Commonwealth Scientific and Industrial Research Organization, Australia

CSIRO Twenty-sixth Annual Report 1973/74

Commonwealth Scientific and Industrial Research Organization, Australia

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This Report of the work of CSIRO
for the year ending 30 June 1974 has been
prepared as required by Section 30
of the Science and Industry Research
Act 1949–1973.

The Executive gratefully acknowledges the
valuable help received from Australian and State
government departments and instrumentalities,
universities and other research bodies,
members of primary and secondary industries,
private individuals, and overseas institutions.

The Executive also wishes to thank those who
have made their knowledge and experience freely
available to the Organization by serving on
its Committees or by personal advice.

J. R. Price (*Chairman*)
V. D. Burgmann
M. F. C. Day
D. L. Ford
L. Lewis
A. E. Pierce
V. E. Jennings
E. J. Underwood
W. J. Vines

CSIRO was established by the Science and Industry Research Act of 1949. Under the Act, CSIRO replaced the former Council for Scientific and Industrial Research established in 1926.

The powers and functions of CSIRO are:

the carrying out of scientific research in connection with Australian primary and secondary industries or any other matter referred to it by the Minister for Science

the training of scientific research workers and the awarding of studentships

the making of grants in aid of scientific research

the recognition and support of research associations

the maintenance of the national standards of measurement

the dissemination of scientific and technical information

the publication of scientific and technical reports

liaison with other countries in matters of scientific research.

Contents

Introduction 8

General 12

Research 20
(see details on right)

Organization 58

Research Activities 60

Staff 65

Advisory Council 89

State Committees 89

Finance 91

Research 20

From pastoral to urban land use 20
Soil surveys designed originally for assessing agricultural potential are now being adapted for planning in the Townsville urban growth centre.

Land forms of the Riverine Plain 20
A land form map of the Riverine Plain should help in the layout of irrigation farms.

Understanding world climate change 21
A basic study of the effect of clouds on radiation has led to some new predictions of possible changes in world climate.

Mysterious 'multiplication' of ice crystals 22
An understanding of the processes of rain formation could lead to more successful artificial rain-making operations.

Steam, fog and a power station 23
Information accumulated in long-term basic research has been used to predict the impact of a Melbourne power station on local fog.

Water availability and wheat growth 23
Knowledge of the mechanisms by which wheat plants balance growth and water loss could help plant-breeders select more productive strains.

Problems with cropping after rice 24
Factors responsible for the poor growth of crops sown after rice are being studied.

Controlling the size of the orange crop 24
Discovery of the causes of variations in yield of orange crops is indicating possible means of control.

More efficient use of fertilizers 26
The timing of fertilizer applications to pastures can affect the balance between grasses and legumes.

Tropical legumes and soil fertility 27
Difference between legumes in their effects on soil fertility may be due to differences in their chemical composition.

Cover

Calibrating net radiometers (radiation-measuring instruments) at the DIVISION OF ATMOSPHERIC PHYSICS, Melbourne, using artificial solar radiation from a xenon arc. The net radiometers were developed by the Division, which is the Accredited Laboratory of the National Association of Testing Authorities in the fields of solar and thermal radiation.

Revegetating mining spoils 27
Methods of revegetating mine dumps containing heavy metal residues are being investigated.

Surveying Australia's rain forests 29
Research shows that the ecology of Australian rain forests is far more complex and interesting than was previously believed.

Breeding disease in northern bulls 30
Young bulls are less susceptible than old bulls to the venereal disease bovine trichomoniasis.

Repair of DNA damage 31
The mechanisms of DNA repair in bacterial cells are being studied.

Prevention of grass tetany 31
A long-life capsule has been developed which protects livestock against grass tetany by providing a regular dose of magnesium.

Leaner meat from lambs 32
Cryptorchid lambs grow faster and produce leaner meat than wethers.

Cattle tick resistance 33
Observations of the behaviour of ticks on resistant breeds of cattle are providing some leads to the mechanisms of natural resistance.

Cattle tick and asthma 33
Research aimed at identifying the reasons why some cattle exhibit natural resistance to cattle tick has led to the isolation of a component of tick saliva related to one of the substances associated with human asthmatic reaction.

Studying the biology of the bandicoot 34
Concern over the conservation of Australia's endangered marsupials has led to research into their ecology and physiology.

Bush flies and computers 35
Computer models are being used to predict the effect of proposed bush fly control measures.

Biological control of sirex wood wasps 35
Introduced nematode and insect parasites are proving effective against the sirex wood wasp, a serious pest of the radiata pine.

Galahs 36
Observations over several years are contributing to an understanding of this common, but unstudied, Australian bird.

Pelagic fish survey 37
The likely presence of schools of jack mackerel can now be predicted using information from aerial surveys.

Edible protein from animal blood 38
A new process for utilizing blood from abattoirs could provide an important source of protein for human consumption.

Safety of microwave ovens tested 38
A cheap and simple device has been developed to detect leakages of energy from microwave ovens and heaters.

Continuous dyeing of wool 39
A new process may overcome problems in the production of black wool by the continuous dyeing process.

New yarns for fine-gauge knitting 40
The self-twist process is being used to combine wool with synthetic filaments to produce yarns for fine-gauge knitting.

Exploring for nickel 40
The presence near the surface of certain minerals with characteristic microtextures can indicate the occurrence of nickel sulphide deposits beneath.

Treating copper ores 41
A novel process has been developed for treating copper concentrates without producing gaseous emissions such as sulphur dioxide.

Recovering metal from waste slags 41
A cheap and simple process for recovering metals from waste slags has been developed.

Industrial carbons from brown coal 42
The discovery of simple methods for demineralizing brown coals has made possible the production of carbons with a high degree of purity.

Electrical techniques in mineral exploration 43
An improved instrument is being developed as an aid to mineral prospecting in Australia.

De-watering wastes 43
The application of soil physics theory could help solve an industrial problem with environmental implications.

Interscan 44
Australia is contributing to the development of a better international landing system for aircraft.

Tunnels and underground excavations 46
Rock mechanics tests give improved design methods for underground excavations.

Carbide tools in rock drilling 47
An experimental rock drill is being used to discover how rock drills wear out.

Improving fire safety in buildings 47
Development of a light-scattering detector provides earlier warning of fires with fewer false alarms.

Acoustic screens for offices 48
Some so-called acoustic screens are not effective in reducing the spread of sound in open-space offices, and work is proceeding on the development of a better design.

Urban planning and air pollution 49
Planning studies being undertaken by the DIVISION OF BUILDING RESEARCH have led to the development of a mathematical planning model called TOPAZ (Technique for the Optimum Placement of Activities into Zones).

Sirofab house construction system 50
A prefabricated panel is the key to a system that reduces the time taken to build the shell of a house.

Cold storage stops grain insects 50
Aeration of silos with cold air may prove a safe and effective means of controlling insects in stored grain.

High-temperature solar water heating 51
Following the success of domestic solar water heaters, efforts are now being directed towards producing units capable of heating water up to 120°C.

Improved atomic absorption spectrophotometer 52
A modified form of the CSIRO-designed atomic absorption spectrophotometer can now be used to analyse metal samples without prior solution.

Lasers and the standard of length 52
Lasers are being used to give more precise standards of length to meet the requirements of today's science and industry.

Crystal landscapes 54
Etch patterns on crystal surfaces can now be viewed directly with a scanning electron microscope.

Testing telescope components 54
A simple technique for testing the accuracy of non-spherical surfaces is being used in the construction of the 3·8-metre Anglo–Australian Telescope.

Organic molecules in space 55
The discovery of organic molecules near the nuclei of galaxies points to the possibility of life elsewhere.

An area of dieback disease in eucalypt forest in the Upper Shoalhaven valley, N.S.W. The first signs of this destructive disease were detected in aerial photographs in 1950. Natural regeneration has not been successful in the area, and recent deaths of eucalypt seedlings have been associated with the presence in the soil of a root rot fungus, *Phytophthora drechsleri*.

The DIVISION OF PLANT INDUSTRY and the Australian National University are pursuing a joint study aimed at developing aids for recognizing the presence of various *Phytophthora* fungi and at identifying the main ecological factors which may influence dieback disease.

Introduction

In general terms about 44% of CSIRO's research effort is concerned with crops, pastures, livestock, conservation, land use, insects and wildlife, 12·5% with the processing of wool and food, 11% with environmental physics, marine science and radio astronomy, 8·5% with mineral exploration and processing, 21% with measurement standards and with chemical, physical and engineering research of industrial interest, and 2·5% with computing and statistics.

Given the nature of CSIRO's research activities, it is obviously undesirable and impracticable for planning to be exclusively a function of the Executive and Secretariat. Different levels of planning and different planning functions are of necessity widely dispersed throughout the Organization, ensuring appropriate decentralization while having regard to the need for effective coordination.

A second feature of planning in CSIRO is that it is a continuing activity that must be capable of responding and adjusting to changing situations. Planning in CSIRO operates in terms of four different time scales. The first of these involves the planning that takes place between annual budgets. The others are concerned with planning on an annual basis, on a triennial basis, and for periods greater than three years. Chiefs of Divisions and senior research staff are concerned particularly with the day to day, week to week, and month to month tactical planning related to the conduct of research. In consultation with Chiefs the Executive, and through it the Minister and Government, is responsible for broad planning decisions on an annual, triennial or longer time base. Given the essentially long-term nature of most scientific research, this broad strategic planning on a long time base is an important factor in research management.

CSIRO plans its activities in terms of research programs, a program being defined as a coherent group of related research activities directed to a stated general objective. Such an objective may be related to an industry or an industry group or to some community need and may be stated in terms of the expected practical outcome of the research. Alternatively, the objective may be stated in terms of the knowledge it is hoped to gain, and the likely contribution that such knowledge could make to the eventual solution of some particular industry or community problem or to the creation of opportunities for new industrial or other innovative activities. In general, a program is divided into a small number of subprograms each of which is intended to contribute to the objectives of the program being pursued. Hence, planning throughout CSIRO is in terms of stated objectives.

This approach is based on the firmly held belief that research results cannot be planned. Planning consists, rather, of identifying objectives, establishing their priorities, allocating resources for their pursuit and evaluating the results. A second general tenet is that the quality as well as the quantity of resources allocated to a particular objective is critically important. This is why in CSIRO so much importance is placed on the quality of research staff.

In general, research programs and their objectives are formulated initially at divisional level. Should the Executive recognize an area requiring new or additional work, it will ask the appropriate Division or Divisions to draw up suitable proposals. Where it recognizes the need for a major new field of endeavour the Executive may set up a new Division or Unit. However, for the most part the Executive is concerned with making decisions about the priorities of research programs recommended by the Chiefs of Divisions and the allocation of resources to them.

Within a particular Division the Chief, research scientists and other senior staff are expected to bring two broad lines of thought to bear on the formulation of research programs and on their modification with time. The first of these lines is an input derived from a multiplicity of contacts with primary and secondary industry, with various State and Australian Government departments and agencies, and with the social, economic and political environment generally. The nature of this input and its means of achievement vary considerably from field to field.

The second but no less important input derives from the ongoing and up-to-date knowledge that CSIRO scientists have of the scientific, technological and engineering possibilities of the problem or field.

In making judgments about program priorities, and in allocating available resources within this framework of priorities, the Executive necessarily has a complex and difficult task. On the one hand, the resources are finite, while, on the other, it has to take account of Government policy and of economic and social needs on the national scene on a time scale often well beyond that of Government policy. The Executive is also constrained by the need to optimize the body of expertise and skill that exists in the Organization at any one time.

The Executive employs many different techniques for ensuring that the program recommendations placed before it are soundly based. It seeks advice from Chiefs and other officers of the Organization and it receives suggestions and comments from the Advisory Council and from State Committees. Individually, its members, including the four part-time members who are drawn from university and industrial life, maintain a diverse range of contacts. In addition, the Executive has an established Secretariat which, among other things, undertakes a considerable amount of liaison with government bodies, committees and agencies, research associations and similar organizations.

For particular purposes, such as critical reviews of existing programs or examination of the need for a new research initiative, the Executive makes use of special external committees largely constituted from members of the Advisory Council and others, external to the Organization, who have special expertise in the particular field. The reports and recommendations of such committees carry considerable weight.

Operationally, the Executive is served by two Program Committees, each comprising three members of the Executive, one dealing with the agricultural and biological sciences and the other with the industrial and physical sciences. Each committee is, in turn, served by the appropriate science branch of the Secretariat.

The specific functions of the two Program Committees are to keep research programs under continuous review, to evaluate and recommend priorities in the annual allocation of resources, to foster interdivisional programs, to identify gaps in the overall research effort, and to conduct searching on-the-spot triennial reviews of the programs of individual Divisions or groups of Divisions. The two committees constitute the operational cores of continuous planning of research programs in the Organization.

The two principal time scales used by these committees and the Executive are one year and three years. These are in conformity with the normal methods of financing and planning in the Australian Government. Where major buildings and other capital works are involved this period may extend to around five years where actual construction may be spread over two or three years.

The arrangements that exist for identifying research goals and obtaining effective relations with the rural industries are of special interest. Here there are a variety of specialist committees under the auspices of the Australian Agricultural Council which provide extensive advice from producers on their identified research needs. This information is supplemented by means of specialist technical conferences and other contacts with individual State Departments of Agriculture and with bodies such as the Bureau of Agricultural Economics. Some $12 million a year is provided for CSIRO work from Rural Industry Research Funds. These funds were established by the Australian Government and have as their source levies on production matched by a contribution by the Government. The allocation of these funds for specific programs is made by the Minister for Agriculture on the recommendations of committees on which there is substantial industry and grower representation. In this way CSIRO programs in rural industry fields are brought under the direct scrutiny of the industry concerned.

In the secondary industry sector, the situation is different in that the Organization, largely at the level of the Division or group of Divisions, needs to establish continuing dialogue with those industries to which the results of CSIRO's research are likely to be relevant. One consequence of this in some areas is the establishment of a wide variety of collaborative and contract arrangements that are specially valuable in orienting the programs of a Division to future industry and national needs. The Division of Building Research, the Minerals Research Laboratories and the Food Research Laboratories are good examples of this kind of relationship.

Although a good deal of CSIRO's research is concerned with problems of primary and secondary industry, much of this research is also relevant to environmental and community issues. Examples of this are work on non-chemical methods of protection against insect pests, prevention of microbial spoilage in canned foods, and pollution control. In addition, there is a substantial program of research that is concerned with environmental and community issues in their own right. In all of these situations both formal and informal arrangements exist which help CSIRO in the identification of its research goals.

To summarize, it may be said that CSIRO has over the years evolved progressively and pragmatically a system of program management, priority assignment and resource allocation which is continuous, comprehensive, and sufficiently detailed for effective and comparative decision-making, and which is capable of absorbing a large number of parameters of judgment. At the same time it is also a system which permits that degree of tactical freedom that is necessary to the scientist at the bench if he is to have adequate scope to exercise his skill, initiative and judgment in tackling the particular problem on hand.

But although the system of research management developed by CSIRO is designed to enable the Organization to respond more readily to the changing needs of society, the Executive must, nevertheless, operate within a set of constraints. There are, of course, obvious constraints placed upon the Organization by the availability of finance and physical facilities such as laboratories, libraries and equipment. But more critical still are the constraints which arise from the fact that research is an activity involving people—people, moreover, who are highly motivated. This means that research is not something that can be stopped and started arbitrarily according to sudden changes in priorities. With careful management a research scientist's talents can, when necessary, be directed into new avenues of research which may prove more productive, but the Executive is not omnipotent; it cannot with the stroke of a pen turn an animal physiologist into a geophysicist. The calibre of its scientific and supporting staff and the diversity of their skills constitute CSIRO's most important resource and it is the management and deployment of this resource that are absolutely critical to the success of CSIRO as a research organization.

J. R. Price

Chairman

General

Finance

The table below summarizes the sources of CSIRO funds for 1973/74 and the categories of expenditure. More than four-fifths of CSIRO's income for the year was provided directly by the Australian Government. About four-fifths of the remainder was contributed by trust funds concerned with the wool, meat, tobacco, dairying, wheat, fishing, dried fruits and chicken meat industries. Most of these funds are derived from a statutory levy on produce supported by an Australian Government contribution.

During 1973/74 CSIRO spent $67·3 million of Treasury funds on salaries and general running expenses, an increase of $11·2 million over the previous year's expenditure.

Almost three-quarters of the increase was absorbed by salary adjustments arising from Arbitration determinations and by increments, reclassifications, and other inescapable commitments in the nature of salary.

The remainder of the increase was allocated as follows:
$1,038,000 for the planned development

Source of funds	Salaries and general running expenses ($)	Grants for studentships and grants to outside bodies ($)	Capital works and services and major items of equipment ($)	Total ($)
Treasury appropriation, including revenue	67,327,337	2,175,340	5,477,780	74,980,457
Wool Research Trust Fund	8,637,166	—	273,554	8,910,720
Meat Research Trust Account	1,900,463	—	49,211	1,949,674
Tobacco Industry Trust Account	294,441	—	—	294,441
Dairy Produce Research Trust Account	260,204	—	—	260,204
Wheat Research Trust Account	202,355	—	9,770	212,125
Fishing Industry Research Trust Account	123,754	—	—	123,754
Dried Fruits Research Trust Account	34,838	—	1,913	36,751
Chicken Meat Research Trust Account	5,591	—	—	5,591
Other contributors	2,712,673	—	308,721	3,021,394
Total	81,498,822	2,175,340	6,120,949	89,795,111

of major projects initiated in earlier years including work on fisheries and oceanography, mineral exploration, grain storage, and the development of new processes to the practical application stage.
$667,000 for the initiation of new projects including studies on water and waste treatment, cotton research, protected proteins, biological control of weeds, built environment, manufacture of polymer materials, solar energy, crop adaptation, atmospheric pollutants and navigational aids for aircraft.
$516,000 for additional support for current research programs and service activities.
$1,026,000 to meet increased costs of goods and services due to price increases during the past year and service costs resulting from the occupation of new accommodation.

In addition to the money that CSIRO received from the Government and from industry and other contributors, some $6·8 million was spent by the Department of Housing and Construction and the Department of Services and Property on buildings and other works for CSIRO and on the acquisition of land.

Buildings

A considerable proportion of CSIRO's financial provision for buildings during 1973/74 was concerned with the construction of the NATIONAL MEASUREMENT LABORATORY at Bradfield Park, Sydney. Construction progress was less rapid than had been scheduled, owing largely to shortage of materials and to industrial problems. It is currently expected that the project will be completed early in 1977. The cost of the Laboratory is in the order of $15,000,000.

CSIRO's building program was adversely affected during the year by rising building costs and in some instances there were difficulties in securing tenderers. As a result, six major building projects that were to have commenced in 1973/74 had to be deferred until the following year. The projects affected were:

ANIMAL HEALTH—Insect-proof cattle accommodation at Long Pocket Laboratories, Indooroopilly, Brisbane; incinerator for disposal of animal wastes at Long Pocket Laboratories; poultry isolator building at Maribyrnong, Melbourne.

FOOD RESEARCH—Enlarged brine-cooling refrigeration plant and modifications and extensions to chiller rooms at North Ryde, Sydney.

HEAD OFFICE—Structural alterations and minor extensions to CSIRO Printery, Collingwood, Melbourne.

WILDLIFE RESEARCH—Buffalo yards and pens at Darwin Laboratories.

Contracts were let for the following major building during 1973/74:

ATMOSPHERIC PHYSICS—Extension to machine shops and laboratory at Aspendale, Melbourne. $283,000.

BUILDING RESEARCH—Urban studies building at Highett, Melbourne. $217,000.

HORTICULTURAL RESEARCH—Laboratory at Merbein, Vic., for research on quality of wine grapes. $64,000. Finance for this project is being provided by the Australian Wine Board.

LAND RESOURCES MANAGEMENT—Development of new site and laboratories for rangelands research at Alice Springs, N.T. $120,000.

RADIOPHYSICS—New laboratory wing at Epping, Sydney. $276,000.

TROPICAL AGRONOMY—Internal alterations to laboratory at Townsville, Qld. $131,000.

WILDLIFE RESEARCH—Laboratory at Helena Valley, W.A. $438,000.

Major projects completed during the year include:

ENTOMOLOGY—Internal alterations and refurbishing of central block at Black Mountain, Canberra. $107,000.
MINERAL CHEMISTRY—Laboratory and services block at Port Melbourne. $225,000.
PLANT INDUSTRY—Herbarium at Black Mountain, Canberra. $280,000.
TROPICAL AGRONOMY—Extension to main laboratory building at Townsville, Qld. $734,000.

Australian National Animal Health Laboratory

In April 1974, Cabinet approved the establishment of a $56 million Australian National Animal Health Laboratory (ANAHL) at Geelong, Victoria. The decision followed a joint Cabinet submission by the Ministers for Science, Health, Primary Industry, and Northern Development. The laboratory, which will be administered and operated on behalf of the Australian Government by the Division of Animal Health, will provide a valuable insurance against the devastating effects that the accidental introduction of an exotic livestock disease, such as foot-and-mouth disease, could have on Australia's animal industries. In 1972/73 these industries had an estimated gross value of production of $3000 million. In the same year the industry's exports were worth an estimated $2000 million.

The principal functions of ANAHL will be the diagnosis of exotic diseases of livestock (mainly virus diseases), the testing of vaccines required for exotic disease control, research on indigenous virus infections of animals, and the production of foot-and-mouth disease vaccine if required.

When fully operational the laboratory will employ a staff of 170 including 25 scientists. Annual running costs will be in the order of $3 million.

Construction is expected to begin in 1976/77 and will be spread over five years. The laboratory complex will be technically the most sophisticated major structure in Australia and the most modern animal diseases laboratory in the world.

The Geelong site, currently the Geelong rifle range, was chosen after extensive consideration of a wide range of alternative sites. The final choice was made on the advice of the Cities Commission in the light of the Australian Government's policy of developing specific growth centres and with the approval of the Victorian Government.

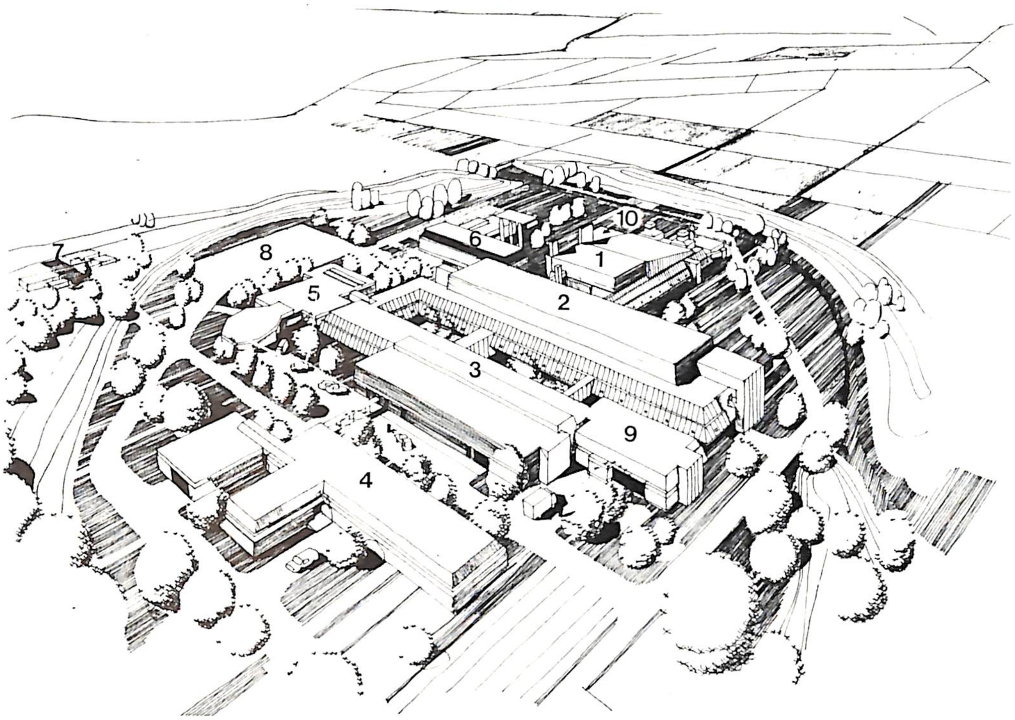
A comprehensive environmental impact statement for the site accompanied the Cabinet submission. The Department of the Environment and Conservation which assessed this statement noted the amount of technical detail supplied and advised that it was satisfied that the environmental issues of the proposal had been adequately covered.

Because of the extreme precautions built into the design, there will be no risk to Australian livestock. The laboratory complex will operate as a series of integrated engineering systems which provide isolation from the external environment. It features multiple fail-safe devices and procedures including air locks, shower locks, filter systems of many kinds and sophisticated waste disposal apparatus.

All air entering or leaving the laboratory will be specially filtered. The air leaving the high-hazard area will be heat sterilized to kill virus particles. Solid wastes will be destroyed or rendered sterile. Operation of the complex will have no detrimental effects on the environment.

In accordance with overseas practice, the keeping of susceptible livestock will not be permitted in a buffer zone a kilometre and a half in radius around

Australian National Animal Health Laboratory



1 **Large animal house**
Vaccine testing and experimental purposes
Animal entry and grain storage

2 **Laboratory wing**
Diagnosis
General virology
Biochemistry

3 **Scientific services and stores wing**
Personnel entry
Media preparation
Tissue culture
Internal canteen
Workshops and laundry

4 **Small animals breeding wing**
Animal breeding
Insectary
Plant equipment

5 **Administration building**
Lecture theatre
Library
Kitchen and cafeteria
Administration offices

6 **Services building**
Plant equipment
Maintenance workshop

7 **Entry checkpoint**
Gatehouse and animal unloading
Wheel bath

8 **Car parking**

9 **Vaccine production unit**

10 **Sewerage treatment storage tanks**

The picture at left shows how the completed Laboratory will appear when viewed from the air looking across Corio Bay to Point Henry.

the laboratory. This will include sheep, cattle, pigs, goats, horses, fowls, turkeys, geese and ducks. The keeping of dogs and cats will be permitted. The Victorian Government has agreed to the relocation of the trotting and dog-racing track currently in the vicinity by the time the laboratory is complete in 1981.

Indonesian laboratory

At the request of the Minister for Foreign Affairs, CSIRO has undertaken to establish a major agricultural research laboratory near Bogor, West Java, in collaboration with the Indonesian Department of Agriculture. The project is part of the Australian Government's overseas aid program.

The laboratory will be concerned mainly with research aimed at increasing production from poultry, sheep, goats, cattle and buffalo, with a long-term objective of raising the production of animal protein in Indonesia.

Research in the fields of genetics, nutrition and animal husbandry will be undertaken and applied to the selection of more suitable stock from local strains of livestock, the introduction of new strains, and the development of improved feeding techniques. The project will also provide training both in Australia and at the laboratory for Indonesian scientists, who will eventually replace Australian personnel.

Dr L. J. Lambourne, who was previously an officer of the DIVISION OF ANIMAL PHYSIOLOGY, has been appointed Officer-in-Charge of the laboratory.

Executive changes

In March 1974 Mr V. E. Jennings was appointed a part-time member of the Executive replacing Sir Henry Somerset who retired. Mr Jennings is Managing Director of A. V. Jennings Industries (Australia) Pty Ltd. He is also Vice-President of the Australian Institute of Urban Studies and Chairman of the Research Committee, Vice-Chairman of the Australian Engineering and Building Industries Research Association, and a member of the Building Research and Development Advisory Committee.

Sir Henry Somerset showed particular interest in the problems of communicating the results of CSIRO research to industry during his nine years with CSIRO and made a substantial contribution to the extensive reviews that led to the establishment of the Minerals Research Laboratories.

Organizational changes and senior appointments

Dr A. K. Lascelles was appointed Chief of the DIVISION OF ANIMAL HEALTH in July 1973. He was formerly Professor of Dairying at the University of Sydney. He succeeds Dr A. E. Pierce who was appointed a member of the CSIRO Executive in 1973.

The four CSIRO Divisions engaged in Animal Research—ANIMAL GENETICS, ANIMAL HEALTH, ANIMAL PHYSIOLOGY and NUTRITIONAL BIOCHEMISTRY—were grouped to form the CSIRO Animal Research Laboratories. A committee comprising Dr K. A. Ferguson, formerly Assistant Chief of the DIVISION OF ANIMAL PHYSIOLOGY, as chairman and the Chiefs of the four Divisions as members was formed to assist the Executive in the development of the research programs in animal research Divisions.

Following the reorganization of CSIRO's land resource Divisions, mentioned in last year's annual report, three new appointments were made. Dr R. J. Millington was appointed Chief of the new DIVISION OF LAND USE RESEARCH. Mr R. A. Perry was appointed Chief of the new DIVISION OF LAND RESOURCES MANAGEMENT. Dr A. E. Martin was appointed Chief of the DIVISION OF SOILS in place of Dr E. G. Hallsworth, who was appointed Chairman of the Land Resources Laboratories Committee which will coordinate the programs of these three Divisions.

In November 1973, CSIRO formed a SOLAR ENERGY STUDIES UNIT under Mr. R. N. Morse, formerly chief of the DIVISION OF MECHANICAL ENGINEERING. Mr. Morse, immediate past President of the International Solar Energy Society, has been designated Director, Solar Energy Studies. He will advise the Executive on planning and policy for solar energy research in CSIRO.

CSIRO has been carrying out continuous research and development for the last 20 years on the utilization of solar energy for domestic and industrial heating.

In 1974 the former DIVISION OF APPLIED CHEMISTRY was divided into two divisions, the DIVISION OF CHEMICAL TECHNOLOGY and the DIVISION OF APPLIED ORGANIC CHEMISTRY. Dr S. D. Hamann was appointed chairman of the committee coordinating the programs of the Applied Chemistry Laboratories.

The DIVISION OF CHEMICAL TECHNOLOGY is concerned with applying chemical and polymer technology to the utilization, recycling and conservation of renewable resources in the supply of water and energy and in the production of pulp, paper and other materials based on cellulose. This Division is based in the Forest Products Laboratory in South Melbourne. Dr D. E. Weiss was appointed Chief of the Division.

The DIVISION OF APPLIED ORGANIC CHEMISTRY based at Fishermens Bend, Victoria, will be concerned primarily with the application of organic chemistry to pest control and the development of useful plant constituents, as well as aspects of organic polymer and physical chemistry. Dr D. H. Solomon was appointed Chief of the Division.

Dr W. G. Crewther was appointed Chief of the DIVISION OF PROTEIN CHEMISTRY in December 1973. He was formerly Assistant Chief of the Division. He replaced Dr F. G. Lennox who is now Australia's Chief Scientific Liaison Officer in Britain.

During the year it was decided that from 1 July 1974, the CSIRO DIVISIONS OF APPLIED PHYSICS and PHYSICS would be combined to form the NATIONAL MEASUREMENT LABORATORY and that Mr F. J. Lehany, formerly Chief of the DIVISION OF APPLIED PHYSICS, would be Director of the new Laboratory. The Laboratory will remain at Chippendale, New South Wales, until about 1976 when it will move to a new laboratory complex at present under construction in the outer Sydney suburb of Bradfield Park. The Laboratory will continue to carry CSIRO's responsibility for the establishment and maintenance of standards of measurement of physical quantities. These standards provide the basis for measurements used in trade, manufacturing industry and science.

Professor J. M. Gani was appointed Chief of the DIVISION OF MATHEMATICAL STATISTICS following the death of the former Chief, Dr E. A. Cornish, in 1973. Professor Gani, who has been Director of the Manchester–Sheffield School of Probability and Statistics, will take up his position with CSIRO in September 1974.

In March 1973 Dr D. F. Kelsall was appointed Chief of the DIVISION OF CHEMICAL ENGINEERING, filling a vacancy caused by the appointment of the former

Chief, Dr H. R. C. Pratt, as Visiting Professor at the Department of Chemical Engineering, University of Melbourne.

Mr Peter Judge was appointed Officer-in-Charge of CSIRO's Central Information, Library and Editorial Section which is based in Melbourne. He was formerly head of the OECD Science and Technology Information Section in Paris.

Regional survey of Alligator Rivers, Arnhem land

In May 1972 the Australian Government and the mining industry agreed to jointly sponsor an environmental fact-finding study of the Alligator Rivers region of Arnhem land. Because of a potential conflict between mining and conservation interests in the area, Government, private organizations and universities were invited to take part in the survey. CSIRO involved its DIVISIONS OF LAND USE RESEARCH, WILDLIFE RESEARCH and ENTOMOLOGY.

The land evaluation survey was carried out by the DIVISION OF LAND USE RESEARCH and Macquarie University. This survey was an extension of a 1955 study made by the Division and used similar methods to those in the earlier survey. Its objective was to map and describe the different types of country in terms of land form, soils and vegetation as a basis for assessing both the potential alternatives and the effects of various types of land use. The DIVISION OF WILDLIFE RESEARCH conducted the survey of fauna except for reptiles, amphibians and freshwater fish which were surveyed by the Australian Museum and the Department of the Northern Territory. The Division also collaborated with the DIVISION OF LAND USE RESEARCH in the survey of flora, particularly in relation to wildlife habitats.

The wildlife survey team reported on the ecological relationships of animals and plant communities, the abundance and seasonal cycles of the animals, and the uniqueness of various species.

The DIVISION OF ENTOMOLOGY conducted the insect survey of the area. Its objectives were to determine the extent of the insect fauna and the presence of any important species that might be affected by disturbance of their habitats, and to look for any species that might serve as useful biological indicators of any ecological upset.

CSIRO's findings and recommendations were contained in the review report of the Alligator Rivers study which was completed in November 1973.

In December the Prime Minister announced that the Government intended to establish a national park in the area, and that it would be named Kakadu after an Aboriginal tribe which originally lived in the area.

Resource survey of Papua New Guinea

At the end of World War II, when a program of rapid regional development was being planned in Papua New Guinea, the extent and nature of the country's natural resources were virtually unknown.

In 1951 the DIVISION OF LAND USE RESEARCH (formerly Land Research) was requested to undertake a natural resource survey of Papua New Guinea to aid national development. Using new rapid survey techniques based on the use of aerial photographs taken during and after the war, the landforms, soils, vegetation, climate, population and land use of regions 3000–5000 square miles in extent were described and mapped each year.

In 1970 it was decided to discontinue the regional survey program and undertake a national resource inventory. This work is now completed, bringing to an end a 23-year resource survey program in Papua New Guinea. The results of the survey have just been published and comprise a number of definitive studies which will be the basis of resource documents in Papua New Guinea for many years to come.

Building research laboratory in Papua New Guinea closed

In December 1973 the DIVISION OF BUILDING RESEARCH closed its branch laboratory in Port Moresby, Papua New Guinea. The laboratory was established in 1962 to provide a research and extension service to cover the special problems of buildings in the tropics.

The Division established a publication called *Tropical Building Research Notes*, which, throughout its 60 editions, provided advice to individuals, local and Australian government departments and various overseas agencies.

The research projects were primarily directed to the use of local building materials, such as clay, limestone, mortar, bamboo and sago palm. Although there is a considerable clay resource in Papua New Guinea, little of it is suitable for bricks. However, studies by the Division indicated that several promising deposits existed throughout the country.

A large research effort was directed towards the development and testing of fungus-resistant paints as well as other metal-coating materials. A special process for the cheap and simple preservation of local timbers was also developed.

A survey was conducted amongst Papua New Guineans and expatriates to arrive at a figure for the temperature, humidity and air velocity considered ideally comfortable. Other work was aimed at solving the problem of cracks in concrete block houses caused by the swelling and contraction of the Port Moresby clay soils.

Some of the functions of the former branch office will be carried on by Papua New Guinea's Public Works Department, others by the Department of Forests and the Institute of Technology in Lae. Officers from the Division expect to make periodic visits to Papua New Guinea to provide specialized advice in the building field.

New computer for CSIRONET

In August 1973 the DIVISION OF COMPUTING RESEARCH installed a Control Data Cyber 76 computer at its headquarters in Canberra. This represents a major step towards the aim of providing Australian scientists and other computer users with a network that can compare favourably with any in the world.

The Cyber 76 replaces the Control Data 3600 which was previously used as the central computer for the extensive network of small PDP computers which in turn drive the remote line printers, card readers and consoles that make up the CSIRONET system. The Cyber 76 can operate many of its functions 20–30 times faster than the 3600. The 3600 has been retained and operates as an interface between the network and the Cyber 76. However, two Control Data 172 machines, to be installed in 1975, will eventually make the 3600 redundant.

CSIRONET at present operates about 30 line printers and card readers, together with 200 teletype or cathode ray tube consoles. Up to 64 of these may be active at any one time.

Research

In a report of this size it is not possible to give a full account of all of CSIRO's current investigations. This section contains one or two items of interest from each Division and is designed to show something of the wide range of CSIRO's research activities. More comprehensive information on the Organization's current research activities can be obtained from the separate annual reports published by each Division. A brief description of the fields of research engaged in by each Division is given on pages 60–64 of this report.

From pastoral to urban land use

Soil surveys designed originally for assessing agricultural potential are now being adapted for planning in the Townsville urban growth centre.

Detailed soil surveys were recently completed by the DIVISION OF SOILS on some 212 000 hectares of the coastal plain within a 50-kilometre radius of Townsville. These studies, comprising soil reports and soil and land capability maps, were originally intended for use in assessing the agricultural and pastoral potential of the area. With the establishment of Townsville as a regional growth centre, the Division found that the basic soil maps, with some re-interpretation, are able to provide a valuable basis for urban planning.

Unlike some larger cities on the east Australian coast, there is little conflict in the Townsville area between rural enterprises and urban development interests. Most soils are naturally of low quality for agricultural or pastoral production, and their use has therefore been almost entirely restricted to low-intensity beef-cattle grazing.

Nevertheless, some soils are more suitable for agriculture or lend themselves to engineering activities better than others. On this basis it has been possible to allocate urban development to certain localities and recommend that other areas be reserved for different uses.

In developing the area, the Division's basic soil inventory can be easily re-interpreted in terms of engineering properties relevant to building and road construction. For example, soils with suitable drainage characteristics and swelling and shrinking properties can be identified. Similarly, soils suitable for parks, gardens and other recreation areas can also be determined from the original soil inventory.

Land forms of the Riverine Plain

A land form map of the Riverine Plain should help in the layout of irrigation farms.

The Riverine Plain, which includes the Riverina district of New South Wales and the northern plains of Victoria, is noteworthy in Australia for the large number of streams and ancient stream patterns that dissect the land surface. Some courses of the former streams on the land surface were distinguished many years ago during soil surveys of irrigable land. Experience has shown that these and the buried stream channels throughout the region make irrigation of some areas very difficult.

One of the projects associated with the International Hydrological Decade has been the compilation of a map showing the different types of stream traces and the other complex land forms that can be identified on the Plain. The work is the result of collaboration since 1966 by three soil scientists, two hydrogeologists and a geomorphologist attached to relevant State institutions, the Australian National University and the DIVISION OF SOILS. The map is drawn to a scale of 1 : 500 000 and shows stream patterns, lake features, wind-sculptured land forms, and different types of adjacent plains characterized by particular surface features. The nature of the junction of the plain with highlands at the south and with wind-sculptured land at the west is shown by extension of the map beyond the limits of the plain. The features shown on the map are dealt with in an explanatory text.

The compilation, entitled 'A Geomorphic Map of the Riverine Plain of South Eastern Australia', has been published by ANU Press.

Understanding world climate change

A basic study of the effect of clouds on radiation has led to some new predictions of possible changes in world climate.

The possibility of the Earth's heading towards another ice age has long fascinated many people, while the reasons for such a phenomenon are important to meteorologists.

Most climatologists believe that changes in the output of radiant energy from the Sun are the basic cause of long-term changes in the climate of the globe.

Scientists have computed that a mere 1% decrease in solar output would lower the surface air temperature by between 1 and 1·5°C—enough to bring about significant changes in the world's climate. But so far these calculations have not taken into account accompanying changes in cloud cover, largely because the processes that govern the overall amount and type of cloud are unknown.

Recently the DIVISION OF ATMOSPHERIC PHYSICS has been looking into the role of radiation in determining the amount of cloud cover and also at the effect of cloud on radiation, because cloud not only modifies radiation from the Sun, but also affects radiation from Earth back into space.

An attempt to obtain an improved knowledge of cause and effect has been made by means of a mathematical synthesis of some recent experiments on the radiative properties of clouds. The results predict that for a 1% increase in output of solar radiation, the surface temperature will rise by 0·3°C (as opposed to the 1 or 1·5°C formerly assumed) and will be accompanied by a 1% increase in cloud.

Support for the validity of these predictions was obtained from another, quite independent source. Between July and January the decrease in the distance between the Sun and the Earth causes the radiation energy supplied to the Earth to increase by 6%.

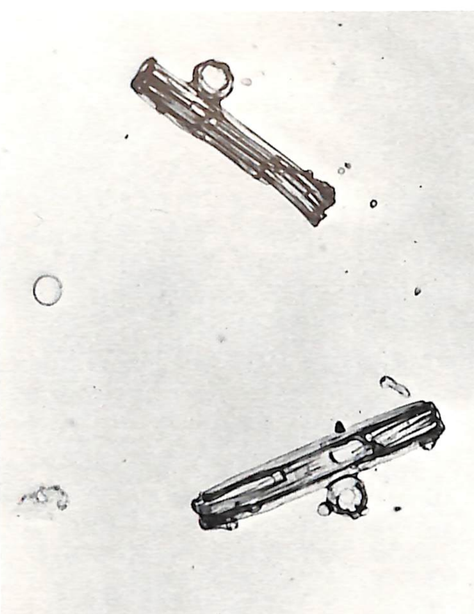
Observations from meteorological satellites show that, as forecast, there is an increasing cloud cover during this period, also amounting to 6%.

Although the evidence supporting these ideas is still scant, the work represents another step forward in understanding climatic change on a global scale.

Mysterious 'multiplication' of ice crystals

An understanding of the processes of rain formation could lead to more successful artificial rain-making operations.

When clouds grow high enough for their tops to be colder than 0°C, the tiny water drops of which they are composed do not necessarily freeze. They stay in a 'supercooled state' and ice crystals only form if suitable dust particles are present to act as ice nuclei, to help the freezing process. These ice nuclei can be counted by making an artificial cloud in a cloud chamber at low temperature and seeing how many ice crystals fall out. Such measurements of the concentration of ice nuclei have led to the belief that natural ice nuclei are rather rare in clouds at temperatures warmer than −20°C.



Replicas of two hexagonal column ice crystals sampled at the −7°C level in a cumulus cloud off Tasmania. They are about 0·4 mm long. They have started to grow by riming, each having captured a large water drop.

In temperate climates, including the southern half of Australia during winter, much of the rain originates from ice crystals. These grow while falling through the clouds and melt on the way to the ground. A dearth of ice nuclei might mean fewer crystals and less rain; conversely, the rainfall might be increased by artificially introducing more ice crystals. This is the basic philosophy underlying most rain-making efforts over the past twenty years.

This view of what happens in clouds was upset some years ago when members of the DIVISION OF CLOUD PHYSICS began sampling supercooled cumulus clouds near the Australian coast in winter.

In some clouds no colder than −10°C they found large numbers of ice crystals, some ten thousand times more numerous than the ice nuclei. There seemed to be some mechanism at work whereby the primary ice crystals, formed upon ice nuclei, could 'multiply'.

Laboratory experiments to reproduce this multiplication process artificially were unsuccessful until late in 1973. Then it was found that an ice-covered rod, moving through a supercooled cloud and sweeping up the drops, shed copious splinters of ice. The process is very sensitive to temperature and droplet size and only occurs at temperatures close to −5°C and in a cloud containing drops larger than 25 micrometres in diameter.

This experiment imitates what happens in a natural cloud when an ice crystal grows large enough to sweep up the water drops in its path and become a snow pellet or embryo hailstone.

The laboratory results indicate that a single ice crystal could shed a hundred daughter particles in the course of its growth. These could then grow, gather rime, and shed splinters in their turn. It is possible to account for the high numbers of ice crystals encountered in cumulus clouds formed in clean air of marine origin.

Obviously, clouds in which such a process of ice crystal multiplication is active are unlikely to yield more rain when seeded with artificial ice nuclei. Conversely, artificial stimulation is likely to be most profitable in continental clouds with high bases where drops larger than 25 micrometres are only found well above the critical $-5°C$ level.

Steam, fog and a power station

Information accumulated in long-term basic research has been used to predict the impact of a Melbourne power station on local fog.

What is the likely increase in fog as a result of warm water from the condenser of a power station being discharged into the sea or an open bay? This question was asked recently of the DIVISION OF ATMOSPHERIC PHYSICS when a proposal to erect a new power station at Newport, near Melbourne, was being considered. Of particular concern was the navigation of ships entering and leaving Melbourne docks in the Hobson's Bay area.

It is well known that as the surface water temperature increases so does evaporation. But the lateral and vertical extent of any resultant fog and the visibility in it are not easily determined and no quantitative determination has been attempted before.

To evaluate the likely increase of fog the Division investigated the natural occurrence of fog in the locality, the types of weather associated with it, and the size, shape and temperature of the warm water plume discharged from the proposed power station.

Results of the study showed that there would be only a small period in each year when shipping would be affected. If for instance the power station operated for 24 hours a day, the natural visibility of 1200 metres would be reduced to 350 metres for only 7 hours per year for large ships and 15 hours per year for small ships.

If the condenser water were injected into the bay beneath the surface, the effect would be even less.

Water availability and wheat growth

Knowledge of the mechanisms by which wheat plants balance growth and water loss could help plant-breeders select more productive strains.

The physical forces involved in the transport and retention of water in plants are fairly well understood in broad terms, but precise measurements are needed for production studies to predict the influences of water stress and to identify plant characteristics that can be measured and used in plant-breeding programs.

The DIVISION OF ENVIRONMENTAL MECHANICS has conducted field studies on water transport in wheat plants and its effects on production in dry conditions typical of the Australian wheat belt. This work has revealed the physical mechanisms by which wheat plants balance production and water conservation under conditions that would often lead to wilting in other crops.

In contrast with many other plants, the stomata of wheat (the leaf pores through which the carbon dioxide used for photosynthesis enters the plant) stay open during periods of moderately high evaporation. However, at times of extreme evaporation stress they close rapidly, thus safeguarding the plant against severe water loss.

This behaviour can now be explained in terms of a number of physical properties important to the water balance of wheat plants. These properties include resistance to water flow through roots and stems, and the relation between the closure of stomata and the plant water state.

Knowledge of these measurable physical properties could help plant breeders select plants for a particular region and so make more effective use of available soil water.

Problems with cropping after rice

Factors responsible for the poor growth of crops sown after rice are being studied.

About 290 000 tonnes of rice were harvested in south-eastern Australia in 1973 and 410 000 tonnes are predicted for the 1974 harvest. This means that 100 000 hectares will either be sown with rice or remain under rice stubble during summer. Rice crop or rice stubble occupies about half of the area of the major rice-growing farms.

Crops grown after rice such as sunflower, maize and sorghum often show poor growth and produce low yields even when they have been heavily fertilized. The efficiency of irrigation farm management is severely restricted unless the area under rice stubble can be quickly brought back into production for forage or cash crop.

Compared with rice, other summer crops require different soil conditions and soil nutrient levels for maximum growth. The levels of oxygen, available phosphorus, nitrogen and other soil nutrients, especially iron, may be adversely altered by a rice crop. Any of these factors, either alone or in combination, can significantly reduce yields of subsequent crops.

The DIVISION OF IRRIGATION RESEARCH is investigating the effect of these factors on the growth of crops sown after rice. Other work is aimed at developing management procedures such as cultivation and fertilizer placement which may correct the disorder.

Controlling the size of the orange crop

Discovery of the causes of variations in yield of orange crops is indicating possible means of control.

The orange crop suffers a number of disadvantages affecting its economic stability. In the variety Late Valencia, which provides over 60% of Australia's citrus, a heavy crop one year is followed by a light crop the next. This phenomenon, known as biennial bearing, adds many additional costs to the industry, and so an understanding of the problem has been sought with a view to developing a method of

This area grew rice in the 1971/72 season. The banks separating the bays were flattened and the whole area graded to a uniform gradient during the 1972 winter. Maize was sown in hills with 150 kg nitrogen and 30 kg phosphorus per hectare by mid November. The field was furrow-irrigated. This aerial photograph taken six weeks after emergence shows the very poor growth of the maize plants on the bay area in contrast with the almost normal growth on the old bank areas.

regulating the yield.

The physiological and environmental factors involved in fruit setting by orange trees were investigated at the DIVISION OF IRRIGATION RESEARCH, Griffith, New South Wales, and in the controlled environment phytotron at the DIVISION OF PLANT INDUSTRY in Canberra.

It has been found that mature fruit on the tree prevent the formation of flowers. Consequently, after a heavy crop there are few flowers to form fruit and hence the biennial process.

The degree of variation in yield is also affected by temperature during November. Low temperature results in fewer fruit being formed. Since 80% of the Valencia crop is grown in the one climatic area—along the Murray and Murrumbidgee Valleys—synchronization of yields exacerbates the problem of economic stability. Preliminary investigations have shown that fruit setting can be manipulated by applying chemicals to reduce photosynthesis for a few days after flowering and hence reduce the size of the crop.

The New South Wales Department of Agriculture and the Division are cooperating in an effort to translate these findings into practical methods of controlling alternate cropping cycles of Valencias. One that has been successful in the Murrumbidgee Irrigation Area depends on reducing the number of flowers prior to a heavy crop by means of the natural compound, gibberellic acid, applied as a mid-winter foliar spray. The reduced crop consisted of larger fruit and the following crop was much heavier than would have been expected had the normal pattern of biennial bearing prevailed. Furthermore, over a two-year period subsequent to treatment yields were increased by about 10% and these more than compensated for the cost of applying the foliar spray.

More efficient use of fertilizers

The timing of fertilizer applications to pastures can affect the balance between grasses and legumes.

Most of Australia's grazing lands are too infertile in their natural state to produce high-quality pasture. Nitrogen and phosphorus are nearly always deficient in the soil, potassium and sulphur are short in many areas, and small traces of elements such as molybdenum, copper and zinc are often needed as well.

Because nitrogen fertilizers are costly, the usual pasture improvement practice is to sow nitrogen-fixing legumes and fertilize them with superphosphate, which contains both phosphorus and sulphur. If other nutrients are needed they are added with the superphosphate.

Where there is already enough nitrogen in the soil and when other deficiencies are corrected, the grasses grow at the expense of the legumes.

Research by the DIVISION OF TROPICAL AGRONOMY has shown that important tropical legumes like Siratro and Townsville stylo compete more strongly for phosphorus than the associated grasses, while the grasses are the stronger competitors for potassium. This means that on soils deficient in both phosphorus and potassium, the first limitation on grass growth is the supply of phosphorus whereas lack of potassium acts more severely on the legume. Thus the current practice of applying quite large amounts of superphosphate at sowing can favour the grass at the expense of the legume.

Field experiments have shown that in some instances the legume can develop more quickly if potassium is applied at sowing and the superphosphate dressing is deferred until the legume is well established. The legume will respond to phosphorus on deficient soils, just as the grass will respond to potassium. It's the difference in the size of these responses that leads to one fertilizer favouring the legume and the other the grass.

More work on the effects of these and other combinations of nutrients on grass–legume mixtures is planned so that fertilizers can be applied to pastures in the most effective way.

Tropical legumes and soil fertility

Difference between legumes in their effects on soil fertility may be due to differences in their chemical composition.

Growing pasture legumes, such as clovers, to improve soil fertility has been an agricultural practice for about four thousand years. Clovers and other legumes improve soil fertility by fixing nitrogen from the air. When the legume plants die and decompose, up to half of this nitrogen rapidly becomes available for use by other plants. The remainder of the legume nitrogen becomes available more slowly. The beneficial effect of subterranean clover pastures on subsequent grain yields in southern Australia is a good example of the value of legumes in Australian agriculture.

Over the last ten years, studies by the DIVISION OF TROPICAL AGRONOMY on the role of tropical legumes in improving soil fertility have shown big differences between species in their short-term effect on both associated grasses and subsequent crops. Some, like Siratro, behave like subterranean clover, releasing nitrogen quickly to stimulate the yield of the associated grass and the subsequent crop. Others, like green-leaf desmodium and Schofield stylo, release their nitrogen only very slowly and it may be years before most of the nitrogen they have accumulated is passed on to other plants.

This raises the question of why these particular plants take so long to decay. The answer appears to lie in their chemical constitution. In green-leaf desmodium it is probably the high content of certain tannin-like polyphenols that protects the protein from decay caused by microbes.

The Division is continuing research on these substances and their effects on soil fertility since they could have an important influence on the practical use of legume species.

Revegetating mining spoils

Methods of revegetating mine dumps containing heavy metal residues are being investigated.

The spoil heaps that accompany mining operations have soil environments that are characteristically hostile to plant establishment and growth. The DIVISION OF PLANT INDUSTRY found that when plants of six species were grown on mine residues from Broken Hill, all showed symptoms of heavy metal toxicity. Some species showed symptoms that suggested an excess of manganese. Other symptoms suggesting magnesium, zinc and potassium deficiencies were also observed.

A subsequent pot culture trial with fennel and lucerne on soil from one of the dumps clearly demonstrated that application of lime, which can counteract heavy metal toxicities in soil in most situations, had virtually no effect either on the acidity of the soil solutions or on the level of manganese.

By contrast, application of relatively small amounts of magnesium carbonate decreased the acidity of the soil solution and markedly reduced the level of manganese, while at the same time alleviating magnesium deficiency. These

Above Unstabilized mine dump at Broken Hill.

Below The same dump three years later, after stabilization by the Zinc Corporation. A variety of native and introduced species were trickle-irrigated with sewage effluent in a joint study with the DIVISION OF PLANT INDUSTRY.

effects resulted in spectacular increases in plant growth.

This finding could lead to considerable improvement in the techniques used for revegetating mine dumps that have heavy metal toxicities, such as those at Broken Hill.

Surveying Australia's rain forests

Research shows that the ecology of Australian rain forests is far more complex and interesting than was previously believed.

For millions of years a dense green belt of wet tropical rain forest has persisted roughly 10 degrees either side of the Equator. Until two centuries ago this ecosystem—one of the most ancient on earth—stretched in an almost unbroken chain through the humid tropical lowlands and uplands of Central and South America, West Africa, South-east Asia, the islands of Indonesia and Papua New Guinea, and north-eastern Australia.

But in the last two hundred years the belt has became fragmented. Huge areas have been clear-felled, burnt and more recently bulldozed to make way for food crops and plantations, or cut for timber and pulpwood. Large areas still persist, notably in the Amazon and parts of Indonesia and Papua New Guinea, but even there the rain forest is retreating before the pressure of human populations. At the present rate of destruction very little is likely to remain by the turn of the century.

In eastern Australia there is only a thin discontinuous strip of rain forest, usually in areas of high rainfall and deep well-drained soils varying in nutrient status. Since the forests were first penetrated by the cedar-seekers soon after settlement by Europeans, over half the rain forest area has been cleared for farming, and most of the remaining forests have been logged. Once cleared, the steep slopes easily erode, and surface run-off increases after storms. Even on gentle slopes, once the soil fertility conserved in the closed nutrient cycle of the natural forests is lost, land without proper management is invaded by weeds and becomes unproductive.

Because rain forests all look much the same to an untrained eye, many people believe that these forests are adequately preserved in the present national parks which are mostly restricted to the rugged mountains of coastal Queensland and northern New South Wales.

However, research by scientists of the DIVISION OF PLANT INDUSTRY has shown that this belief is fallacious. On a broad regional scale, the rain forests of south-eastern Australia as far north as Mackay have many important biological differences from the tropical rain forests and monsoon forests farther north. Subtropical types cannot, therefore, be regarded simply as cooler southern versions of the tropical rain forests. Mountain rain forests, the adjacent lowland rain forests, and the subcoastal hoop pine and bottle tree 'scrubs' are also fundamentally different. In the wet lowland region alone, the Division described 20 distinct forest associations near Cairns, and recommended that samples of each be preserved and managed as national parks. So far 12 of these areas, in whole or part, have been set aside for this purpose.

On a local scale the Division has shown that the rain forest also exhibits great variety in structure and botanical composition. Further steps have been made towards understanding the factors responsible for the biological complexity and changing patterns of the tropical vegetation. In north-eastern Australia (and the problem is much greater in the humid tropics than elsewhere) the plants of the rain forests are not well known. Collections by the Division indicate that approximately 100 species of trees and shrubs in north Queensland are new to science. Authorities on evolution regard north Queensland as a remnant of the original 'cradle' of the flowering plants (Angiosperms), and this small area of rain forest contains the greatest concentration of primitive flowering plants surviving in the world.

The special environment of the rain forest provides shelter and food for a remarkable variety of animals. Many species have evolved along with a particular type of rain forest. This co-adaptation is being studied by the Division, in collaboration with the University of Queensland and the Queensland Forestry Department. The studies will provide an essential basis for the selection and management of conservation areas, whether natural or disturbed.

Another multidisciplinary project involving the Division and the above authorities is aimed at identifying those aspects of the rain forest which are becoming recognized as important for recreation and education.

An Australian Phytochemical Survey was initiated during World War II by CSIRO and conducted in conjunction with the Universities of Sydney and Melbourne. The survey concentrated on the chemical investigation of over 4000 species of plants in Australia, and has identified from the rain forest some 500 alkaloids (physiologically active compounds such as strychnine and cocaine), about 200 of which were previously unknown. Much of this work has been carried on by the DIVISION OF APPLIED ORGANIC CHEMISTRY.

Breeding disease in northern bulls

Young bulls are less susceptible than old bulls to the venereal disease bovine trichomoniasis.

Venereal disease specific to cattle occurs in herd cattle in many parts of Australia but is most prevalent in station herds in the far north. While venereal disease is only one of several factors causing low calving rates in northern herds, it is probably the cheapest and easiest factor to control.

Recent research by the DIVISION OF ANIMAL HEALTH into the two venereal diseases bovine vibriosis and bovine trichomoniasis shows that both diseases can probably be controlled by eliminating the agents *Vibrio fetus* and *Trichomonas foetus* from herd bulls without bringing in all the cows for treatment.

Annual vaccination of bulls with vaccines made from *Vibrio fetus* prevents them from carrying and distributing this infection to female cattle. Although two types of *Vibrio fetus* are found in cattle in the far north, effective vaccines can probably be produced from both types. All bulls would have to be vaccinated annually to control the disease.

Recent studies on *Trichomonas foetus* infection in bulls has shown that 1-year-old, 2-year-old and 3-year-old bulls are relatively non-susceptible, whereas older bulls acquire infection easily. It is therefore possible to control bovine trichomoniasis in large beef herds by using the younger bulls for mating cows during a short breeding season. While simple, this method is expensive to implement rapidly. Further efforts are being made to find a less expensive method that can be used in station herds practising all-year mating.

Repair of DNA damage

The mechanisms of DNA repair in bacterial cells are being studied.

All the information needed to maintain and to reproduce a living cell, whether of man or bacterium, is stored in the structure of very long molecules of a substance called DNA. Scientists are becoming more convinced that old age, cancer and many inherited abnormalities in man are caused by damage to DNA. On the other hand, radiation or chemical treatment to damage DNA and produce mutations has been used as a method of producing new varieties of plants.

Because it is important to the organism that the DNA store be preserved intact, all cells, whether from humans or bacteria, have very effective methods of repairing their DNA structure, and this enables them to tolerate considerable damage. The number of mutations observed in any organism therefore depends on both the amount of damage to the DNA and the efficiency of repair of this damage.

The DIVISION OF ANIMAL GENETICS has been studying the way in which DNA is repaired in the bacterial cell and how this repair can be helped or hindered.

DNA inside a living cell is broken by a number of agents including ultraviolet rays, X-rays and mild heat. The Division found that repair of ultraviolet ray damage was blocked by a large number of compounds. Some of these, such as the coumarins, are commonly employed in the cosmetic and food industry as flavour or perfume constituents. Certain other substances tested prevented the repair of X-ray damage to the DNA and these could be useful for increasing the anti-tumour effects of X-irradiation.

Another range of inexpensive non-toxic substances blocked the repair to bacteria of DNA damage produced by heat. These substances will be tested to see if they can be used to improve the efficiency of current sterilization and pasteurization procedures. The effect of these blocking substances is quite dramatic. When the common intestinal bacteria *Escherichia coli* were exposed to an inhibitor that prevented the DNA molecules from repairing heat damage, exposure to a temperature of 45°C proved highly lethal to the bacteria, even though *Escherichia coli* bacteria are not normally susceptible to temperatures much below 60°C.

Prevention of grass tetany

A long-life capsule has been developed which protects livestock against grass tetany by providing a regular dose of magnesium.

Grass tetany, lactation tetany, grass staggers and hypomagnesaemia are all names for the outward signs of a deficiency of magnesium in the blood stream of cattle and sheep. The disease is fairly widespread in Australia wherever soils low in magnesium are used to produce pasture and forage crops. The danger is intensified when pastures are young and lush.

Blood magnesium levels in affected animals fall to less than half the normal levels. Although both cattle and sheep can suffer from the disease, lactating cattle are the most likely victims. Calves on a milk diet are also highly susceptible.

In mild cases the animals affected are 'off their feed', uneasy and a little unsteady on their legs; the milk production of lactating cows falls. In acute cases, the victims are excitable, have a staggering gait and make convulsive movements. The pupils of their eyes are dilated and their mouths are drawn back in a grimace rather like the sardonic smile of the tetanus victim. They have diarrhoea and urinate frequently.

If a veterinarian reaches the animals in time, he can relieve the symptoms by injections of magnesium sulphate. To ensure that the symptoms do not reappear he will probably recommend a daily supplement of magnesite, with extra roughage. However, some less aggressive animals, or those with lower feed intake than average, may not obtain enough supplement to make up the deficiency.

A method of administering magnesium evolved by the DIVISION OF ANIMAL PHYSIOLOGY ensures that cattle on magnesium-deficient areas receive a daily dose of the element. The animal swallows a capsule formed from two hollow, boat-shaped half-cylinders of magnesium or magnesium alloy bonded together with rubber. Inside the capsule is a steel wool cathode, electrically connected to the magnesium anode. Magnesium ions are released by electrolysis in the acid rumen contents, the rate of magnesium release depending on the area of the cathode. The metal components of the capsule are gradually corroded away in the rumen, and the animal regurgitates the other parts.

Although the magnesium output from the experimental capsule is not enough to compensate fully for the usual degree of deficiency in Australian pastures, it is enough to raise blood magnesium above the tetany level for about six weeks.

Capsules are now being tested in the field. Meanwhile CSIRO has filed a patent application in Australia and is at present negotiating with potential licensees.

Leaner meat from lambs

Cryptorchid lambs grow faster and produce leaner meat than wethers.

Castrated lambs do not grow as fast as rams, and produce meat with more fat. However, buyers have tended to discriminate against ram lambs.

Research by the DIVISION OF ANIMAL PHYSIOLOGY has shown that cryptorchid lambs have similar advantages to ram lambs and do not suffer discrimination by buyers.

Cryptorchid lambs have testicles which have not descended into the scrotum. Such animals are usually sterile.

At the Pastoral Research Laboratory, Armidale, members of the Division artificially induced cryptorchidism in lambs 1–2 weeks old by pushing the testes into the body cavity after detaching them from the fibrous tissue lining the scrotum. The testes still secreted some hormones although the treated animals had very little libido and were sterile. The operation took only about 90 seconds for each animal.

Cryptorchids reached a standard killing weight of 32 kilograms some 25–39 days earlier than wethers and ewes, but after dressing gave slightly lighter carcasses because each produced about 1 kilogram more offal, and a slightly heavier fleece. The meat was less fatty and a taste panel at the Meat Research Laboratory, Cannon Hill, found the flesh to have good flavour and appearance.

Cattle tick resistance

Observations of the behaviour of ticks on resistant breeds of cattle are providing some leads to the mechanisms of natural resistance.

Some cattle are less susceptible to infestation by cattle tick than others. Because control of the pest costs nearly $15 million a year, there is an obvious economic reason for attempting to exploit the natural phenomenon of tick resistance. Such exploitation depends on a clear understanding of why ticks are unable to complete their life cycle on some host cattle.

Research by the DIVISION OF ANIMAL HEALTH has revealed that resistance in British breeds of cattle is expressed mainly against the early stages of larval attachment. When a larva attaches itself to the skin of a resistant beast it causes a localized reaction which renders the site unattractive so that the parasite cannot continue to feed. Alternatively, the reaction stimulates the animal to groom itself and in this way many larvae are removed before they begin to feed. Other work showed that the larvae that remain on resistant hosts spend more of their time wandering about the host and less time feeding than do larvae on susceptible animals. These observations suggest that during attachment the tick must inject some substance into the skin which causes resistant hosts to react.

In an attempt to collect and identify this substance, a technique has been developed for rearing tick larvae artificially. Thin slices of cattle skin are stretched over and stuck onto a Perspex ring. The ring, skin surface down, is placed on filter paper which is perfused with a nutrient solution. Tick larvae are placed within the ring and retained there by a cover of nylon gauze. The tick larvae attach themselves to the slice of skin through which they ingest the nutrient material. Any saliva or other material injected by the larvae through the thin skin can then be collected, analysed and identified.

By means of this novel technique it may be possible to acquire a better understanding of the mechanism of tick resistance in cattle.

Cattle tick and asthma

Research aimed at identifying the reasons why some cattle exhibit natural resistance to cattle tick has led to the isolation of a component of tick saliva related to one of the substances associated with human asthmatic reaction.

The two most important agents causing the distressing symptoms of asthma and some other allergic diseases are believed to be histamine and SRS-A (slow reacting substance of anaphylaxis). These agents are released when an antigen–antibody reaction occurs in the skin of sensitized individuals.

Histamine has been studied extensively and its chemical structure has been known for a long time. A large number of pharmaceutical preparations called anti-histamines are available to counteract its effects.

On the other hand, despite its importance, SRS-A has been studied relatively little since it was discovered at the Walter and Eliza Hall Institute in Melbourne in 1937. Its structure is still unknown. As in the case of the development of the anti-histamines, a knowledge of the structure of SRS-A could assist in the development of additional specific inhibitors to treat asthma sufferers.

The DIVISION OF ENTOMOLOGY has

detected a substance in the saliva of the cattle tick with the physical, chemical and pharmacological properties of SRS-A. Indications are that the substance is released when an antigen in the tick's saliva is injected into the animal's skin where it combines with the specific antibody and sets off the allergic reaction. In feeding, the tick probably sucks up the substance with the rest of its meal, digests the proteins and other nutrients and returns the unwanted substance to the host via the saliva.

Under these circumstances the substance may be relatively uncontaminated with other skin components such as the fats and fat-like substances called lipids. One of the reasons why the chemical structure of SRS-A has not been determined is because the best preparations available for study so far have contained considerable quantities of lipid contaminants. Further work on the isolation and chemical structure of the purified substance from cattle tick saliva is progressing in conjunction with the Asthma Foundation of Queensland.

Studying the biology of the bandicoot

Concern over the conservation of Australia's endangered marsupials has led to research into their ecology and physiology.

Two hundred years ago Australia had about 120 species of marsupials. While some of these have flourished since the arrival of the white man, others have become extinct or are listed as endangered species.

To enable rational conservation programs to be adopted, both ecological and physiological knowledge of all marsupials is required. As part of the research being undertaken throughout Australia the DIVISION OF ANIMAL PHYSIOLOGY has set up a unit at Prospect to study the reproductive, environmental and nutritional factors that control marsupial populations.

The unit has established colonies of two species of bandicoots, *Perameles nasuta*, a long-nose species, and *Isoodon macrourus*, a short-nosed species.

Bandicoots, marsupials about the size of a cat, were once much more common than they are today. Of the twelve species that were once part of Australia's fauna, five are already extinct, rare or endangered.

The bandicoots are proving to be excellent subjects for studies in marsupial physiology as they are easily handled, fairly hardy and not difficult to feed. Some of them are kept under conditions simulating normal daylight, while others are exposed to a reversed daylight pattern so that their behaviour as nocturnal animals may be studied during the day. Closed-circuit television has been set up to keep a close check on certain selected members of the colonies.

Previously, attempts to breed bandicoots in captivity had not been very successful, but the Division has now bred a number of litters and has been studying the growth and development of the young.

In both species, the young bandicoot spends a remarkably short time (about 12½ days) in the uterus—the shortest gestation period recorded for any mammal. The extremely immature animal is then born, making its way to the mother's pouch where it attaches itself to one of her eight teats. One to five young are born, but the litter size is usually two or three.

The baby bandicoot is born completely hairless. Its nostrils are well developed, but its eyes and ears are skin-covered, and its hind legs are extremely small. Firmly attached to the mother's teat, the baby spends the next nine weeks in the pouch, undergoing rapid development into an almost half-grown animal by the time it is weaned. Before this happens the mother has probably become pregnant again.

The Division has recently begun recording the pouch life of bandicoots on film and will soon begin filming the embryonic development of these animals.

Bush flies and computers

Computer models are being used to predict the effect of proposed bush fly control measures.

Australia's pestiferous bush fly is one problem being tackled on several fronts by CSIRO. A team from the DIVISION OF ENTOMOLOGY is searching for suitable dung-burying beetles from the African continent which may help in reducing the flies' breeding grounds. Another team in Canberra, comprising staff from the DIVISIONS OF ENTOMOLOGY and COMPUTING RESEARCH, is working on a computer model that will be used to predict the effect of natural parasites and introduced dung beetles on the population trends of the bush fly.

The model takes into account influences of the environment such as temperature, rainfall, and pasture quality on the various stages of the fly's life cycle. A submodel concerned only with adult flies has been written and checked against data obtained by the DIVISION OF ENTOMOLOGY between 1969 and 1970. This model applies to a laboratory population of adult flies exposed to normal daily variations in temperature.

The results from the constructed submodel emphasized that laboratory experiments are not necessarily capable of giving the death rates of free living insects. In this case laboratory data suggested several possible forms of the death rate based on temperature and the stage of the insects' development. Simulation experiments with the submodel provided details of the factors responsible and helped resolve ambiguities in the results of the laboratory experiments.

The simulations produced by the computer agreed closely with the laboratory data obtained in spring 1969 but the flies actually lived longer in autumn 1970 than would be expected on the basis of their behaviour in spring.

Experiments are currently under way to investigate the reasons for the discrepancy between computer simulations and laboratory observed data.

Two possibilities being considered are firstly that the size of the flies directly affects the death rate—autumn flies are consistently smaller than spring flies—and secondly, that the poorer diet available to the larval stages of the fly in autumn gives rise to flies better adapted to surviving low temperatures, so enabling the species to survive over winter in northern New South Wales or Queensland.

Experience with this model is highlighting the manner in which computer simulation models can be valuable aids to entomologists in their understanding of insect populations.

Biological control of sirex wood wasps

Introduced nematode and insect parasites are proving effective against the sirex wood wasp, a serious pest of the radiata pine.

Since its discovery in Tasmania in 1952 and in Victoria in 1961, the sirex wood wasp, *Sirex noctilio*, has steadily extended its range and is still spreading westward in Victoria towards the plantations around Mount Gambier in South Australia. It poses a serious threat to Australia's valuable radiata pine plantations.

Female sirex drill into tree-trunks to deposit their eggs together with a toxic mucus and a fungus. Susceptible trees are killed by the mucus and fungus. The sirex eggs hatch as soon as the fungus is established and the larvae feed on the fungus as it spreads in the wood. Sirex normally kills only suppressed, unhealthy and damaged trees, but when the population is very high it can also kill healthy trees by repeated attack over a number of years.

Since 1962 the DIVISION OF ENTOMOLOGY has engaged in studies on sirex ecology and on a comprehensive program of biological control. Twenty-four species of wasp parasites which attack sirex larvae have been introduced from Europe, Turkey, North Africa, North America, Japan, India and Pakistan. In addition, seven species of nematodes have been imported. These minute parasitic worms sterilize the female sirex that transmits them.

About half of the insect parasite species and four strains of the most promising nematode species have been released so far in Tasmania and Victoria. Further releases are envisaged when more recent imports have been reared and when necessary tests have been completed.

It will probably be four to five years before the impact of species released since 1970 can be assessed but there is little doubt that they will increase the total parasitism.

Seven species or subspecies of insect parasites are known to be established at one or more sites and the nematodes are already well established. At Pittwater near Hobart, the first four species established appear to have reached equilibrium and the results indicate that they will destroy 70–80% of each generation of sirex. Relative numbers of parasites are still increasing at another major site, a State plantation near Scottsdale in northern Tasmania. A North American species, *Megarhyssa nortoni*, is dominant at all sites.

The success of female sirex in widely dispersing the nematode *Deladenus siricidicola* was demonstrated by the results of a recent field trial in the forest near Scottsdale. In one sirex generation the nematode spread from 10–15% to an estimated 92% of trees and over 92% of the sirex emerging from these trees were also infected.

The DIVISION OF ENTOMOLOGY hopes that the combined effect of the insect parasites and nematodes will substantially reduce the sirex population. Provided the number of susceptible trees is kept low by good silvicultural practice, the resulting damage should be economically negligible.

Galahs

Observations over several years are contributing to an understanding of this common, but unstudied, Australian bird.

Galahs, being grain-eaters, have been regarded as pests by wheat farmers for many years.

In 1970 the DIVISION OF WILDLIFE RESEARCH began to study the galah, *Cacatua roseicapilla*, in Western Australia. Most of the field work is centred on an area of 50 square kilometres in the wheat belt, 190 kilometres north-east of Perth, where the Division has established a population of tagged birds. Each breeding season many nestlings are also tagged and by the end of 1973 a total of 2053 galahs had been banded, half of them as juveniles or nestlings.

Prior to white settlement, galahs probably inhabited the open woodlands and semi-arid scrubs, feeding on a wide variety of seeds on the ground. The expansion of agriculture and the establishment of extensive grain-growing areas have suited the galah. Harvesting methods appropriate for large-scale farming leave a surprisingly large volume of grain in the paddocks, on the roads, and particularly around the silos. The galahs thrive on the spilt grain, and research indicates that because of this artificial food supply, the bird is probably extending into areas that are not part of its native range.

Specimens have been collected at monthly intervals to provide material for food analysis. Although this program is still in progress, early results show that wheat is obviously the mainstay of the galah, with *Erodium* species important in spring before the wheat crop sets seed.

Both breeding and non-breeding birds feed in flocks. This has several advantages for the species. Less time is spent locating food as one or two feeding birds soon attract the attention of others. There is also less danger from predators, for although many heads will be down feeding, there will always be a few birds on the move with heads up, and these will sound the alarm. This is particularly important for birds that feed in the open, remote from cover. Successful flock species must possess what is called a 'positive social tendency'. This means that they must actively seek the company of others of their species. Galahs do this from the time they fledge.

Studies on the behaviour of the flocks are particularly important, for these are the social units which conflict most often with man's interests.

Pelagic fish survey

The likely presence of schools of jack mackerel can now be predicted using information from aerial surveys.

A recent event in the Australian fisheries industry has been the introduction of purse-seine fishing for jack mackerel. A purse-seine is a large net set in a circle around a school of fish. The fish are trapped by closing the bottom of the net in much the same way as the drawstrings close a woman's purse—hence the name. Purse-seine fishing involves the use of larger and more powerful vessels than previously used and marks a major step in the continuing expansion of the fishing industry in Australia.

The jack mackerel can be harvested by the purse-seine method and used as a canned product or to produce fish meal. The catch in the 1973/74 season was low due to a scarcity of surface schools, which was probably the result of unusual oceanographic conditions. Sonar information and studies by the Fisheries Department of New South Wales suggest that surface-occurring schools form only a small part of the total population as concentrations of fish of possibly larger size groups have at times been recorded below the surface.

The DIVISION OF FISHERIES AND OCEANOGRAPHY, in cooperation with the Australian Department of Agriculture and State Fisheries Departments, has been engaged in a one-year preliminary study of the jack mackerel resource and has investigated possible reasons for this year's scarcity.

CSIRO scientists have been working on board the *Laurus*, a commercial vessel chartered by the Australian Department of Agriculture and funded by the Fisheries Development Trust Account, to carry out the survey. They have been collecting data on the growth rate, age composition and reproduction cycle of the jack mackerel.

The major part of the study has been an intensive regular aerial survey of the inshore waters of south-eastern Australia. Detailed records have been made of the positions and abundance of all surface-occurring fish schools. Sea surface temperatures have been recorded from the air with the aid of an infrared radiometer.

Results so far indicate that surface schools of jack mackerel may occur in abundance only within a particular temperature band. Information on sea surface temperatures might therefore be used to forecast the areas within which jack mackerel are likely to occur and so reduce costly searching by the commercial fishing fleet.

As a service to industry, computer print-outs of all sightings and sea temperature recordings are circulated to firms and to the various fisheries organizations.

CSIRO will continue the aerial survey of pelagic resources for several years, with support from the Fishing Industry Research Trust Account, in order to document both the seasonal and year-to-year changes in abundance of fish at the surface. The Division is also planning a study of fish distribution at all depths using acoustic and trawling techniques.

Edible protein from animal blood

A new process for utilizing blood from abattoirs could provide an important source of protein for human consumption.

Blood from animals slaughtered in Australian abattoirs is normally treated in such a way that it can be used only as animal feed or fertilizer. Estimates suggest that the blood from cattle alone could yield about 15 000 tonnes of edible protein suitable for use in human food, although 5000 tonnes is perhaps a more realistic figure since there would be collection and treatment problems in some circumstances.

A process developed by the DIVISION OF CHEMICAL ENGINEERING, for which an Australian patent application was made in 1972, provided an incentive for the Meat Research Laboratory of the DIVISION OF FOOD RESEARCH to look more thoroughly into more profitable and useful ways of utilizing blood protein. Collaboration between scientists in the two Divisions resulted in an improved, more economical process for which a further Australian patent application has been made.

The product of the process is an odourless, tasteless white powder and trials incorporating it in sausages, frankfurters and hamburgers are taking place.

Methods of improving the hygiene of collecting blood from abattoirs are also being investigated. Other trials are planned in which the blood protein will be used in conjunction with the new textured vegetable proteins.

Safety of microwave ovens tested

A cheap and simple device has been developed to detect leakages of energy from microwave ovens and heaters.

The NATIONAL MEASUREMENT LABORATORY (NML) has established a facility for calibrating microwave power-density meters operating in the industrial scientific and medical band centred on 2450 MHz. These are used to test microwave cooking ovens and industrial microwave heaters to ensure that any leakage of microwave energy remains below a level that could create a hazard to the operator.

At present there is considerable interest in power-density measurements among the national standards laboratories in other countries but as yet few have established calibration facilities. As a result of progress made at the NML, it was chosen by the Consultative Committee on Electricity of the International Committee of Weights and Measures to serve as a pilot laboratory for an international comparison of power-density measurements.

A power-density meter usually consists of a thermocouple detector mounted at the tip of a hand-held probe connected to a portable monitor containing the measuring circuits and meter. For calibration, probes are placed in an electromagnetic field of known intensity. The surroundings are lined with panels covered by large cones of carbon-filled foamed plastic, which absorb almost all the incident radiation. The antennae and most of the equipment were made at the NML.

All microwave cooking ovens intended for sale in Australia are tested for compliance with a safety standard drawn up by a committee of the Standards Association of Australia on which the Laboratory is represented. The testing is undertaken by the Sydney County Council on behalf of the electricity supply authorities throughout Australia.

The power-density meters used for these tests must be calibrated periodically at the NML. Similar meters are used by the Australian and State Health Departments and by oven manufacturers and distributors.

The power-density meters now available are too expensive for purchase by most electrical service organizations or by the general public. Because ovens can deteriorate with time and misuse, there is a need for a simple and cheap indicator of power leakage. To meet this need, NML has devised and filed patents on several very simple leakage indicators, which should be cheap to manufacture and which provide an immediate check on the safety of any oven. A simple power indicator of this kind should also prove useful to the medical profession where it can be used to avoid the possibility of accidental exposure of patients to high levels of radiation.

Continuous dyeing of wool

A new process may overcome problems in the production of black wool by the continuous dyeing process.

The continuous wool-dyeing process developed at the DIVISION OF TEXTILE INDUSTRY shared one major shortcoming with other continuous wool-dyeing processes—it could not be used to produce a black shade as economically as the conventional chrome-dyeing process, which involves prolonged boiling or steaming. Of two possible alternatives for solving the problem of continuous dyeing of black shades, the deposition of oxidation-base blacks appeared more attractive than the use of aniline black because of dangers caused by the toxicity and poor aging properties of aniline black.

A method was developed using the oxidation principle and tests carried out at the Division suggest that the technique will be successful. A deep black which does not go green after washing was produced on coarse wool with a steaming time of only seven minutes. A range of dyes is now being formulated at the DIVISION OF PROTEIN CHEMISTRY to provide different shades of black as well as navy blues and dark browns.

New yarns for fine-gauge knitting

The self-twist process is being used to combine wool with synthetic filaments to produce yarns for fine-gauge knitting.

Self-twist spinning, developed by the DIVISION OF TEXTILE INDUSTRY in collaboration with Repco Ltd in 1970, is employed world wide and there are more than 1000 self-twist spinners in use in 24 different countries.

The Division is now applying the self-twist principle to make yarns that are a combination of 90% wool and 10% continuous-filament synthetics. A prototype machine designed for this purpose is now operating and producing yarn for processing and consumer trials.

The new yarns can be made much finer than ordinary self-twist yarns and are ideally suited for use in fine-gauge knitting machines. The new yarns have many advantages over the conventional ones apart from their lower cost. They are stronger, more uniform, contain less knots, and do not suffer from the problem of twist liveliness that occurs in conventional yarns.

This results in much improved performance in knitting and produces fabrics with less faults in them. The fabrics are also stronger and more even, and have higher resistance to abrasion and pilling.

Satisfactory wear trials have been carried out using the fabric in men's suits, slacks, and shirts, in ladies' dresses and skirts, and in youths' and children's clothing.

Exploring for nickel

The presence near the surface of certain minerals with characteristic microtextures can indicate the occurrence of nickel sulphide deposits beneath.

In the very old and stable land surfaces of Western Australia, weathering processes have penetrated to extraordinary depths, breaking down rocks and ores into almost unrecognizable end products. Consequently many valuable nickel sulphide deposits in that State are overlain by a deep layer of weathered material that bears little resemblance to the original nickel sulphide ore from which it was derived.

The DIVISION OF MINERALOGY has been collaborating with Western Mining Corporation to determine whether the presence in the weathered zone of certain minerals with a characteristic micro-structure indicates the previous existence in that zone of a nickel ore body. Studies of ore shoots at Kambalda have shown that over some millions of years of weathering these bodies have behaved like a giant battery. The region of the ore body near the surface, where atmospheric oxygen penetrated down to the water-table, acted as a cathode or electron-absorbing zone. Electrons were generated at depth by conversion of the primary nickel-ore mineral, pentlandite, to a mineral, violarite, with a distinctive octahedral cleavage pattern. This reaction also liberated some nickel which reacted with a nearby iron sulphide mineral, pyrrhotite, to form another crop of violarite crystals, this time with a distinctive lamellar pattern.

Once formed, this association of octahedral and lamellar textures persisted through all subsequent stages of weathering. When seen under the microscope, these distinctive texture patterns provide evidence of the previous presence of significant amounts of nickel sulphides in the original rock, even though no appreciable amounts of nickel may be present in the decomposed weathering products near the ground surface. These microtextures, therefore, provide the exploration geologist with a valuable guide to those regions where drilling operations are likely to reveal nickel sulphide deposits below the surface.

Treating copper ores

A novel process has been developed for treating copper concentrates without producing gaseous emissions such as sulphur dioxide.

The major copper ores in Australia occur as sulphides which are currently treated by smelting, a process that produces copper metal and sulphur dioxide gas. Problems concerned with the discharge of gaseous products to the atmosphere have led to a search for alternative methods of treatment. For some years the DIVISION OF MINERAL CHEMISTRY has been investigating hydrometallurgical methods that produce the copper in solution and the sulphur and other by-products in a solid or dissolved form. This work has resulted in a novel hydrometallurgical process for the treatment of copper concentrates.

Copper occurs mainly as the mineral chalcopyrite which consists of copper, iron and sulphur. Chalcopyrite is difficult to treat hydrometallurgically, firstly because it is attacked only slowly by most leaching agents, and secondly because of the large amount of iron associated with the copper. Three methods for overcoming these difficulties have been studied.

One approach has been to electrolyse a slurry of copper ore concentrate in a hydrochloric acid solution in contact with a lead cathode. This results in an almost iron-free copper sulphide. A second approach involves heating the copper concentrate with sulphur. The chalcopyrite is chemically altered to a compound with a higher copper-to-iron ratio while the iron is fixed in a relatively inert form. A somewhat similar result can be obtained by activating the concentrate by steam.

The products from any one of these three processes can be readily leached by cupric chloride solution to give a solution of cuprous chloride containing some dissolved iron. This iron can be precipitated in the form of inert ferric oxide. The residues of the leaching process contain insoluble iron compounds and elemental sulphur which can be recovered or recycled.

Metallic copper can be deposited from the cuprous chloride solution by electrolysis and the Division has shown that smooth cathode deposits can be obtained by choosing the appropriate conditions. Smooth deposits have proved difficult to obtain in the past when using chloride solutions for copper electrolysis. Simultaneously with the metal deposition, cupric chloride is produced at the anode and this is recycled for further leaching.

Recovering metal from waste slags

A cheap and simple process for recovering metals from waste slags has been developed.

During recovery of metals from ores and concentrates by conventional smelting and refining operations, the unwanted materials are removed into a waste liquid slag. The slag inevitably contains valuable metal compounds and this can represent a major loss of metal.

The DIVISION OF CHEMICAL ENGINEERING is developing a method of submerged combustion for increasing metal recovery by treating slags produced during the smelting of ores and concentrates of tin, nickel and copper. High-temperature submerged combustion, involving injecting fuel and air into a bath of liquid slag, results in a rapid removal of valuable metal from the slag due to fast rates of reaction and to efficient heat transfer between the slag and reducing gases. The size of the plant is therefore kept small and the fuel requirements are kept low.

In the case of tin there is a world-wide trend towards the production of lower-grade concentrates from lode deposits. These are expensive to treat by conventional techniques. However, tests in the Division on low-grade concentrates have shown that a combination of concentrate smelting and slag cleaning by submerged combustion results in more efficient smelting and improved recoveries of metal.

The Division has also found that for both copper and nickel smelter slags a combination of submerged combustion and addition of sulphide minerals results in enhanced recoveries of these valuable metals.

A small pilot plant has been built by the Division to develop the process further.

Industrial carbons from brown coal

The discovery of simple methods for demineralizing brown coals has made possible the production of carbons with a high degree of purity.

The mineral matter in coals is an obstacle to the production of high-purity carbon from this source. In brown coal, part of the mineral matter is chemically bonded into the coal structure, and the remainder is present as identifiable mineral species.

The DIVISION OF MINERAL CHEMISTRY has developed a simple method for demineralizing brown coals in a sequence of physical and chemical treatment steps, comprising froth flotation and agitation with sulphur dioxide and ammonium salt solutions. Filtration and drying of the treated material produces a demineralized coal that can be carbonized to give a high-purity carbon in the form of granules, lumps, tablets or powder, according to the intended use. If the demineralized coal is treated with an alkali before it is carbonized, hard, coke-like lumps are obtained.

Low-ash carbon made in this way provides a sufficiently pure raw material for the manufacture of electrodes for use in the production of aluminium and electric-furnace steels. The porosity of the carbons can be controlled to any desired level by depositing pyrolytic carbon within their structure.

The new low-ash carbons can be activated by established methods, such as steaming at high temperatures, to produce very pure active carbons that can absorb impurities from liquids and gases. A higher yield of active carbon can be obtained from the low-ash demineralized material than from conventional raw materials.

The Division has tested several variations of the new procedure. Treatment of some coals by carbon dioxide solutions under pressure, or with brine, has also shown promising results.

All these methods have been devised with a view to developing practical and inexpensive processes for the industrial production of high-purity carbons. Patents have been applied for in Australia, Japan, Canada and the United States and a patent has already been granted in New Zealand. These methods are suitable for treating lignites as well as brown coals.

Electrical techniques in mineral exploration

An improved instrument is being developed as an aid to mineral prospecting in Australia.

Although geophysical techniques based on electrical and electromagnetic properties of minerals have assisted mineral exploration overseas, they have not always been as useful in Australian soils. The thick layer of weathered rock that covers many parts of Australia makes mineral exploration unusually difficult. Salinity gives the soil a high electrical conductivity, which also masks the electrical messages from minerals beneath.

The DIVISION OF MINERAL PHYSICS has been investigating several aspects of this problem. Studies have led to a greater understanding of how the overburden masks electrical messages and have also provided information needed by the exploration geophysicist to interpret field data.

An instrument is being developed which overcomes the screening effect of the overburden by operating at very low frequencies. In addition, the adaptation of techniques used in space research has enabled the instrument to reject both man-made interference and natural interference from such things as lightning. Trials in several parts of Australia have shown that these adaptations lead to a much better ability to see the weak signal that indicates the presence of mineralization.

The prototype instrument is expected to be ready for field trials in late 1974.

De-watering wastes

The application of soil physics theory could help solve an industrial problem with environmental implications.

The wastes of a number of industrial processes are slurries—solid–liquid suspensions containing a high proportion of water. Such effluents are difficult to handle and dispose of, and tie up vast quantities of water and chemicals that, if recovered, could be re-used.

The 'red muds' left when alumina has been extracted from bauxite by the Bayer process are typical of industrial slurries. In Western Australia in 1973 over 20 million tonnes of these noxious alkaline wastes were produced. Disposal alone of this material amounts to a considerable economic and environmental problem.

The DIVISION OF ENVIRONMENTAL MECHANICS is exploring strategies of handling and de-watering industrial slurries in terms of the predictions of a physical theory developed by members of the Division to describe water movement in swelling soils. It was predicted that simple self-weight filtration must in all cases ultimately yield more liquid than would sedimentation. Experimental work in the Division has confirmed this prediction. In experiments with a sample of red mud, for example, 8·5 cm of caustic soda solution were recovered by self-weight filtration from a column initially 30 cm long and 76% by volume liquid. An identical column yielded only 3·9 cm of solution after sedimentation.

The theory is quite general and enables prediction of liquid recovery as a function of initial liquid content and depth of slurry.

Better recovery of water also results when self-weight filtration is applied to other types of slurries, such as dispersed colloid from sand-washing processes and phosphate slimes produced during the extraction of rock phosphate.

Interscan

Australia is contributing to the development of a better international landing system for aircraft.

The DIVISION OF RADIOPHYSICS and the Department of Transport are collaborating in the development of a new microwave approach and landing guidance system known as Interscan, which has evolved from techniques developed during the Division's radio astronomy research program.

This system has been submitted by Australia to the International Civil Aviation Organisation for evaluation, together with proposals from Britain, the United States, Germany and France. The selected system will be implemented towards the end of this decade to meet the needs of civil aviation until the end of the century.

In the Interscan system, two narrow radio beams scanning the sky give an approaching aircraft its angular position relative to the runway. One beam sweeping from side to side provides azimuth angle and the second sweeping up and down provides elevation angle. The addition of distance information gives a complete position fix. During the final stages of landing, a third scanning beam provides the aircraft with precise height information.

With the aid of an on-board computer, the pilot can fly a variety of curved flight paths to or from the runway. Careful selection of these paths should reduce noise levels in populated areas.

Interscan differs from other scanning beam systems being evaluated in the United States in the method of generating the scanning beam and coding it with the required angle information.

A novel form of aerial radiates a fan-shaped beam which, by simple electronic methods, can be rapidly and smoothly scanned through wide angles without distortion. By scanning the beam to and fro at a precise rate, the angle of the aircraft relative to the runway can be derived in the aircraft from a simple measurement of the time interval between the two pulses received in each scan cycle.

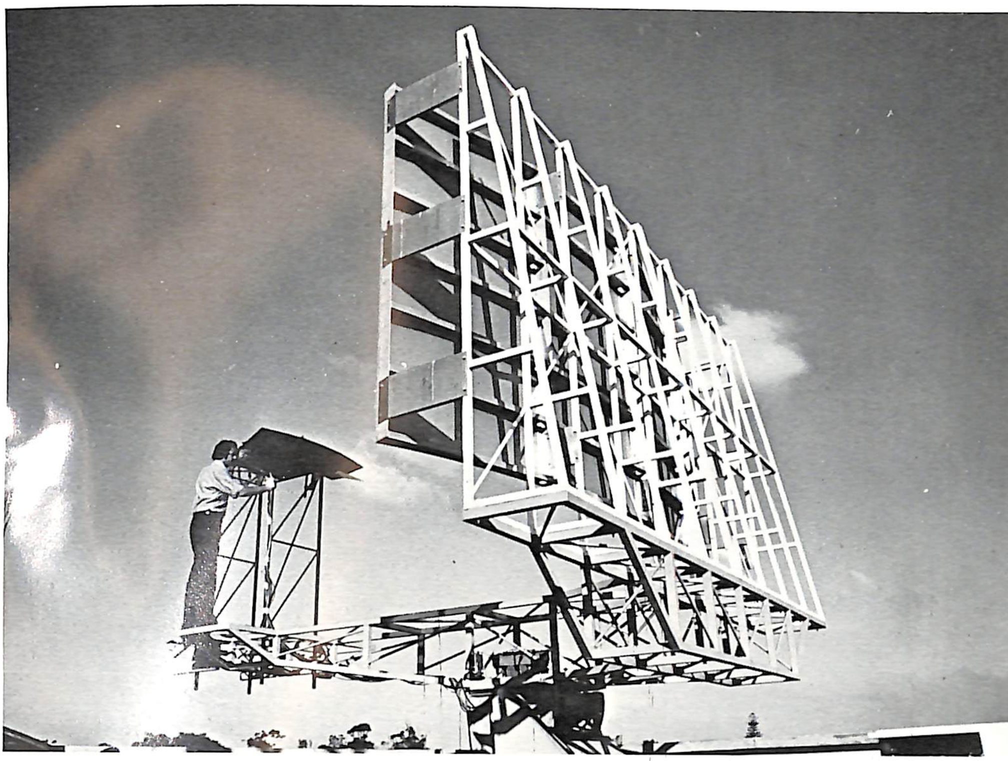
This technique simplifies the aircraft equipment and minimizes the bandwidth occupied in the radio spectrum. In addition, the high scan rate possible with electronic scanning allows more frequent measurements of aircraft position.

Interscan will be evaluated by ground and flight tests at Tullamarine Airport, Melbourne, using a range of equipment produced by Amalgamated Wireless Australasia as prime contractor to the Department of Transport for this project.

These tests will provide the data needed by ICAO to select a system in late 1975 for adoption as a world-wide standard.

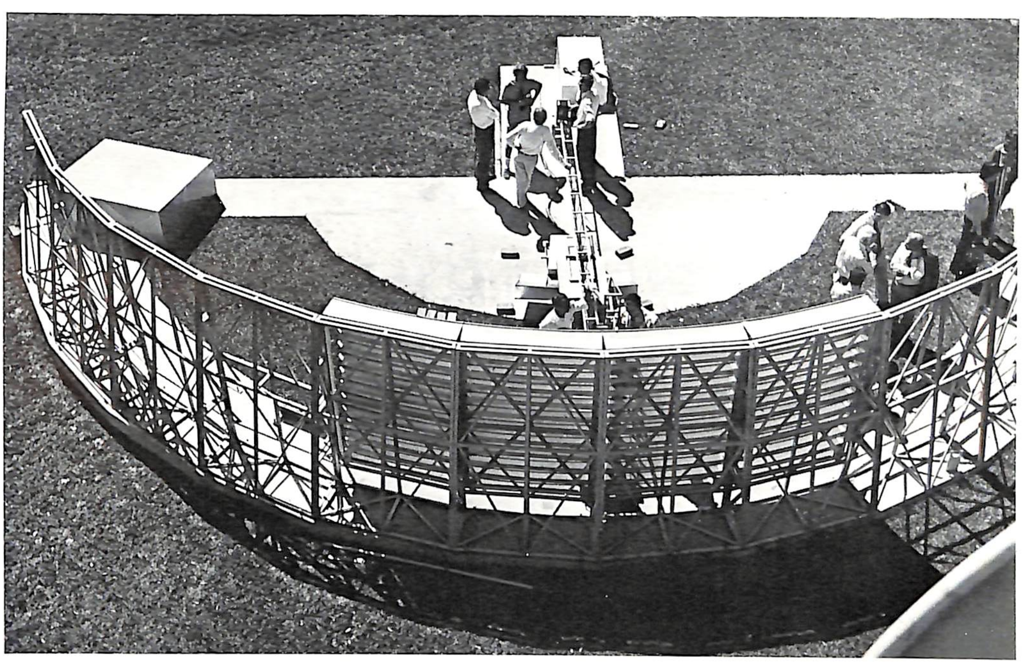
A team of United States technical experts, who recently visited the Division to investigate the Interscan concepts, gave a favourable report of the system to the U.S. Federal Aviation Administration. As a result the F.A.A. is seeking to evaluate the Interscan technique in their own development program, before deciding which technique they should recommend. Australia expects to participate actively in the U.S. tests of the system and in the evaluations leading to this decision.

Interscan represents Australia's contribution as a major aviation nation to the development of a sound internationally acceptable system. Participation in this development will also help to ensure that the system selected meets the special requirements of Australian aviation. Whatever system is finally adopted, the Interscan project should help to establish the techniques and technology needed in Australia to enable industry to equip our airports with the new system.



Above An Interscan aerial installation on the roof of the Radiophysics Laboratory at Epping, Sydney.

Below A team of United States technical experts inspecting an aerial alignment testing rig at Epping with members of the DIVISION OF RADIOPHYSICS.



Tunnels and underground excavations

Rock mechanics tests give improved design methods for underground excavations.

The growing importance of rock mechanics tests for underground excavation and tunnels is illustrated by two examples drawn from investigations of the DIVISION OF APPLIED GEOMECHANICS in collaboration with the Snowy Mountains Engineering Corporation, New South Wales. One project, in Papua New Guinea, was on behalf of the Australian Department of Housing and Construction and the other was on behalf of the Metropolitan Water, Sewerage and Drainage Board, Sydney.

Additional hydroelectric power for Papua New Guinea is being developed at the Ramu 1 Power Station, in the eastern highlands district, for the Papua New Guinea Electricity Commission. The station is located 213 metres underground in jointed marble. The problem is to assure conditions most favourable to stability of the rock during excavation of the machine hall, and throughout the life of the station, by choosing the most suitable orientation and shape of the machine hall.

In the past, the choice has often been made on considerations of rock quality, directions of jointing and other engineering requirements without reference to the natural stress state in the rock.

In this project, measurements of the principal directions and magnitudes of the initial stress in the rock were made, and movements of the jointed rock around the access shaft and tailwater tunnel were monitored at different distances behind the walls during excavation of the shaft and tunnel. The stress field was found to have a directional pattern on one side of a fault passing through the test area. On the other side, however, the pattern was not confirmed.

The data enabled an assessment to be made of stress and deformation conditions and support requirements in alternative designs and orientations of the power station.

Sydney's water supply is to be increased by bringing in water from the Shoalhaven River system in southern New South Wales. In addition, a pumped storage facility for the generation of electricity is included in the project. This is a large engineering scheme and necessitates pumping water through a system of pipelines, tunnels, shafts and aqueducts to the elevation of the Sydney catchment area. The cost of the steel lining for the Kangaroo Valley tunnel is a major expenditure, and investigations were made of rock conditions through which the tunnel passes to see whether the rock can share the water load with the steel and therefore permit a reduction in the thickness of the steel.

In the past, the deformability of a rock mass has been tested either by plate loading on small areas of the exposed surface, in which results are unduly affected by loosening of the near-surface rock, or by expensive pressurizing tests of a section of the tunnel. Methods of testing the deformability in depth have not measured movements on joints that would occur in full-scale operation.

In the present investigation, plate loading tests on the surface were supplemented by monitoring of the deformation in the rock at different depths during tunnelling. In conjunction with the measurement of rock stress, it was possible to determine the overall deformability of the rock to depths influenced by the pressure in the tunnel.

Carbide tools in rock drilling

An experimental rock drill is being used to discover how rock drills wear out.

The cost of replacing worn drill bits in mining operations can influence the economic viability of drilling in hard rocks.

Studies of wear in tungsten carbide drill bits by the DIVISION OF TRIBOPHYSICS have shown that the removal of cobalt from between the tungsten carbide grains coincides with the rapid wear of the working surface of the tool. When the cobalt is removed, small surface cracks appear on the surface and a layer about one grain diameter in thickness fractures from the surface. These observations have helped to explain why many factors affect the rate of wear of a tool and its rate of penetration.

The Division is using an experimental rock drill to determine how operating and environmental factors also affect the wear of tools. The equipment has been designed to show how variables such as drill and rock temperatures, drill load, speed and torque, rock type, fragment size, lubrication and the chemical environment affect drill wear and the rate of penetration.

Data from previous drilling experiments have shown considerable variation. Work at the Division suggests that three distinct wear or penetration regimes occur, and that the differences in these regimes may explain the scattered variation in previous experiments.

Work with the experimental rock drill seems to show that the most important factor affecting the rate of wear and penetration is the temperature at the interface between the rock and the drill. The beginning of each of the wear or penetration regimes appears to be directly related to a certain temperature level at the interface. When the drill reaches its final penetration regime and skids in the bottom of the hole, temperatures are sufficiently high for constituents of the rock to form a 'glass'.

Improving fire safety in buildings

Development of a light-scattering detector provides earlier warning of fires with fewer false alarms.

Many alarms designed to provide early warning of fire rely on smoke detectors of the ionization type. These systems have not always been reliable, and in tests in telecommunication installations, some fires that produced considerable smoke were not detected by the alarm system.

A fire can be well established before the alarm is triggered because the detector heads have to be desensitized to allow for normal changes in the smoke content of the air. The detectors can also be triggered by such things as changes in room temperature and humidity.

The shielding of detector heads by ceiling beams can also prevent them from operating correctly, and air-conditioning systems that are designed to force air downwards sometimes prevent smoke from reaching detectors mounted on the ceiling.

There is obviously an advantage in sampling smoke in the return air ducts of ventilation systems, but previously no detectors have proved reliable or sensitive enough to be practical.

Recent work by the Fire Research Section of the DIVISION OF CHEMICAL TECHNOLOGY has shown that a highly sensitive light-scattering detector called a nephelometer is very efficient at detecting traces of smoke in air ducts.

The instrument is at least one hundred times more sensitive than conventional smoke detectors.

The prototype detector has been developed by the Division's Fire Section and the Postmaster-General's Department and a patent application for the device has been lodged.

The detector was developed from an instrument used by the Division to study smoke from bush fires.

The main objective of the nephelometer is to provide the best possible warning of incipient fires with the minimum number of false alarms.

The slightest trace of smoke causes some light from a flashing xenon lamp to be scattered out of the direct light beam. This scattered light is then detected by a photomultiplier which gives out an electrical signal. The size of the signal depends on the amount of scattered light and therefore on the amount of smoke. Even smoke from a burning match can be detected.

The extreme sensitivity of the unit has allowed the inclusion of several special features in the alarm system.

Instead of the usual on/off alarm, the system provides several levels of alarm, giving yellow, orange and red signals.

The yellow system is an alert calling the supervisor's attention to an unusual concentration of smoke in a particular return air duct. If the smoke concentration rises above this level, an orange signal indicates that the cause needs immediate investigation. Finally, if a fire condition exists, a red signal triggers a call to the fire brigade.

Such a three-level warning system will ensure that smoke is detected early so that any potential fire can be prevented from spreading. It should also minimize false alarms to the fire brigade.

Sudden small short-term increases in smoke concentration—perhaps caused by someone smoking close to the return air duct—can be discriminated in the read-out circuits of the system. The desensitizing of the detector can therefore be avoided.

A dual-beam system was devised to overcome the problem caused by levels of smoke that are always present, such as the normal levels of air pollution in a city. One beam of light is shone through the air sampled within the building, another beam through a sample of outside air. The difference in the amount of light scattered is then measured and any adverse anomaly relayed to the alarm system.

Although development and testing of this unit has been centred on the needs of telecommunication systems, there is much scope for its application to high-rise buildings with forced ventilation.

In such buildings an early fire alarm system is essential to permit time for the occupants to be evacuated.

The output from the nephelometer is also ideally suited for automatic data processing, for it permits a comprehensive network of fire detectors in a large high-rise building or in a system of telephone exchanges.

Extensive tests of the unit are now in progress in the Melbourne area and a commercial manufacturer of the nephelometer will soon be sought.

Acoustic screens for offices

Some so-called acoustic screens are not effective in reducing the spread of sound in open-space offices, and work is proceeding on the development of a better design.

Demands for more flexibility in offices without the restrictions of fixed partitions have led to a revival of the open-plan office where many people are employed in a variety of activities in one large space. Research by the DIVISION OF BUILDING RESEARCH has shown that many so-called acoustic screens, designed for visual and acoustic privacy, actually help to reflect sound from one location to another.

Acoustic ceilings and carpeted floors help to reduce the reflection of some sounds but most of the disturbing office noises cannot be avoided by these methods alone.

Overseas studies have established values, called absorption coefficients, that indicate the effectiveness of screens and ceilings in absorbing sound.

The studies have shown that the average absorption coefficient at the frequencies that cover the range of speech should ideally be 0·8 or greater for both the ceiling and acoustic screens to prevent the spread of sound. As the floor is generally covered with furniture it does not need such high values, but should be covered with a carpet laid on a porous underfelt.

The usual screen found in such a large office area consists of an impervious layer, such as plain plywood or hardboard, sandwiched between two layers of a porous sound-absorbing material. The sound absorption coefficient of such a screen can be well below 0·8. Considerable improvements in this absorption value can be achieved by replacing the impervious layer by a perforated material such as perforated hardboard, plywood or metal sheet. Such a layer will allow more sound to be transmitted through the screen than an unperforated material, but indications are that at the important speech frequencies, considerably more sound still passes around the screen than through it; so the noise transmitted to the adjacent station is increased very little. Experiments are proceeding to improve the absorption–sound transmission properties of these screens.

Urban planning and air pollution

Planning studies being undertaken by the DIVISION OF BUILDING RESEARCH *have led to the development of a mathematical planning model called TOPAZ (Technique for the Optimum Placement of Activities into Zones).*

An urban planning model, called TOPAZ-URBAN, has been applied to studies of future growth of Melbourne, Darwin and the Gosford–Wyong region in New South Wales by the DIVISION OF BUILDING RESEARCH. The model suggests the most suitable location of future urban activity and evaluates, by submodels, the economic and social consequences of this growth in terms of transport and service costs, accessibility, benefits from amenities, and air pollution from traffic.

The air pollution submodel estimates the generation and diffusion of vehicle exhaust emissions for a given pattern of traffic flows. These traffic flows for a given layout of urban activity must be first estimated by a transportation submodel.

TOPAZ-URBAN used figures on planned growths in Melbourne to look at potential air pollution problems up to the year 2000. The city was divided into 40 zones for the study, and the total emission of carbon monoxide was estimated from the total number of vehicle kilometres generated by local and through traffic in each zone each day. The emissions from each zone were then diffused over all zones, using data on the speed, frequency and direction of local wind, to give an indication of average annual air pollution levels expected in the absence of any pollution controls.

The model showed that the area of expected maximum pollution from carbon monoxide is to the south-east of the central business district. The effect of other vehicle emissions, such as hydrocarbons and nitrogen oxides or industrial or domestic emissions, can also be studied.

The model can be further used to predict the results of controls on emissions, reductions in congestion and the use of private transport, as well as other patterns of development.

Sirofab house construction system

A prefabricated panel is the key to a system that reduces the time taken to build the shell of a house.

An experimental house built at the DIVISION OF BUILDING RESEARCH has demonstrated that significant savings are possible in the time needed to finish the shell of a house. For an average-size house it normally takes two weeks to finish the shell, but the new method could reduce this time to two to three days.

The concept employs one type of panel to serve as the basic structural element in the floor, walls, ceiling and roof. The core of the panel is a wooden grid with a structural grade of plywood used to sheathe one side. The designer can then decide what, if anything, is required on the other side, depending on position, finance or imagination.

The lightweight panels are made from either 20 mm by 40 mm or 20 mm by 80 mm dried timber ribs with a skin of 8-mm structural plywood, a most efficient use of forest resources.

They are made in a standard length of 2·4 m and in widths from 0·9 to 3·6 m and are ideally suited for factory production although they only require equipment normally found in a joinery shop.

Instead of having to handle and fasten every single piece of material, the builder only has to fasten panels together, a considerable saving in on-site labour.

Even the largest of the basic panels (2·4 m by 3·6 m) can be readily handled without specialized equipment. The panels are joined by using two simple types of nailed metal plates designed to minimize variation in quality of workmanship.

The use of only two sizes of timber in the grid has in itself distinct advantages and this simplification may be carried through into the joinery used in doors, windows and architraves. It is economical to use seasoned timber in small cross sections, thus eliminating the problems sometimes found with green timber.

Windows and doorways can be cut simply either in the factory or on site, while the panel design lends itself ideally to the provision of services such as electrical wiring and insulation.

The wide range of options of internal and external cladding materials open to the designer permits the concept to be considered for both conventional and low-cost or emergency housing.

Cold storage stops grain insects

Aeration of silos with cold air may prove a safe and effective means of controlling insects in stored grain.

Control of insects in bulk-stored grain has been attempted in many ways. Since the 1960s the most successful method has been to spray the grain with the protectant malathion. However, the grain industry now faces the prospect of widespread insect resistance to malathion and alternative treatments are being sought urgently. Other chemical treatments such as fumigation with methyl bromide may well prove impractical in storages with a capacity greater than 25 000 tonnes. Moreover, grain insects have already exhibited resistance to the alternative chemical treatments at present on the market.

For some years the DIVISION OF MECHANICAL ENGINEERING, in close collaboration with the Wheat Industry Research Council, has been investigating the aeration of grain with cool atmospheric air as a means of controlling insects in stored grain. Because of the higher temperatures in the wheat-growing areas of Queensland, the Division has begun trials on the Darling Downs using air that has been cooled by refrigeration.

The first phase of a grain refrigeration program commenced in November 1973 at the Brookstead Depot of the Queensland State Wheat Board about 65 kilometres west of Toowoomba. A 5000-tonne squat silo was insulated with 50 mm of sprayed polyurethane foam and fitted with a brine chiller of 70 kW cooling capacity. The existing aeration system was modified to recirculate air through the grain bulk, and other necessary air-handling facilities were provided.

After the wheat was received into the silo, the system cooled the bulk from 29°C to 14° in 6 weeks thereby arresting insect breeding which ceases at about 15°. The grain near the wall of the silo remained at 16–18°, at which temperature little breeding occurs.

Future work will involve installation of grain refrigeration on a pilot scale in a commercial horizontal storage with a capacity of about 25 000 tonnes.

High-temperature solar water heating

Following the success of domestic solar water heaters, efforts are now being directed towards producing units capable of heating water up to 120°C.

Considerable publicity has been given to the possible use of solar energy as a primary energy resource. A recent report from the Australian Academy of Science has suggested that by the year 2000 approximately 25% of our primary energy could be supplied by solar energy, one-half of this being needed for heating applications operating at temperatures up to 120°C.

At the present time the only application of any significance in Australia is in the field of domestic solar water heaters which operate at temperatures up to 55°C. There are now well over 10 000 operating in Australia and the numbers are increasing considerably year by year. However, the potential for domestic water heating provides less than 10% of the target figure suggested by the Academy of Science; hence the need to use solar energy for other commercial and industrial processes such as space heating and cooling, drying and steam generation, together with water heating for such applications as mineral and food processing plants where water at temperatures up to about 95°C are required.

Using four designs of solar collectors, a water heater has been designed and set up at Griffith by the DIVISION OF MECHANICAL ENGINEERING to assess the feasibility of heating water economically up to a temperature of about 95°C. In this arrangement each set of absorbers operates over a particular temperature range, the low-temperature absorbers being connected to the bottom part of the storage tank and the high-temperature absorbers operating at the top. This system is being used to test the validity of computer simulations and also to help in assessing the overall economics. In particular the relationship between the value of energy saved per year and the cost of the solar components is being examined.

Improved atomic absorption spectrophotometer

A modified form of the CSIRO-designed atomic absorption spectrophotometer can now be used to analyse metal samples without prior solution.

Since its invention in the DIVISION OF CHEMICAL PHYSICS over 20 years ago, the atomic absorption spectrophotometer has become standard equipment in laboratories throughout the world for the rapid determination of metallic elements.

Analysis by these instruments depends on the fact that atoms of a particular element only absorb light of certain wavelengths that are characteristic of that element. An atomic vapour is produced from the sample and the concentration of a given element is determined by measuring the absorbing power of the vapour at the appropriate wavelength.

The most widely used method of producing an atomic vapour has been to spray a solution of the sample into a flame. This technique is fast and simple, but it is limited in that solid samples must first be dissolved, an operation that in many cases is laborious and time-consuming.

For the past fifteen years the DIVISION OF CHEMICAL PHYSICS has investigated the possibility of developing methods in which solid samples can be analysed without prior solution.

During the past year a successful technique for the analysis of metals and alloys has been developed. In this technique, an atomic vapour of the metal being analysed is produced by a process called cathodic sputtering which occurs when the sample surface is bombarded with charged atoms generated in a low-pressure electrical discharge. The bombarding atoms liberate sufficient atoms of the sample for accurate absorption measurements to be made on the atomic vapour produced.

By using this new technique, metals and alloys can be analysed for minor impurities and alloying constituents. An important application is the determination of nickel, chromium and copper in low-alloy steels. Such analyses can be brought within the range of a conventional atomic absorption spectrophotometer simply by using the discharge chamber in place of the flame.

Sputtered vapours have also been used in atomic fluorescence analysis of metal samples. In this case, the absorbed energy that is re-emitted by atoms in the vapour is measured.

The possibility of extending absorption and fluorescence methods to identify non-metallic elements such as carbon, sulphur and phosphorus is being investigated. These elements cannot be determined by using conventional atomic absorption methods of analysis.

Lasers and the standard of length

Lasers are being used to give more precise standards of length to meet the requirements of today's science and industry.

Length is one of the basic physical quantities and every measurement of length is directly or indirectly a comparison against the fundamental standard of length. The NATIONAL MEASUREMENT LABORATORY is responsible for maintaining the standard of length for Australia, and one of its main tasks is to see that the standard meets the exacting requirements of modern science and technology and of the community in general. To do this the scientists concerned collaborate with scientists in other major standards laboratories overseas to ensure that the 'metre' used in each country has the same length.

For many years the most precise measurements of length have been made optically, and since 1960 the 'metre' itself has been defined in terms of the wavelength of light from a particular source—a discharge lamp filled with an isotope of krypton. Because the lamp emits light over a small wavelength band, measurements with the present standard are limited in accuracy to about one part in a hundred million. In recent years there have been several instances in which this standard has limited the accuracy with which certain important physical measurements could be made. One example is the determination of the acceleration due to gravity.

The gas laser has revolutionized optical measurement of length because the light emitted is intense and within an extremely small wavelength band. It is eminently suitable for the measurement of length over long distances and recent work has shown that it is capable of providing a greatly improved fundamental standard of length that will meet all requirements in the foreseeable future.

A laser for this purpose has been designed and built in the NATIONAL MEASUREMENT LABORATORY. An essential requirement is that the wavelength emitted by the laser should not vary and this has been approached in two ways. Short-term fluctuations of the wavelength have been kept small by an extremely rigid method of construction from fused silica. The importance of this can be judged from the fact that in order to maintain the wavelength within 1 in 10 thousand million (1 in 10^{10}) it is necessary to keep the distance between the two laser mirrors constant to within a few millionths of a micrometre. Long-term changes of the wavelength are minimized by an electronic control system. This maintains the emitted wavelength exactly at the centre of a line in the spectrum of a suitable absorbing gas vapour, in this case from the isotope iodine-129.

Before the laser light could be used to measure length, it was necessary to determine what degree of stability of the wavelength had been achieved. This has been done by building two identical lasers and comparing their wavelengths by a technique called 'beat frequency'. These tests have shown that the variations in wavelength for measurements of time from less than a thousandth of a second to several hours amount to less than 1 in 10^{11}. The reproducibility from one laser to another, an important consideration for an international standard, appears to be better than 1 in 10^{10}, about a hundredfold improvement over the present standard of length. The NATIONAL MEASUREMENT LABORATORY has also measured the wavelength of the laser light to an accuracy limited only by the present standard, so that length measurements made by this new light source will be consistent with the best measurements made directly with the present standard.

Crystal landscapes

Etch patterns on crystal surfaces can now be viewed directly with a scanning electron microscope.

Scientists at the DIVISION OF CHEMICAL PHYSICS have been using a scanning electron microscope to observe the effects of etching and other surface treatments on surfaces of single crystals of zinc oxide. This type of microscope has the great advantage over an optical microscope of combining high magnification—up to 100 000 times—with considerable depth of focus.

By viewing the surface from a variety of different angles, the scanning electron microscope shows a sharply contrasted panorama of a crystal surface.

Zinc oxide is one chemical of interest because it has a wide range of uses, as in paints, pharmaceuticals and electrostatic photocopying processes. It also serves as a useful prototype in the study of more complex oxide structures.

Single crystals of zinc oxide consist of parallel pairs of sheets of zinc and oxygen atoms. Within a pair, a sheet of zinc atoms is strongly bonded to a sheet of oxygen atoms, while the bonding between the sheets of zinc and oxygen atoms in adjacent pairs is weaker.

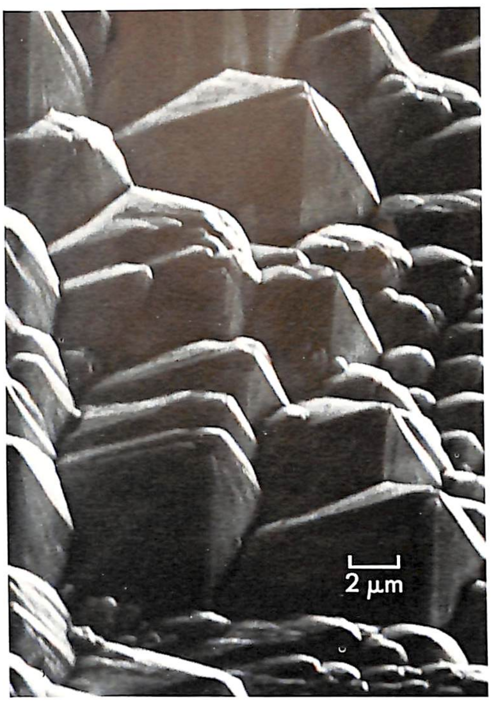
Since the crystals can for this reason be cleaved fairly easily between pairs of sheets, it is possible to obtain one cleavage surface composed of zinc atoms and the other of oxygen atoms.

A view of the etched surfaces in a scanning electron microscope shows that these two types of cleavage surface react entirely differently to acid etching.

Measurements on the topography of these surfaces have been made from the corresponding scanning electron micrographs.

The technique also illustrates the differences in mechanism of various etching processes. For example, when etching a zinc oxide surface with hydrochloric acid the addition of a small amount of ferric chloride to the acid drastically changes the pattern of the resultant surface.

Surface studies such as these could lead to a deeper understanding of the weathering of painted surfaces.



A scanning electron micrograph of a cleavage surface of a zinc oxide single crystal after etching with hydrochloric acid (1 µm is one-thousandth of a millimetre).

Testing telescope components

A simple technique for testing the accuracy of non-spherical surfaces is being used in the construction of the 3·8-metre Anglo–Australian Telescope.

A number of projects for the construction of large astronomical telescopes are currently in progress in Australia and are helping sustain the local industry involved in manufacturing optical components for telescopes. Since modern telescope designs call for hyperbolic or other non-spherical surfaces which are smooth and to shape within one ten-millionth of a metre (0·1 μm), a need has arisen for simple methods of testing the figure of a large optical surface both during its manufacture and in its finished state.

Spherical mirrors can be tested with the Foucault knife-edge test, a simple and accurate test for the precision of focus of a beam of light. This test relies on the fact that light from a point source at the centre of curvature of a spherical mirror will, if the mirror is perfect, be brought to an exact focus at a point coinciding with the source.

In general, non-spherical mirrors cannot be tested directly in such a simple manner because they do not bring light from a point source to an exact point focus. The DIVISION OF CHEMICAL PHYSICS, however, has extended the use of the Foucault test to a wide variety of non-spherical mirrors by using it in conjunction with subsidiary optical systems.

The basic approach is to try to design an optical system for producing a beam of light that will be brought to a sufficiently precise focus for the mirror to be tested with the required degree of accuracy. For testing a hyperbolic mirror it has been discovered that only one highly accurate spherical mirror is required in the subsidiary optical system. The test arrangement that gives the most precise focus from the hyperbolic mirror is calculated by means of a computer ray-tracing program which assumes that the hyperbolic mirror is perfect. Any inaccuracies in the mirror under test will then show up as a lack of precision in the focus, and hence they can be detected by a Foucault test.

Subsidiary optical systems have also been designed which permit optical components other than mirrors to be tested by similar procedures. For example, the Division has designed a test of the corrector plate for the primary mirror of the 3·8-metre telescope under construction at Siding Spring, New South Wales. The Division has also advised the Anglo–Australian Telescope Board, which is directing the project, on a number of procedures for testing other optical components associated with the telescope.

Organic molecules in space

The discovery of organic molecules near the nuclei of galaxies points to the possibility of life elsewhere.

The central regions of galaxies are rich in molecules. High concentrations of molecules in the nucleus of our own Galaxy, the Milky Way system of stars, were first found in 1964 when the DIVISION OF RADIOPHYSICS radio telescope at Parkes detected dense clouds of hydroxyl molecules. Five years later American radio astronomers detected surprisingly large amounts of ammonia, water vapour and formaldehyde in the Milky Way.

The discovery in space of the organic molecule formaldehyde triggered off a remarkable series of discoveries and provided the first indication of the possible existence of life in space. Sagittarius B2, a dense cloud of gas near the centre of the Galaxy, where star formation is proceeding most actively, is the prime source of organic molecules in our Galaxy.

So far 29 molecules have been discovered in Sagittarius B2, including formaldehyde, methanimine, methanol, acetaldehyde and methylamine. Methylamine, the most recent discovery, was detected with the Parkes radio telescope in March 1974, in collaboration with a microwave spectroscopist from Toyama University in Japan.

Recent work at Parkes has shown that the nuclei of other galaxies also contain high concentrations of molecules. Clouds of both hydroxyl and formaldehyde molecules have been detected in the nuclei of the spiral galaxies NGC 253 and NGC 4945 in the southern sky. NGC 253 is 10 million light years from our Galaxy, while NGC 4945 is 15 million light years away. The processes of synthesizing molecules and forming stars seen in the centre of our own Galaxy are therefore likely to be taking place in a large fraction of the 100 000 000 000 other spiral galaxies in the Universe.

The DIVISION OF CLOUD PHYSICS has been developing methods of collecting and analysing particles in the stratosphere that are thought to be the products of exhaust from supersonic aircraft. This electron microscope photograph shows a group of particles caught in the stratosphere on a surface covered with a layer of barium chloride that has been previously exposed to alcohol vapour. Particles containing sulphates react under these conditions to form insoluble barium sulphate in a large ring surrounding the original particle. Non-sulphate inclusions remain near the centre. By using this method the Division has found that over 90% of particles sampled from the stratosphere contain sulphate and in most it is by far the most important constituent. (1 μ equals one-millionth of a metre.)

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1 μ

Organization

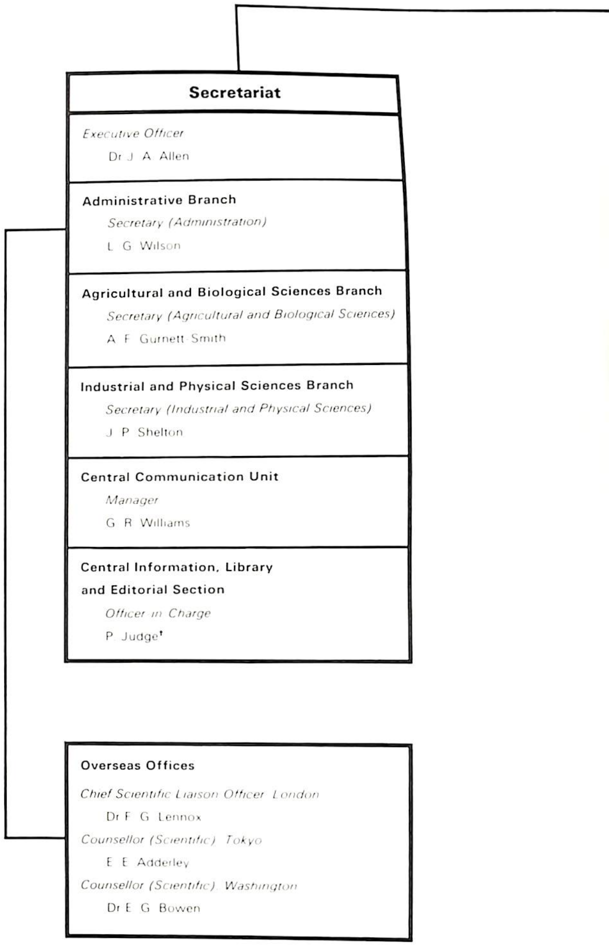
CSIRO has a total staff of some 6700 people located in more than 100 laboratories and field stations throughout Australia. About one-third of the staff are scientists.

CSIRO is governed by an Executive comprising a full-time Chairman, four other full-time members, and four part-time members. Most of the members of the Executive are scientists. The Executive is responsible to the Minister for Science for the policy and work of the Organization.

CSIRO has 36 research Divisions, each led by a Chief who is responsible to the Executive for the work of that Division. There are also four smaller research Units. The staff of a Division consists of research scientists, experimental officers, other professional staff engaged on a variety of service functions, and supporting technical, administrative, and trades staff. A number of Divisions have been linked together in what are known as group laboratories.

The Executive is assisted in the development, administration, and implementation of its policies by a Secretariat comprising an Administrative Branch, an Agricultural and Biological Sciences Branch, an Industrial and Physical Sciences Branch, a Central Communication Unit, and a Central Library, Information and Editorial Section. The Executive and Secretariat are located at the Organization's Head Office in Canberra. Some of the administrative functions of the Administrative Branch relating to financial and personnel matters have been decentralized by the creation of Regional Administrative Offices in Brisbane, Canberra, Melbourne and Sydney.

The chart opposite shows the organizational structure of CSIRO as at 1 July 1974.



[1] from August 1974

* from September 1974

Executive

Chairman
Dr J. R. Price
Members
V. D. Burgmann
Dr M. F. C. Day
L. Lewis
Dr A. E. Pierce
Dr D. L. Ford, *part-time*
V. E. Jennings, *part-time*
Professor E. J. Underwood, *part-time*
W. J. Vines, *part-time*

Divisions and Chiefs

Animal Research Laboratories

Animal Genetics	Dr J. M. Rendel
Animal Health	Dr A. K. Lascelles
Animal Physiology	Dr I. W. McDonald
Nutritional Biochemistry	Dr A. T. Dick

Animal Research Laboratories Committee
Chairman
Dr K. A. Ferguson

Applied Chemistry Laboratories

Applied Organic Chemistry	Dr D. H. Solomon
Chemical Technology	Dr D. E. Weiss

Applied Chemistry Laboratories Committee
Chairman
Dr S. D. Hamann

Environmental Physics Research Laboratories

Atmospheric Physics	Dr G. B. Tucker
Cloud Physics	J. Warner
Environmental Mechanics	Dr J. R. Philip

Environmental Physics Research Laboratories
Chairman
Dr C. H. B. Priestley

Land Resources Laboratories

Land Resources Management	R. A. Perry
Land Use Research	Dr R. J. Millington
Soils	Dr A. E. Martin

Land Resources Laboratories Committee
Chairman
Dr E. G. Hallsworth

Minerals Research Laboratories

Chemical Engineering	Dr D. F. Kelsall
Mineral Chemistry	Dr D. F. A. Koch
Mineral Physics	Dr K. G. McCracken
Mineralogy	A. J. Gaskin

Minerals Research Laboratories
Director
I. E. Newnham

Wool Research Laboratories

Protein Chemistry	Dr W. G. Crewther
Textile Industry	Dr M. Lipson
Textile Physics	J. G. Downes

Wool Research Laboratories Committee
Chairman
Dr M. Lipson

Applied Geomechanics	Dr G. D. Aitchison
Building Research	Dr R. W. R. Muncey
Chemical Physics	Dr A. L. G. Rees
Computing Research	Dr G. N. Lance
Entomology	Dr D. F. Waterhouse
Fisheries and Oceanography	Dr K. Radway Allen
Food Research	M. V. Tracey
Horticultural Research	Dr J. V. Possingham
Irrigation Research	E. R. Hoare
Mathematical Statistics	Dr J. M. Gani*
Mechanical Engineering	Dr J. J. Kowalczewski, acting
Plant Industry	Dr L. T. Evans
Radiophysics	Dr J. P. Wild
Tribophysics	Dr J. R. Anderson
Tropical Agronomy	Dr E. M. Hutton
Wildlife Research	Dr H. J. Frith

National Measurement Laboratory
F. J. Lehany, Director

Units and Officers-in-Charge

Agro-industrial Research	G. A. Stewart
Marine Biochemistry	Dr G. F. Humphrey
Solar Energy Studies	R. N. Morse, Director
Wheat Research	E. E. Bond

Research Activities

The various CSIRO Divisions, their fields of research, and the location of their laboratories and field stations are as follows:

ANIMAL GENETICS

Genetics and its application to the improvement of beef cattle, dairy cattle, sheep and poultry through breeding and selection; genetics and the control of rabbits by myxomatosis.
Sydney, with a laboratory and field station at Rockhampton, Qld., field stations at Armidale and Badgery's Creek, N.S.W., and a field investigation unit at Wollongbar, N.S.W.

ANIMAL HEALTH

Diseases of livestock and poultry caused by bacteria, viruses, mycoplasmas, protozoa and plant poisons; external parasites—cattle tick, lice and biting insects—as potential transmitters of disease; worm parasites of sheep and cattle; immunology.
Melbourne, with laboratories in Sydney, Brisbane, Perth and Townsville, Qld., and field stations at Maribyrnong, Sungarrin, Werribee and Tooradin, Vic., Badgery's Creek, N.S.W., and Jimboomba and Magnetic Island, Qld.

ANIMAL PHYSIOLOGY

Physiology, endocrinology, nutrition and ecology of sheep and cattle in relation to reproductive performance and the production of wool and meat; production of meat and dairy products with a higher than normal proportion of polyunsaturated fats; control of metabolic disorders in grazing ruminants; use of chemical methods for defleecing sheep; marsupial physiology.
Sydney, with the Pastoral Research Laboratory at Armidale, N.S.W., the Beef Cattle Research Unit at Townsville, Qld., and the Bloat Research Unit at Melbourne.

APPLIED GEOMECHANICS

Properties and behaviour of soils and rocks in relation to the design of civil and mining engineering structures such as building foundations, earthen embankments, road pavements, surface excavations and underground openings.
Melbourne, with a laboratory in Adelaide and a field station at Cobar, N.S.W.

APPLIED ORGANIC CHEMISTRY

Application of chemistry to problems of national and industrial importance. Investigations concerned with synthesis of potentially useful new chemicals; natural and synthetic biologically active compounds; organometallic compounds; catalysis polymer chemistry; mechanisms of chemical reactions at normal and high pressures; nucleation and growth of crystals; surface chemistry; physical chemistry; atmospheric chemistry.
Melbourne.

ATMOSPHERIC PHYSICS

Physical and chemical atmospheric processes that underlie and control the weather and are responsible for the distribution of airborne material including gases; the physical basis of climate and variations in climate; development of numerical and laboratory models that simulate atmospheric behaviour and application of these models to improving the accuracy and time-scale of weather predictions.
Melbourne. The Division also has a group of officers located at the Commonwealth Meteorology Research Centre, Melbourne. The Centre is operated jointly by the Bureau of Meteorology and the Division.

BUILDING RESEARCH

Development of the built environment, community planning and urban design; systems research; physical performance

of buildings in relation to the well-being of occupants; building operations and economics; structural design and engineering; conversion of forest products for the production of wood-based building elements; design and improvement of building components and systems; development, processing and properties of building materials.
Melbourne.

CHEMICAL ENGINEERING
Mechanisms of selected unit operations related to the minerals and other process industries, process simulation, design, evaluation, improvement, optimization and control, including pollution control.
Melbourne.

CHEMICAL PHYSICS
Development and application of chemical–physical techniques and instruments in the fields of spectroscopy, mass spectroscopy, electron diffraction, electron microscopy, X-ray diffraction, theoretical chemistry and solid-state chemistry.
Melbourne.

CHEMICAL TECHNOLOGY
Application of chemical technology and particularly polymer technology to developing ways whereby Australia's renewable and recyclable resources can be more effectively utilized and protected. Investigations include fractionation of plants to produce fibre in conjunction with protein and other marketable products; studies of pulp and paper and the use of cellulose materials in packaging, writing, printing and building products; technology for purifying and recycling water; energy collection, transmission and conservation; biodegradable packaging materials; fire research for the protection of forests.
Melbourne.

CLOUD PHYSICS
Natural mechanisms of cloud and rain formation; artificial induction of rainfall by techniques such as cloud-seeding; studies of atmospheric particles.
Sydney.

COMPUTING RESEARCH
Computer science and the application of computers to research and development projects. The Division also provides a computer service to other Divisions, certain Australian Government Departments and some universities.
The Division operates a computer network which has its centre in Canberra and is linked by Australian Post Office lines to subsidiary installations in Adelaide, Brisbane, Melbourne (various locations), Perth, Sydney (various locations), Armidale and Griffith, N.S.W., and Rockhampton and Townsville, Qld.

ENTOMOLOGY
Taxonomy, ecology, population dynamics, genetics, behaviour, physiology and biochemistry of insects, particularly in relation to the development of methods of control that reduce or eliminate the disadvantages commonly associated with the use of pesticides.
Canberra, with laboratories in Brisbane, Perth and Sydney, and field stations at Armidale, Trangie and Wilton, N.S.W., Rockhampton, Qld., and Hobart. The Division also has biological control units at Curitiba, Brazil; Montpellier, France; Tehran, Iran; and Pretoria, South Africa.

ENVIRONMENTAL MECHANICS
Transfer processes in the natural environment (physical interactions between soils, plants and the lowest layers of the atmosphere involving the exchange of energy, water and carbon dioxide) and their effect on plant growth; mathematical and physical aspects of ecology.
Canberra.

FISHERIES AND OCEANOGRAPHY

Survey and appraisal of certain marine fishery resources including rock lobsters, prawns and pelagic fisheries of the south-eastern area of Australia; biology of the western rock lobster and prawn species of commercial importance; biological, chemical and physical oceanography of south-east Indian Ocean and south-west Pacific Ocean; studies on the dynamics of Australian estuarine ecosystems.
Sydney, with laboratories in Brisbane and Perth and field stations at Darwin and Groote Eylandt, N.T., Karumba and Weipa, Qld., and Sams Creek, W.A.

FOOD RESEARCH

Properties, preservation, processing, packaging, storage and transport of foods; quality at the consumer level; properties of bacterial spores; membrane structure and biochemistry; identification and evaluation of flavours; plant physiology; polyunsaturated meat and dairy products; new protein and dairy foods; treatment and utilization of processing wastes.
Headquarters and Food Research Laboratory, Sydney; Meat Research Laboratory, Brisbane; Dairy Research Laboratory, Melbourne; Tasmanian Food Research Unit, Hobart.

HORTICULTURAL RESEARCH

Development of varieties of fruit-trees and grape-vines better suited to Australian conditions; physiology and biochemistry of horticultural plants; orchard ecology; production of grape crops; plant parasitic nematodes.
Adelaide, a laboratory and field station at Merbein, Vic., and a laboratory at Hobart.

IRRIGATION RESEARCH

Water management and engineering in irrigation; soil–plant–atmosphere interactions; crop growth, management and quality of irrigated crops, especially oil-seed crops and vegetables; environmental plant physiology and biochemistry; data capture and processing systems.
Griffith, N.S.W.

LAND RESOURCES MANAGEMENT

Principles for management of Australia's land resources for efficient productivity consistent with conservation of those resources; environmental implications of land use in pastoral, agricultural, forested and near-urban areas.
Perth, with laboratories at Deniliquin N.S.W., Alice Springs, N.T., Canberra, A.C.T., and field stations at Baker's Hill, W.A., and Deniliquin, N.S.W.

LAND USE RESEARCH

Inventory of land and water resources and assessment of their current and potential uses. Development of methods for relating these natural and socio-economic resources in developing balanced land use planning techniques.
Canberra, with laboratories at Kununurra, W.A., and Lawes, Qld.

MATHEMATICAL STATISTICS

Mathematical statistics and the development of suitable methods for statistical design and analysis of experiments for research in physical, chemical and biological sciences. The Division also provides advice and consultation services to other Divisions on statistical matters.
Adelaide, with officers stationed with a number of Divisions at Brisbane, Canberra, Hobart, Melbourne, Perth and Sydney, and at Townsville, Qld., and the University of Melbourne.

MECHANICAL ENGINEERING

Controlled-environment engineering; utilization of solar energy; industrial fluid dynamics; physical methods of preservation of grain; agricultural mechanization.
Melbourne.

MINERAL CHEMISTRY

Application of chemistry and metallurgy to mineral beneficiation and utilization and to improving the efficiency of existing mineral treatment processes; development of new mineral processing techniques.
Melbourne, with a laboratory in Sydney.

MINERAL PHYSICS

Application of physical techniques to mineral exploration; exploitation of physical properties of minerals in processing and extraction.
Sydney, with a laboratory in Melbourne.

MINERALOGY

Role of physical and chemical factors in the origin of mineral deposits and the effect of these factors on the relationships between mineral deposits and the surrounding rocks; application of this knowledge to mineral exploration and to the characterization of known ore bodies.
Perth, with laboratories in Canberra and Sydney.

NATIONAL MEASUREMENT LABORATORY

Establishment and maintenance of the Commonwealth legal standards for the measurement of physical quantities; problems associated with precise measurements; magnetic and dielectric properties of materials; solid-state physics; physics of fluids; optics; solar physics; molecular collisions; air glow.
Sydney, with an optical observatory at the CSIRO Solar Observatory, Culgoora, N.S.W.

NUTRITIONAL BIOCHEMISTRY

Biochemistry of nutritional processes in sheep and cattle with particular emphasis on the utilization of food for the production of useful animal products.
Adelaide, with a field station at O'Halloran Hill, S.A.

PLANT INDUSTRY

Research in the plant sciences as a basis for the development and utilization of crops and pastures better adapted to Australian conditions; ecology and conservation of plant communities.
Canberra, with laboratories in Brisbane and Narrabri, N.S.W., and an experimental farm at Canberra.

PROTEIN CHEMISTRY

Structure and chemistry of wool fibres as a basis for developing new and improved wool manufacturing processes; tanning and leather manufacture; meat proteins; plant proteins; biologically active proteins.
Melbourne.

RADIOPHYSICS

Cosmic and solar radio astronomy; development of microwave instrument landing systems for aircraft.
Sydney, with the Australian National Radio Astronomy Observatory at Parkes, N.S.W., and a radio observatory at the CSIRO Solar Observatory, Culgoora, N.S.W.

SOILS

Physics, chemistry, mineralogy and biology of soils in relation to growth and health of plants, animals and man. Soils in relation to forestry, water supplies and land use problems in urban and rural areas.
Adelaide, with laboratories in Brisbane, Canberra, Townsville, Qld., and Hobart.

TEXTILE INDUSTRY

Development of new and improved methods and machinery for processing wool; development of new and improved textile products from wool; relationships between fleece properties and processing; new uses for wool; cotton processing.
Geelong, Vic.

TEXTILE PHYSICS

Development of methods of testing wool

as an aid to marketing and manufacturing; physical properties and behaviour of wool and wool products; processing studies; surface properties of polymers.
Sydney.

TRIBOPHYSICS
Properties, behaviour and utilization of industrially important metals, alloys, ceramics and refractories; structure of these materials in relation to bulk properties such as strength and plasticity and surface reactions such as catalysis, adsorption and oxidation.
Melbourne.

TROPICAL AGRONOMY
Development of efficient systems for beef production in northern Australia (excluding arid zones); research on some tropical crops; agronomic research integrated with work on introduction, selection and breeding of new pasture and crop varieties; studies on pasture and crop nutrition, genetics, physiology and biochemistry, and on legume nodulation and animal nutrition.
Brisbane, with laboratories at Townsville and Lawes, Qld., and field stations at Beerwah, Mareeba, Mundubbera, Samford and Townsville, Qld., and at Katherine, N.T.

WILDLIFE RESEARCH
Biology of birds and mammals, both native and introduced, in relation to pest control and conservation. Species investigated include those which are clearly pests, such as the rabbit and wild pig, those which are exploited, such as the water-fowl and quail, and those which need to be conserved.
Canberra, with laboratories at Perth and Darwin, and staff located at Alice Springs, N.T.

In addition to the above Divisions, CSIRO has four small research units. They are:

AGRO-INDUSTRIAL RESEARCH UNIT
Potential innovations in agricultural technology, in particular the year-round harvesting of tropical crops, the industrial processing of crop products and the feeding of animals on crop and industrial by-products
Canberra.

MARINE BIOCHEMISTRY UNIT
Distribution, structure and biochemistry of unicellular marine algae, particularly in relation to the effects of environmental variations.
Sydney.

SOLAR ENERGY STUDIES UNIT
Development of policy and planning of research within CSIRO on the use of solar energy and advising Executive on allocation of resources; feasibility studies; analysis and provision of data; contact with research workers in Australia and overseas.
Melbourne.

WHEAT RESEARCH UNIT
Structure and biochemistry of the wheat grain and relationship to flour quality; rapid methods for grain protein determination and wheat variety identification.
Sydney.

Staff

The following is a list of professional and senior staff of the Organization as at 30 June 1974.

Head Office
Limestone Avenue, Campbell, A.C.T.

Executive

CHAIRMAN
J. R. Price, D.Phil., D.Sc., F.A.A.

MEMBERS OF THE EXECUTIVE
V. D. Burgmann, B.Sc., B.E.
M. F. C. Day, B.Sc., Ph.D., F.A.A.
D. L. Ford, M.Sc., Ph.D. (part-time)
V. E. Jennings, B.E.(Civil) (part-time)
L. Lewis, B.Met.E.
A. E. Pierce, Ph.D., D.Sc., F.R.C.V.S., D.V.S.M., F.A.C.V.Sc.
Professor E. J. Underwood, C.B.E., Ph.D., D.Rur.Sc., D.Sc.(Agric.), F.A.A., F.R.S. (part-time)
W. J. Vines, C.M.G., F.A.S.A., A.C.I.S., L.C.A. (part-time)

Secretariat

Executive Officer
J. A. Allen, M.Sc., Ph.D.

Administrative Branch
SECRETARY (ADMINISTRATION)
L. G. Wilson, M.Sc.

SENIOR ASSISTANT SECRETARY (ADMINISTRATION)
J. Coombe

L. G. Cook
J. W. Graham
F. S. Lowson, A.C.W.A.
N. R. Pummeroy, B.Sc.
J. M. Short, A.A.S.A., A.C.I.S. (*at Melbourne*)
P. M. Ward

ASSISTANT SECRETARY (PERSONNEL)
H. C. Crozier, B.A., Dip.Ed.

G. C. Barnes, M.I.E.(Aust.)
G. Batchelor
M. J. Beech
T. D. Brodie
P. J. R. Chivers, B.Sc., B.A.
E. C. French
N. H. Grafen
J. W. Hallam, A.M.T.C.
I. L. Harvey, B.Sc., B.A.
J. F. Mitchell
R. M. Moore, B.E.
R. W. Murnain, B.Sc.
R. A. Riches
L. C. R. Thompson, B.Sc.
J. R. Warwick, B.A.
I. D. Whiting, B.A.
D. V. Young, B.A.

SENIOR ASSISTANT SECRETARY (FINANCE AND PROPERTIES)
R. W. Viney, M.B.E., F.A.S.A., A.C.I.S.

G. A. Cave (*at Brisbane*)
E. B. Leaver, B.Com.
F. G. Martich
J. B. Sleigh (*at Melbourne*)
P. B. Steele (*at Sydney*)

ASSISTANT SECRETARY (WORKS AND BUILDINGS)
J. V. Dunn, A.R.A.I.A., Dip.Arch.

W. C. Curnow, B.Arch. (*at Brisbane*)
R. B. Fuller, F.R.A.I.A., Dip.Arch., F.R.M.T.C.
B. G. Gibbs, B.E., F.S.A.S.M.
D. K. Pincus, F.R.A.I.A., B.Arch., Dip.T.R.P.
P. G. A. Relf, F.R.A.I.A.
G. F. Smith, A.R.A.I.A.

ASSISTANT SECRETARY (FINANCE AND SUPPLIES)
R. C. McVilly, F.A.S.A., A.C.I.S.

K. N. Baker
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P. J. Byrne
M. F. Combe
W. P. Dominguez, B.A.
H. Kwong
B. P. Pope
M. G. Sinclair
V. J. Taylor, B.Com., A.C.I.S.

ASSISTANT SECRETARY (EXTERNAL RELATIONS)
G. D. McLennan, B.Com.

T. J. Healy, B.Sc. (*seconded to the Office of the Minister for Science*)
I. D. Gordon
G. G. Wines, B.A.

LIAISON OVERSEAS
London
CHIEF SCIENTIFIC LIAISON OFFICER
F. G. Lennox, D.Sc.
SCIENTIFIC LIAISON OFFICERS
R. D. Croll, B.Agr.Sc.
F. J. Whitty, F.A.S.A., A.C.I.S.
Tokyo
COUNSELLOR (SCIENTIFIC)
E. E. Adderley, B.Sc.
Washington
COUNSELLOR (SCIENTIFIC)
E. G. Bowen, O.B.E., C.B.E., M.Sc., Ph.D., Hon.D.Sc., F.A.A.
SCIENTIFIC ATTACHÉ
J. H. Whittem, B.V.Sc.

Agricultural and Biological Sciences Branch

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H. R. Webb, B.Agr.Sc., B.Com.
SCIENTIFIC SERVICES OFFICERS
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D. W. Horwood, M.Ag.Sc.
B. G. Johnston, B.Agr.Sc.
N. B. Lee, M.A.
J. A. Lumbers, B.Sc., Dip.Ed.
P. S. Muecke, B.Sc., Ph.D.
G. T. Sibley, M.Agr.Sc.
D. V. Walters, M.Agr.Sc. (*seconded to Queensland Department of Primary Industries*)
B. J. Woodruff, B.Sc.(For.)

Central Communication Unit

MANAGER
G. R. Williams, B.Ec.

H. P. Black
Mrs D. P. Braxton
S. T. Evans, B.Sc.
S. J. Ford
C. D. Kimpton, B.Agr.Sc.
Miss W. L. Parsons, B.A.
D. A. Peace
N. J. Roffey-Mitchell

Central Information, Library and Editorial Section

ACTING OFFICER-IN-CHARGE
L. G. Wilson, M.Sc.

*Information Service**
MANAGER
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Mrs M. F. L. Campbell, B.Sc.
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N. E. Hollier, B.Sc.
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H. J. Katz, B.Sc., Ph.D.
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*Library**
CHIEF LIBRARIAN
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P. Aukland, B.A.
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Mrs J. M. Crowther, B.A.
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G. Hitoun, B.A.
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M. Prazak (*at Brisbane*)
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Miss F. B. South, B.A., A.L.A.A.
Miss J. E. Stump, B.A., A.L.A.A.
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G. A. Forster, B.Sc., B.A.
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R. J. Leydon, B.Sc., Ph.D.
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SENIOR ASSISTANT SECRETARY
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J. R. Yates, M.A., Ph.D.
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R. L. Aujard, B.Sc.
J. A. Bell, B.Sc.
D. Burgess, B.Sc.
A. D. Duncan, M.Sc., A.R.C.S., F.I.P.A.A.
S. Y. Ip, B.Ec., Dip.Appl.Chem., Dip.Chem.Eng.
W. J. Land, B.Sc., A.M.
R. S. McCredie, B.Sc., Ph.D.

* 314 Albert Street, East Melbourne, Vic.

† 372 Albert Street, East Melbourne, Vic.

Regional Administrative Offices

Regional Administrative Office, Brisbane
Hibernian Building, 246 Queen Street, Brisbane, Qld.
REGIONAL ADMINISTRATIVE OFFICER
D. B. Thomas, B.A.
ACCOUNTANT
K. J. Turner, B.Com.
PERSONNEL OFFICER
M. H. Lamont

W. E. Rees

Regional Administrative Office, Canberra
Limestone Avenue, Campbell, A.C.T.
REGIONAL ADMINISTRATIVE OFFICER
K. J. Prowse
ACCOUNTANT
I. L. Farrar, A.A.S.A., A.C.I.S.
PERSONNEL OFFICER
A. J. Culnane

K. J. V. Carr
F. Sebesta
H. L. Taylor

Regional Administrative Office, Melbourne
314 Albert Street, East Melbourne, Vic.
REGIONAL ADMINISTRATIVE OFFICER
A. P. Patterson, F.A.S.A.
ACCOUNTANT
W. C. Hosking, A.A.S.A., A.C.I.S.
PERSONNEL OFFICER
J. Bourne

T. V. Benfold
A. L. Ford
B. J. Gleeson
M. Johnston
V. H. Leonard
J. R. Williamson

Regional Administrative Office, Sydney
Grace Bros. Building, 213 Broadway, Sydney, N.S.W.
REGIONAL ADMINISTRATIVE OFFICER
T. C. Clark, A.A.S.A., A.C.I.S.
PERSONNEL OFFICER
T. G. Brock, D.P.A.

P. V. Batson
C. W. McIlveen
D. M. Moore
R. W. Potent
L. W. Richards
S. A. Ryan

Unattached Officers

G. B. Gresford, B.Sc., A.R.M.T.C. (*seconded to Department of Foreign Affairs*)
H. R. C. Pratt, Ph.D., D.Sc. (*seconded to Department of Chemical Engineering, University of Melbourne*)
D. G. Thomas, M.Sc. (*seconded to Commonwealth Scientific Committee, as Secretary*)

Agro-industrial Research Unit

Headquarters: AMP Building, Hobart Place, Canberra, A.C.T.
OFFICER-IN-CHARGE
G. A. Stewart, M.Agr.Sc.

Animal Genetics, Division of

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S. J. J. F. Davies, M.A., Ph.D.
I. C. R. Rowley, B.Agr.Sc.
RESEARCH SCIENTIST
G. T. Smith, B.Sc., Ph.D.
EXPERIMENTAL OFFICERS
K. D. Casperson, B.Sc.
T. A. Knight, B.Sc.
D. A. Saunders, B.Sc.
At Alice Springs Research Station, Alice Springs, N.T.
EXPERIMENTAL OFFICERS
L. W. Best, M.Sc.
L. K. Corbett, B.Sc.
At Darwin Laboratories, McMillan Road, Darwin, N.T.
ADMINISTRATIVE OFFICER
B. C. Abbey
PRINCIPAL RESEARCH SCIENTIST
M. G. Ridpath, B.Sc., Ph.D.
RESEARCH SCIENTISTS
R. H. Barrett, M.S., Ph.D.
A. R. E. Sinclair, B.Sc., D.Phil.
C. K. Williams, B.Sc., Ph.D.
EXPERIMENTAL OFFICERS
Ms J. P. Burrell, M.Sc., Ph.D.
T. D. Redhead, B.Sc.

Wool Research Laboratories
The Wool Research Laboratories comprise the Divisions of Protein Chemistry, Textile Industry, and Textile Physics.
WOOL RESEARCH LABORATORIES COMMITTEE
M. Lipson, B.Sc., Ph.D. (*Chairman*)
J. G. Downes, B.Sc.
F. G. Lennox, D.Sc.

Advisory Council

Executive

J. R. Price, D.Phil., D.Sc., F.A.A. (*Chairman*)
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L. Lewis, B.Met.E.
A. E. Pierce, Ph.D., D.Sc., F.R.C.V.S., D.V.S.M., F.A.C.V.Sc.
D. L. Ford, M.Sc., Ph.D.
V. E. Jennings, B.E., M.I.E.(Aust.)
Professor E. J. Underwood, C.B.E., Ph.D., D.Rur.Sc., D.Sc.(Agric.), F.A.A., F.R.S.
W. J. Vines, C.M.G., F.A.S.A., A.C.I.S., L.C.A.

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WESTERN AUSTRALIA—L. C. Brodie-Hall, A.W.A.S.M.

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J. M. Harvey, D.Sc.
The Hon. C. R. Kelly, M.H.R.
R. S. McInnes
W. D. L. Ride, M.A., D.Phil.
Professor Sir Rutherford Robertson, C.M.G., Ph.D., D.Sc., F.A.A., F.R.S.
B. W. Scott, M.B.A., B.Ec.
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Professor H. R. Vallentine, B.E., M.S.
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R. M. Watts, B.V.Sc.
R. Whan, M.H.R.
Professor B. R. Williams, M.A.

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Professor B. R. Williams, M.A.

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E. B. de N. Joyce, O.B.E.
I. W. Morely, I.S.O., B.M.E., B.Met.E.
Sir Ellis Murphy, M.B., Ch.M., F.R.C.P., F.R.A.C.P.
L. W. Price, O.B.E.
P. M. Reynolds
E. P. S. Roberts, C.M.G.
W. J. D. Shaw, O.B.E.
Professor M. Shaw, M.Eng., M.Mech.E.
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South Australian State Committee

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B. J. Hailstone, M.I.T.A.
R. G. M. Harvey, B.Sc.Agr.
J. E. Harris, B.E.
D. R. Hawkes
M. R. Irving, B.V.Sc.
J. F. Jenkinson, A.A.S.A., A.C.I.S.
Brigadier J. G. McKinna, C.B.E., D.S.O., M.V.O., C.St.J., E.D.
L. W. Parkin, M.Sc., A.S.T.C.
Emeritus Professor J. A. Prescott, C.B.E., D.Sc., Hon.D.Ag.Sc., F.A.A., F.R.S.
H. C. Schmidt
E. W. Schroder, B.E., A.A.S.A.
H. Wilckens, F.I.O.B.Lond., F.A.I.B., F.A.I.M.

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E. J. Cameron, C.B.E., M.A.
R. J. Downie
T. A. Frankcomb, O.B.E.
R. W. Henry, C.B.E., B.Sc.
A. W. Knight, C.M.G., B.Sc., B.Comm., M.E.
A. R. Mead, Dip.Comm.
J. G. Symons, B.E., F.S.A.S.M.
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Western Australian State Committee

L. C. Brodie-Hall, A.W.A.S.M. (*Chairman*)
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G. H. Cooper
D. M. Cullity, B.Sc.
R. R. H. Doran, F.I.E.Aust.
K. W. Edwards, C.B.E., A.A.S.A.
Air Chief Marshal Sir Basil Embry (R.A.F. retired), G.C.B., K.B.E., D.S.O. (4 bars), D.F.C., A.F.C.
J. N. Langford
P. B. Lefroy
G. N. Lewis, Dip.Agr.
T. J. Lewis
Professor R. J. Moir, B.Sc.(Agric.)
Professor J. P. Quirk, B.Sc.Agr., Ph.D., D.Sc.
W. D. L. Ride, M.A., D.Phil.
J. H. Shepherd, B.Sc., B.Agr.Sc., Dip.For.
Professor W. R. Stern, M.Sc.Agr., Ph.D.
Professor E. J. Underwood, C.B.E., Ph.D., Hon.D.Rur.Sc., Hon.D.Sc.(Agric.), F.A.A., F.R.S.
R. Woodall, M.Sc.

Finance

Annual Expenditure

The following summary gives details of expenditure by CSIRO Divisions and Sections on other than capital items from 1 July 1973 to 30 June 1974.

DIVISION OR SECTION	Treasury funds ($)	Contributory funds ($)	Total ($)
Head Office			
The main items of expenditure under this heading are salaries and travelling expenses of the administrative staff at Head Office and the Regional Administrative Offices, salaries and expenses of officers at the Liaison Offices in London, Washington and Tokyo, and general office expenditure.	5,473,298	9,880	5,483,178
Research Programs			
Animal Health and Reproduction			
Animal Genetics	1,642,992	719,126	2,362,118
Animal Health	2,746,493	770,123	3,516,616
Animal Physiology	1,098,514	2,011,268	3,109,782
Nutritional Biochemistry	699,029	176,912	875,941
Bogor Animal Research Institute	—	27,772	27,772
Plant Industry	4,214,750	570,195	4,784,945
Entomology and Wildlife			
Entomology	3,080,784	943,002	4,023,786
Wildlife Research	1,202,999	412,126	1,615,125
Horticulture and Irrigation			
Horticultural Research	915,384	39,327	954,711
Irrigation Research	760,899	37,370	798,269
Tropical Agronomy	2,534,299	723,639	3,257,938
Land Resources			
Soils	2,392,583	50,046	2,442,629
Land Use Research	1,759,362	397,465	2,156,827
Agro-Industrial Research Unit	73,411	—	73,411
Land Resources Management	1,476,017	531,774	2,007,791
Processing of Agricultural Products			
Food Research	3,168,619	873,531	4,042,150
Wheat Research	69,470	92,849	162,319
Textile Industry	127,496	1,961,334	2,088,830
Textile Physics	70,112	1,336,406	1,406,518
Protein Chemistry	322,953	1,160,742	1,483,695
Fisheries and Oceanography			
Fisheries and Oceanography	2,400,199	199,294	2,599,493
Marine Biochemistry	65,025	—	65,025
Chemical Research of Industrial Interest			
Applied Chemistry	2,956,726	154,459	3,111,185
Chemical Physics	1,509,002	8,323	1,517,325
Processing and Use of Mineral Products			
Chemical Engineering	1,188,406	13,558	1,201,964
Mineral Chemistry	2,757,193	54,640	2,811,833
Mineralogy	1,418,843	29,849	1,448,692
Mineral Physics	824,102	17,703	841,805
Baas Becking Geobiological Group	13,400	74,728	88,128
Physical Research of Industrial Interest			
Physics	1,618,360	8,695	1,627,055
Applied Physics	2,730,310	—	2,730,310

DIVISION OR SECTION	Treasury funds ($)	Contributory funds ($)	Total ($)
General Physical Research			
Radiophysics	2,418,086	250,876	2,668,962
Atmospheric Physics	1,179,546	5,494	1,185,040
Cloud Physics	647,314	3,524	650,838
Environmental Mechanics	360,793	17,627	378,420
Commonwealth Meteorological Research Centre	144,179	—	144,179
General Industrial Research			
Building Research	3,239,095	110,101	3,349,196
Tribophysics	1,409,096	7,493	1,416,589
Applied Geomechanics	934,124	137,752	1,071,876
Mechanical Engineering	1,018,084	125,398	1,143,482
Solar Energy Studies Unit	20,287	—	20,287
Research Services			
Computing Research	517,553	—	517,553
Mathematical Statistics	1,134,393	—	1,134,393
Western Australian Administrative Group	229,455	—	229,455
Extra-mural grants	78,404	—	78,404
Australian Mineral Development Laboratories	58,648	—	58,648
Developmental projects	167,186	—	167,186
Radio Research Board	50,000	—	50,000
Information and Publications			
Central Library	642,988	—	642,988
Editorial and Publications Service	942,190	—	942,190
Film and Video Centre	141,373	1,106	142,479
Miscellaneous	683,513	105,978	789,491
Grants			
Research Associations	531,905	—	531,905
Research Studentships	322,654	—	322,654
Other grants and contributions	1,320,781	—	1,320,781
Total expenditure	69,502,677	14,171,485	83,674,162

Capital Expenditure under CSIRO Control

The table which follows shows capital expenditure from funds made available directly to CSIRO. It includes expenditure on capital and developmental works and on items of equipment costing more than $10,000 each.

DIVISION OR SECTION	Treasury funds ($)	Contributory funds ($)	Total ($)
Head Office	45,592	—	45,592
Animal Health and Reproduction			
Animal Genetics	93,473	51,706	145,179
Animal Health	40,914	16,159	57,073
Animal Physiology	18,845	109,456	128,301
Plant Industry	108,864	81,010	189,874
Entomology and Wildlife			
Entomology	31,546	24,438	55,984
Wildlife Research	10,445	—	10,445
Horticulture and Irrigation			
Horticultural Research	22,789	20,238	43,027
Irrigation Research	1,740	—	1,740
Tropical Agronomy	99,342	20,738	120,080
Land Resources			
Soils	4,296	—	4,296
Land Use Research	—	50	50
Land Resources Management	66,926	2,443	69,369
Processing of Agricultural Products			
Food Research	103,844	117,486	221,330
Textile Industry	25,030	57,032	82,062
Textile Physics	—	10,090	10,090
Protein Chemistry	15,793	44,752	60,545
Fisheries and Oceanography	33,216	3,723	36,939
Chemical Research of Industrial Interest			
Applied Chemistry	96,499	—	96,499
Chemical Physics	53,455	—	53,455
Processing and Use of Mineral Products			
Chemical Engineering	22,076	—	22,076
Mineral Chemistry	78,579	—	78,579
Mineralogy	31,910	—	31,910
Mineral Physics	42,120	—	42,120
Physical Research of Industrial Interest			
Physics	66,424	—	66,424
Applied Physics	35,149	—	35,149
General Physical Research			
Radiophysics	70,349	—	70,349
Atmospheric Physics	66,320	—	66,320
Cloud Physics	273	—	273
Environmental Mechanics	642	—	642
General Industrial Research			
Building Research	48,674	—	48,674
Tribophysics	22,551	—	22,551
Applied Geomechanics	44,970	20,900	65,870
Mechanical Engineering	15,295	9,770	25,065
Research Services			
Computing Research	3,980,421	—	3,980,421
Western Australian Administrative Group	13,382	—	13,382
Information and Publications			
Editorial and Publications	24,000	—	24,000
Miscellaneous	42,036	53,178	95,214
Total capital expenditure	5,477,780	643,169	6,120,949

Contributions

This table summarizes receipts and expenditure during 1973/74 of funds provided by contributors and recorded in a special account entitled 'Specific Research Account'. The largest amounts contributed for specific research projects are provided from joint Commonwealth–Industry Research Funds such as the Wool Research Trust Fund and the Meat Research Trust Account. However, sums which are quite substantial in total are contributed by industrial organizations and other bodies.

DIVISION OR SECTION	**Receipts 1973/74 and balances brought forward** ($)	**Expenditure 1973/74** ($)
Animal Genetics		
Wool Research Trust Fund	553,753	545,515
Meat Research Trust Account	133,424	140,631*
Other contributors	80,189	84,686*
Animal Health		
Wool Research Trust Fund	407,292	398,918
Meat Research Trust Account	303,775	318,951*
Dairy Produce Research Trust Account	22,288	20,879
Other contributors	53,391	47,534
Animal Physiology		
Wool Research Trust Fund	1,917,900	1,888,533
Meat Research Trust Account	91,208	77,618
Other contributors	231,639	154,572
Nutritional Biochemistry		
Wool Research Trust Fund	177,840	174,454
Other contributors	—	2,458*
Bogor Animal Research Institute		
Other contributors	27,772	27,772
Plant Industry		
Wool Research Trust Fund	404,545	404,333
Wheat Research Trust Account	13,559	12,661
Dairy Produce Research Trust Account	148	—
Tobacco Industry Trust Account	23,105	21,976
Other contributors	250,174	212,235
Entomology		
Wool Research Trust Fund	72,950	67,494
Meat Research Trust Account	482,963	489,450*
Wheat Research Trust Account	25,631	25,521
Other contributors	456,390	384,976
Wildlife Research		
Wool Research Trust Fund	277,248	284,164*
Meat Research Trust Account	126,088	123,864
Other contributors	4,131	4,098
Horticultural Research		
Dried Fruits Research Trust Account	46,878	28,428
Other contributors	68,997	31,138
Irrigation Research		
Other contributors	71,644	37,370
Tropical Agronomy		
Meat Research Trust Account	267,582	264,359
Dairy Produce Research Trust Account	47,016	42,375
Tobacco Industry Trust Account	281,309	272,465
Other contributors	232,888	165,178
Soils		
Wheat Research Trust Account	7,457	6,527
Other contributors	56,074	43,519
Land Use Research		
Wool Research Trust Fund	138,894	52,241
Other contributors	451,547	345,274

* Expenditure in excess of receipts will be recovered in 1974/75.

DIVISION OR SECTION	Receipts 1973/74 and balances brought forward ($)	Expenditure 1973/74 ($)
Land Resources Management		
Wool Research Trust Fund	347,361	475,394*
Other contributors	76,386	58,823
Food Research		
Meat Research Trust Account	593,733	534,802
Dairy Produce Research Trust Account	208,393	196,949
Fishing Industry Research Trust Account	13,943	13,698
Dried Fruits Research Trust Account	7,874	8,323*
Chicken Meat Research Trust Account	5,593	5,591
Other contributors	270,733	231,654
Wheat Research		
Wheat Research Trust Account	89,183	87,379
Other contributors	6,383	5,470
Textile Industry		
Wool Research Trust Fund	2,031,700	1,982,973
Other contributors	45,523	35,395
Textile Physics		
Wool Research Trust Fund	1,328,512	1,343,117*
Other contributors	6,736	3,379
Film and Video Centre		
Other contributors	4,141	1,106
Applied Chemistry		
Other contributors	250,864	154,459
Chemical Physics		
Other contributors	12,556	8,322
Protein Chemistry		
Wool Research Trust Fund	1,254,562	1,152,725
Other contributors	54,885	52,769
Fisheries and Oceanography		
Fishing Industry Research Trust Account	122,523	110,056
Other contributors	112,795	92,961
Chemical Engineering		
Other contributors	10,879	6,680
Mineral Chemistry		
Other contributors	4,674	4,000
Mineralogy		
Other contributors	5,566	—
Baas Becking Geobiological Group		
Other contributors	89,944	74,728
Minerals Research Laboratories†		
Other contributors	248,359	105,069
Physics		
Other contributors	6,092	8,695*
Radiophysics		
Other contributors	478,401	250,876
Atmospheric Physics		
Other contributors	3,204	5,494*
Cloud Physics		
Other contributors	17,390	3,524
Environmental Mechanics		
Other contributors	20,200	17,627
Building Research		
Other contributors	176,324	110,101

* Expenditure in excess of receipts will be recovered in 1974/75.

† Accounts have been established for a number of broad research programs concerned with the minerals industries and grouped under the Minerals Research Laboratories, a complex comprising the Divisions of Chemical Engineering, Mineral Chemistry, Mineralogy and Mineral Physics.

DIVISION OR SECTION	Receipts 1973/74 and balances brought forward ($)	Expenditure 1973/74 ($)
Tribophysics		
Other contributors	25,809	7,492
Applied Geomechanics		
Other contributors	235,724	158,652
Mechanical Engineering		
Wheat Research Trust Account	81,456	80,037
Other contributors	111,935	55,131
Mathematical Statistics		
Other contributors	142	—
Head Office		
Wool Research Trust Fund	11,623	9,880
Miscellaneous		
Wool Research Trust Fund	127,800	130,979*
Other contributors	337,357	28,177
Total contributions	16,644,947	14,814,654

* Expenditure in excess of receipts will be recovered in 1974/75.

General Revenue

During 1973/74, general revenue amounting to $714,018 was received by the Organization. Details of receipts are as follows:

	($)
Sale of publications	82,020
Receipts in respect of expenditure of former years	177,890
Sale of produce, including livestock	130,451
Royalties from patents	132,103*
Testing fees	66,999
Miscellaneous receipts	124,555
Total	714,018

Of the above sum $594,677 was spent during 1973/74. This expenditure was approved by the Minister for Science and the Treasurer as part of the general estimates.

* A further $293,857 was received as royalties on CSIRO patents and was paid to the Department of Primary Industry for credit to the Wool Research Trust Fund. The patent royalties included $281,299 for the self-twist spinning machine.

AUDITOR-GENERAL'S OFFICE
Prudential Building, University Avenue,
Canberra City, A.C.T. 2601
20 August 1974

The Honourable the Minister for
Science,
Parliament House,
CANBERRA, A.C.T.

Dear Sir,

Commonwealth Scientific and Industrial Research Organization

In compliance with Section 30(2.) of the Science and Industry Research Act 1949–1973, financial statements of the Commonwealth Scientific and Industrial Research Organization for the year ended 30 June 1974 have been submitted for my report. These comprise—

Summary of Receipts and Payments
Consolidated Statement of Payments
Statement of Payments—Special Account
Statement of Payments—Specific Research Account

One set of the statements, which are in the form approved by the Treasurer, is attached.

I now report, in terms of Section 30(2.) of the Act that, in my opinion—

(a) the accompanying statements are based on accounts and financial records kept in accordance with the Act;
(b) the statements are in agreement with the accounts and financial records and show fairly the financial operations of the Organization; and
(c) the receipt, expenditure and investment of moneys, and the acquisition and disposal of other property, by the Organization during the year have been in accordance with the Act.

Yours faithfully,

(Sgd.) D. R. STEELE CRAIK

(D. R. STEELE CRAIK)
AUDITOR-GENERAL

Summary of Receipts and Payments

	Funds held 1 July 1973 ($)	Receipts ($)	Total funds available ($)	Payments ($)	Funds held 30 June 1974 ($)
Special Account					
Parliamentary Appropriation: Operational	—	68,908,000.00	68,908,000.00	68,908,000.00	—
	(—)*	(57,326,000.00)	(57,326,000.00)	(57,326,000.00)	(—)
Parliamentary Appropriation: Capital	44,238.00)	5,550,000.00)	5,594,238.00)	5,477,780.19)	116,457.81
	(3,751.64)	(1,893,000.00)	(1,896,751.64)	(1,852,513.64)	(44,238.00)
Revenue and Other Receipts	98,659.11	714,017.86	812,676.97	594,677.18	217,999.79
	(234,925.65)	(594,204.84)	(829,130.49)	(730,471.38)	(98,659.11)
Total: Special Account	142,897.11	75,172,017.86	75,314,914.97	74,980,457.37	334,457.60
	(238,677.29)	(59,813,204.84)	(60,051,882.13)	(59,908,985.02)	(142,897.11)
Specific Research Account	2,576,520.59	14,068,426.14	16,644,946.73	14,814,654.27	1,830,292.46†
	(2,642,359.99)	(13,213,677.69)	(15,856,037.68)	(13,279,517.09)	(2,576,520.59)
Other Trust Moneys‡	126,243.80	1,356,442.85	1,482,686.65	1,287,276.43	195,410.22
	(18,922.66)	(551,620.52)	(570,543.18)	(444,299.38)	(126,243.80)
Cafeteria Account§	7,612.60	63,095.77	70,708.37	64,139.26	6,569.11
	(6,179.53)	(64,362.55)	(70,542.08)	(62,929.48)	(7,612.60)
Total	**2,853,274.10**	**90,659,982.62**	**93,513,256.72**	**91,146,527.33**	**2,366,729.39**
	(2,906,139.47)	**(73,642,865.60)**	**(76,549,005.07)**	**(73,695,730.97)**	**(2,853,274.10)**

* Figures in brackets refer to 1972/73 financial year.
† Includes investments totalling $176,750.00.
‡ Moneys held temporarily on behalf of other organizations and individuals.
§ Operating receipts and expenses of CSIRO cafeterias at Melbourne.

J. R. Price (*Chairman*)

R. W. Viney (*Senior Assistant Secretary, Finance and Properties*)

Consolidated Statement of Payments

1972/73 ($)		1973/74 ($)
	Head Office (including Regional Administrative Offices)	
3,275,893	Salaries and allowances	3,956,374
240,892	Travelling and subsistence	279,840
303,774	Postage, telegrams and telephone	327,418
647,871	Incidental and other expenditure	919,546
4,468,430		5,483,178
	Research Programs	
	Agricultural research	
8,410,801	Animal health and reproduction	9,892,229
4,464,941	Plant industry	4,784,945
4,834,705	Entomology and wildlife	5,638,911
2,364,463	Soils*	–
1,502,463	Horticulture and irrigation	1,752,980
2,298,102	Tropical agronomy	3,257,938
3,354,392	Land resources	6,680,658
6,761,619	Processing of agricultural products	9,183,513
1,779,045	Fisheries and oceanography	2,664,518
6,354,009	Chemical research of industrial interest	4,628,509
4,415,700	Processing and use of mineral products	6,392,422
3,705,846	Physical research of industrial interest	4,357,365
4,245,249	General physical research	5,027,439
5,926,846	General industrial research	7,001,430
1,791,707	Research services	2,235,639
1,395,565	Information and publications	1,727,657
563,135	Miscellaneous	789,491
64,168,588		76,015,644
	Grants	
454,984	Research associations	531,905
315,990	Research studentships	322,654
1,146,475	Other grants and contributions	1,320,781
1,917,449		2,175,340
	Capital Works and Services	
1,064,283	Buildings, works, plant and developmental expenditure	989,621
–	Major items of laboratory equipment	1,178,309
539,952	Scientific computing equipment†	–
804,936	Other equipment†	–
39,594	Development of new area for Ginninderra field station	19,263
185,270	Expansion of CSIRO computer network	3,933,756
–	Construction of research vessel	–
2,634,035		6,120,949
	Other Trust Moneys	
306,588	Remittance of revenue from investigations financed from Industry Trust Accounts	589,029
137,711	Other miscellaneous remittances	698,248
444,299		1,287,277

1972/73 ($)		1973/74 ($)
	Cafeteria Account	
62,929	Operating expenses of CSIRO cafeterias at Melbourne	64,139
62,929		64,139
73,695,730	**Total Expenditure**	**91,146,527**

* As from 1 July 1973 the research activities of this Division were integrated with the land resources laboratories.

† This expenditure is now included with major items of laboratory equipment.

J. R. Price (*Chairman*) R. W. Viney (*Senior Assistant Secretary, Finance and Properties*)

Statement of Payments—Special Account*

1972/73 ($)		1973/74 ($)
	Head Office (including Regional Administrative Offices)	
3,264,751	Salaries and allowances	3,946,913
240,435	Travelling and subsistence	279,671
303,774	Postage, telegrams and telephone	327,418
647,202	Incidental and other expenditure	919,296
4,456,162		5,473,298
	Research Programs	
	Agricultural research	
5,293,750	Animal health and reproduction	6,187,028
3,682,596	Plant industry	4,214,750
3,652,121	Entomology and wildlife	4,283,783
2,292,413	Soils†	–
1,435,830	Horticulture and irrigation	1,676,282
1,923,025	Tropical agronomy	2,534,299
2,480,547	Land resources	5,701,373
2,862,930	Processing of agricultural products	3,758,650
1,679,037	Fisheries and oceanography	2,465,224
5,151,088	Chemical research of industrial interest	4,465,728
4,214,735	Processing and use of mineral products	6,201,945
3,699,399	Physical research of industrial interest	4,348,670
4,055,558	General physical research	4,749,918
5,551,953	General industrial research	6,620,686
1,791,707	Research services	2,235,639
1,391,706	Information and publications	1,726,551
524,466	Miscellaneous	683,513
51,682,861		61,854,039
	Grants	
454,984	Research associations	531,905
315,990	Research studentships	322,654
1,146,475	Other grants and contributions	1,320,781
1,917,449		2,175,340
	Capital Works and Services	
412,198	Buildings, works, plant and developmental expenditure	519,480
–	Major items of laboratory equipment	1,020,004
539,952	Scientific computing equipment‡	–
675,499	Other equipment‡	–
39,594	Development of new area for Ginninderra field station	19,263
185,270	Expansion of CSIRO computer network	3,919,033
–	Construction of research vessel	–
1,852,513		5,477,780
59,908,985	**Total Expenditure**	**74,980,457**

* Special Account refers to moneys paid to CSIRO out of the Consolidated Revenue Fund of the Commonwealth and other related moneys specifically covered by Section 26C of the Science and Industry Research Act 1949–1973.

† As from 1 July 1973 the research activities of this Division were integrated with the land resources laboratories.

‡ This expenditure is now included with major items of laboratory equipment.

J. R. Price (*Chairman*) R. W. Viney (*Senior Assistant Secretary, Finance and Properties*)

Statement of Payments—Specific Research Account

1972/73 ($)		1973/74 ($)
	Head Office (including Regional Administrative Offices)	
11,142	Salaries and allowances	9,461
457	Travelling and subsistence	169
–	Postage, telegrams and telephone	–
669	Incidental and other expenditure	250
12,268		9,880
	Research Programs	
	Agricultural research	
3,117,051	Animal health and reproduction	3,705,201
782,345	Plant industry	570,195
1,182,584	Entomology and wildlife	1,355,128
72,050	Soils*	–
66,633	Horticulture and irrigation	76,698
375,077	Tropical agronomy	723,639
873,845	Land resources	979,285
3,898,689	Processing of agricultural products	5,424,863
100,008	Fisheries and oceanography	199,294
1,202,921	Chemical research of industrial interest	162,781
200,965	Processing and use of mineral products	190,477
6,447	Physical research of industrial interest	8,695
189,691	General physical research	277,521
374,893	General industrial research	380,744
–	Research services	–
3,859	Information and publications	1,106
38,669	Miscellaneous	105,978
12,485,727		14,161,605
	Capital Works and Services	
652,085	Buildings, works, plant and developmental expenditure	470,141
–	Major items of laboratory equipment	158,305
129,437	Other equipment†	–
–	Expansion of CSIRO computer network	14,723
781,522		643,169
13,279,517	**Total Expenditure**	**14,814,654**

* As from 1 July 1973 the research activities of this Division were integrated with the land resources laboratories.

† This expenditure is now included with major items of laboratory equipment.

J. R. Price (*Chairman*) R. W. Viney (*Senior Assistant Secretary, Finance and Properties*)

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