.P. Craig, DSc, FAA, FRS
W.L. Hughes, CBE, DPhil
H.M. Morgan, LLB, BCom
S.B. Myer, MA
P.D.A. Wright

INSTITUTE OF ANIMAL AND FOOD SCIENCES

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

INSTITUTE OF BIOLOGICAL RESOURCES

Director	M.V. Tracey, AO, MA, FTS
Divisions	**Chiefs**
Entomology	M.J. Whitten, PhD
Forest Research	J.J. Landsberg, PhD
Horticultural Research	J.V. Possingham, DSc, FTS
Plant Industry	W.J. Peacock, PhD, FAA, FRS
Soils	A.E. Martin, DAgrSc
Tropical Crops and Pastures	E.F. Henzell, DPhil, FTS
Water and Land Resources	R.J. Millington, PhD, FTS
Wildlife Research	C.J. Krebs, PhD, FRAC

Units	Officers-in-Charge
Centre for Irrigation Research	D.S. Mitchell, PhD
Laboratory for Rural Research (Perth)	*(to be appointed)*

INSTITUTE OF ENERGY AND EARTH RESOURCES

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

INSTITUTE OF INDUSTRIAL TECHNOLOGY

Director	W.I. Whitton, PhD, 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
Protein Chemistry	W.G. Crewther, DSc
Textile Industry	D.S. Taylor, PhD, FTS
Textile Physics	A.R. Haly, DSc

INSTITUTE OF PHYSICAL SCIENCES

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

BUREAU OF SCIENTIFIC SERVICES

Director	S. Lattimore, BSc, ARCS

Units	Officers-in-Charge
Central Information, Library and Editorial 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	K.T. Smith, BCom, AASA

PERSONNEL

Secretary	K.J. Thrift, BA
Deputy Secretary	I.D. Whiting, BA

OVERSEAS OFFICE

Counsellor (Scientific) Tokyo and Seoul	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 and Territory Committee members

ADVISORY COUNCIL

Chairman

*Sir Peter Derham, BSc, FAIM, LPIA, FInstD, former Managing Director, Nylex Corporation Ltd.

Chairmen of State/Northern Territory Committees

*G.I. Alexander, BVSc, MSc, PhD, FACVSc, Director-General, Queensland Department of Primary Industries (*Queensland*) (from 1 September 1981).

A. Boden, BSc, Chairman, Hardman Chemicals Pty Ltd (*New South Wales*) (until 31 August 1981).

Sir Laurence Brodie-Hall, CMG, AWASM, Company Director (*Western Australia*) (until 31 August 1981).

*R.A. Footner, AM, Chairman and Joint Managing Director, Bridgestone Australia Pty Ltd (*South Australia*) (from 1 September 1981).

J.E. Harris, BEng, Managing Director, Adelaide and Wallaroo Fertilizers Ltd (*South Australia*) (until 31 August 1981).

*D.B. Horgan, FSA, Company Director (*Western Australia*) (from 1 September 1981).

*J.E. Kolm, IngChemEng, Consultant and Company Director (*Victoria*).

*G.A. Letts, CBE, DVSc, Director, Conservation Commission of the Northern Territory (*Northern Territory*) (from 1 September 1981).

E.P.S. Roberts, CMG, (*Acting*), Grazier (*Queensland*) (until 31 August 1981).

*K. Satchwell, BSc, MSc, Managing Director, AFL Holdings Ltd (*New South Wales*) (from 1 September 1981).

*Professor P. Scott, OBE, PhD, Acting Vice-Chancellor, University of Tasmania (*Tasmania*).

Other Members

*S.C. Bambrick, BEcon, PhD, Sub-Dean, Faculty of Economics, Australian National University.

*F.N. Bennett, BEc, Deputy Secretary, Department of Industry and Commerce (from 10 November 1981).

*Professor L.M. Birt, CBE, DPhil, Vice-Chancellor, University of New South Wales.

*V.A. Brown, MSc, PhD, Lecturer, Centre for Adult Teaching, Canberra College of Advanced Education.

Sir Neil Currie, CBE, BA, former Secretary, Department of Industry and Commerce (until November 1981).

*L.P. Duthie, BCom, Secretary, Department of Primary Industry.

J.L. Farrands, PhD, FTS, former Secretary, Department of Science and Technology (until January 1982).

*Professor F.J. Fenner, CMG, MBE, MD, FAA, FRS, John Curtin School of Medical Research, Australian National University.

*Professor P.T. Fink, CBE, BE, FTS, Chief Defence Scientist, Department of Defence.

*R.K. Gosper, BA, Chairman and Chief Executive Officer, Shell Company of Australia (from 1 September 1981).

*D. Hartley, BE, Hartley Computer Applications Pty Ltd (from 1 September 1981).
*J.H.S. Heussler, Grazier.
*D.J. Ives, BSc, BEcon, Deputy Secretary, Department of National Development and Energy (from November 1981).
*B.O. Jones, MA, LLB, ACTT, MP, Member for Lalor.
*Professor P.H. Karmel, AC, CBE, PhD, LLD, DLitt, Chairman, Tertiary Education Commission.
*G.A. Letts, CBE, DVSc, Director, Conservation Commission of the Northern Territory (until 31 August 1981; currently Chairman of Northern Territory Committee).
Sir Ian McLennan, KCMG, KBE, DEng, Chairman, ANZ Banking Group Ltd (until 31 August 1981).
*P.R. Marsh, BEcon, Industrial Officer, Victorian Trades Hall Council (from 1 September 1981).
J.A. Michael, BE, former Executive Director, Association of Professional Engineers of Australia (until 31 August 1981).
*B.W. Scott, DBusAdm, Managing Director, W.D. Scott & Co Pty Ltd.
*M.S. Shanahan, Member of Australian Wheat Board (from 1 September 1981).
*W.J.McG. Tegart, PhD, FTS, Secretary, Department of Science and Technology (from January 1982).
*Senator A.M. Thomas, Western Australia.
A.J. Woods, BEc, Secretary, Department of National Development and Energy (until March 1982).

Observers
*Professor Sir Geoffrey Badger, AO, DSc, FTS, FAA, Chairman, Australian Science and Technology Council.
*I. Castles, OBE, BCom, 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 (until July 1981).
*I.D. Gordon, Assistant Secretary (from August 1981).
*Mrs B. Magi, Administrative Assistant.

STATE/NORTHERN TERRITORY COMMITTEES

New South Wales
*K. Satchwell, BSc, MSc, (*Chairman*), Managing Director, AFL Holdings Ltd (from 1 September 1981).
A. Boden, BSc, (*Chairman*), Chairman, Hardman Chemicals Pty Ltd (until 31 August 1981).
D.G. Badger, PhD, Consultant (until November 1981).
*C.S. Barnes, PhD, Manager, Research, Biotechnology Pty Ltd.
*C.G. Coulter, BE, ME, FIE, Officer-in-Charge, Power Development Division, NSW Electricity Commission (from January 1982).
*K.P. Farthing, ASTC, Executive Director, Manufacturing, Metal Manufacturers Ltd (from January 1982).
*W.J. Hucker, OBE, Chairman, Air Programs International Pty Ltd.
*R.A.K. Long, BSc, PhD, Assistant Director, NSW Department of Industrial Development and Decentralisation (from January 1982).
*D.J. McGarry, BSc, Managing Director, Australian Oil and Gas Corporation.
*D.R.H. MacIntyre, Grazier (from January 1982).
D.G. MacLennan, PhD, Chairman, Biotechnology Australia Pty Ltd (until November 1981).

H.E. Mitchell, Assistant General Secretary, Miscellaneous Workers Union (until November 1981).

C.H. Monk, AM, FIE, FAIM, Chairman, NSW Board of Education (until November 1981).

*G.R. Peart, MRurSc, Agricultural Consultant.

*D.A.J. Swinkels, PhD, Minerals Process Research Manager, BHP Central Research Laboratories.

N.R. Tieck, Company Director and Consultant (until November 1981).

*Professor A.R. Toakley, PhD, Professor of Building and Head of School of Building, University of NSW (from January 1982).

N.A. Whiffen, FRACI, MSc, Managing Director, Nethel Pty Ltd (until November 1981).

*R.A. Williams, BSc, Cotton Farmer (from January 1982).

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

Queensland

*G.I. Alexander, BVSc, MSc, PhD, FACVSc, (*Chairman*), Director-General, Queensland Department of Primary Industries (from 1 September 1981).

E.P.S. Roberts, CMG, (Acting Chairman), Grazier (until 31 August 1981).

G.I. Alexander, BVSc, MSc, PhD, FACVSc, Director-General, Queensland Department of Primary Industries (until 31 August 1981).

*J.A. Allen, PhD, FTS, Chairman, Board of Advanced Education.

*A.J. Allingham, Grazier.

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

*D.W. Beattie, BE, FIE, Commissioner of Water Resources, Queensland (from January 1982).

W.G. Hamilton, BSc, Personnel Manager, Consolidated Fertilizers Ltd (until November 1981).

*J.M. Hudson, Grazier (from January 1982).

*B.J. Meynink, BSc, Lecturer (from January 1982).

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

*D.M. Traves, OBE, BSc, Consultant, Peat, Marwick & Mitchell.

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

H.N. Walker, MIEAust, Chief Engineer, Queensland Railway Department (until November 1981).

*R.J. White, FASA, DipCom, Managing Director, Consolidated Fertilizers Ltd (from January 1982).

*C.D. Williams, MAIMM, Research Manager, MIM Holdings Limited.

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

South Australia

*R.A. Footner, AM, (*Chairman*), Chairman and Joint Managing Director, Bridgestone Australia Pty Ltd (from 1 September 1981).

J.E. Harris, BEng, (*Chairman*), Managing Director, Adelaide and Wallaroo Fertilizers Ltd (until 31 August 1981).

*F.E. Acton, General Manager, South Australian Co-operative Bulk Handling Ltd (from January 1982).

*D. Andary, OBE, FAIM, Chairman, Berri Co-op Packing Union Limited.

Sir Ben Dickinson, MSc, Company Director and Mining and Energy Consultant (until November 1981).

J.M. Kerin, JP, Grazier (until November 1981).

*I.J. Kowalick, BSc, BEc, Deputy Director-General, Department of Trade and Industry (from January 1982).

M. Knapman, General Manager, Corporate Engineering, Simpson Ltd (until November 1981).

*J.E. Harris, BEng, Managing Director, Adelaide and Wallaroo Fertilizers Ltd (from 1 September 1981).
*J.C. McColl, MAgrSc, Director-General, Department of Agriculture.
*R.J. Mierisch, ME(Civil), Managing Director, A.W. Baulderstone Pty Ltd.
*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 & Forests Department South Australia.
*G.G. Spurling, B. Tech, MAE, ED, Managing Director, Mitsubishi Motors Australia Limited (from January 1982).
*R. Woodall, AO, BSc, MSc, Director of Exploration, Western Mining Corporation Ltd (from January 1982).
*B.W. Bartlett, AASA, (*Secretary*), Divisional Secretary, CSIRO Division of Human Nutrition.

Tasmania

*Professor P. Scott, OBE, PhD, (*Chairman*), Acting Vice-Chancellor, University of Tasmania.
*J.R. Ashton, BCivilEng, Commissioner, Hydro-Electric Commission, Tasmania.
*R.D. Barker, Dip Metallurgy, Dip ChemEng, General Manager, Electrolytic Zinc Co (from January 1982).
*A.S. Bickford, AASA, ACISA, Mill Controller, Sheridan Domestic Textiles (from January 1982).
*E.C. Best, BSc, BE, Manufacturing Manager, Cadbury-Schweppes Ltd (from January 1982).
Professor D Caro, OBE, PhD, LLD, former Vice-Chancellor, University of Tasmania (until November 1981).
*M.C.P. Courtney, Editor, Launceston 'Examiner'.
*T.M. Cunningham, BSc, BFor, PhD, Commissioner (Management), Tasmanian Forestry Commission (from January 1982).
*R.J. Downie, Grazier.
*P.J. Fountain, BSc, Director, Tasmanian Department of Agriculture.
A.G. Kemp, AASA, Managing Director, Kemp and Denning Ltd (until November 1981).
*Professor J.N. Lickiss, MD, FRACP, FRCP, Professor of Community Health, University of Tasmania (from January 1982).
J.B. Piggott, CBE, LLB, Senior Partner, Piggott, Wood & Baker (until November 1981).
J.G. Symons, BE, former Director of Mines, Tasmania (until November 1981).
P.T. Unwin, DipFor, MIFA, Chief Commissioner, Forestry Commission, Tasmania (until November 1981).
*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.

Victoria

J.E. Kolm, IngChemEng, (*Chairman*), Consultant and Company Director.
*J.D. Brookes, MC, MSc, Director of Conservation, Ministry for Conservation Victoria.
*D.J. Constable, BE(Civil), Commissioner, State Rivers and Water Supply Commission, Victoria (from January 1982).
*A.J. Farnworth, MBE, PhD, Chief General Manager, Australian Wool Corporation.

A.G. Gibbs, AO, BE, former Chairman, Victorian Railways Board (until November 1981).

*R.N. Gottliebsen, Editor, Business Review Weekly.

*Professor K.H. Hunt, FTS, MA, Professor of Mechanical Engineering, Monash University.

*F.C. James, MSc, Dean, Faculty of Applied Science, RMIT.

*J.A. Kelly, Executive Member, Cattle Council of Australia.

*Sir Laurence Muir, VRD,LLB, former Senior Partner, Potter Partners.

*R.D.E. Parry-Okeden, BE, Managing Director, Vickers Ruwolt (from January 1982).

*E.F. Sandbach, BA, BSc, Director of Research, Telecom Australia.

*S.D.M. Wallis, BComm, AASA, ACIS, Managing Director, Australian Paper Manufacturers Ltd.

*J.A. Pattison, MBE, AASA, (*Secretary*), Divisional Secretary, CSIRO Division of Building Research.

Western Australia

*D.B. Horgan, FSA, (*Chairman*), Company Director (from 1 September 1981).

Sir Laurence Brodie-Hall, CMB, AWASM, (Chairman) Company Director (until 31 August 1981).

*E.N. Fitzpatrick, MAgSc, Director, Department of Agriculture.

*E.R. Gorham, BE, Coordinator of Industrial Development, Department of Industrial Development.

*R.M. Hillman, BEng, Director of Engineering, Public Works Department.

*W.J. Hughes, Chairman, Westwools Group (from January 1982).

R.D. Ireland, MBE, AASA, Chairman and Managing Director, Millars Timber (WA) (until August 1981).

*J.B. Kirkwood, FInstEngsA, FTS, Commissioner, State Energy Commission.

*J.R. de Laeter, PhD, Chairman of the Division of Manufacturing and Science, Western Australian Institute of Technology.

M.J. Mulcahy, PhD, Head, Special Services Branch, Department of Conservation and Environment (until August 1981).

*S.L.G. Morgan, BE, Director, Westfi Manufacturing Ltd (from January 1982).

J.B. Oliver, FAIM, General Manager (Projects) Western Mining Corp Ltd (until August 1981).

W.T. Peart, Managing Director, Vickers Hoskins Pty Ltd (until August 1981).

*J. Shepherd, BSc, Farmer and Agricultural Scientist.

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

J.M. Vann Jnr, BAdm, General Manager (Alumina Division), Alcoa of Australia Ltd (August 1981 to May 1982).

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

Northern Territory

*G.A. Letts, CBE, DVSc, (*Chairman*), Director, Conservation Commission of the Northern Territory.

*B.J. Cameron, BAgSc, Chairman, Agricultural Development and Marketing Authority (from April 1982).

*W.J. Fisher, Mining Consultant (from April 1982).

*G.J. Hunt, BArch, Principal of Gary Hunt & Associates (from April 1982).

*W.M. Kirke, Research Writer (from April 1982).

*R.M. Morrison, DipArch, FRAIA, ARIBA, Architect (from April 1982).

*J.V. Quinn, MD, Assistant Secretary, Environmental Health Division, Northern Territory Department of Health (from April 1982).

*C. Rioli, Member of Executive, Tiwi Land Council (from April 1982).

*M.J. Tilley, Company Director and Farmer (from April 1982).

*W.J. Waudby, Pastoralist (from April 1982).

*M.G. Ridpath, BSc, PhD, (*Secretary*), Officer-in-Charge, CSIRO Darwin Laboratories.

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* Current member

CSIRO Annual Report 1981/82