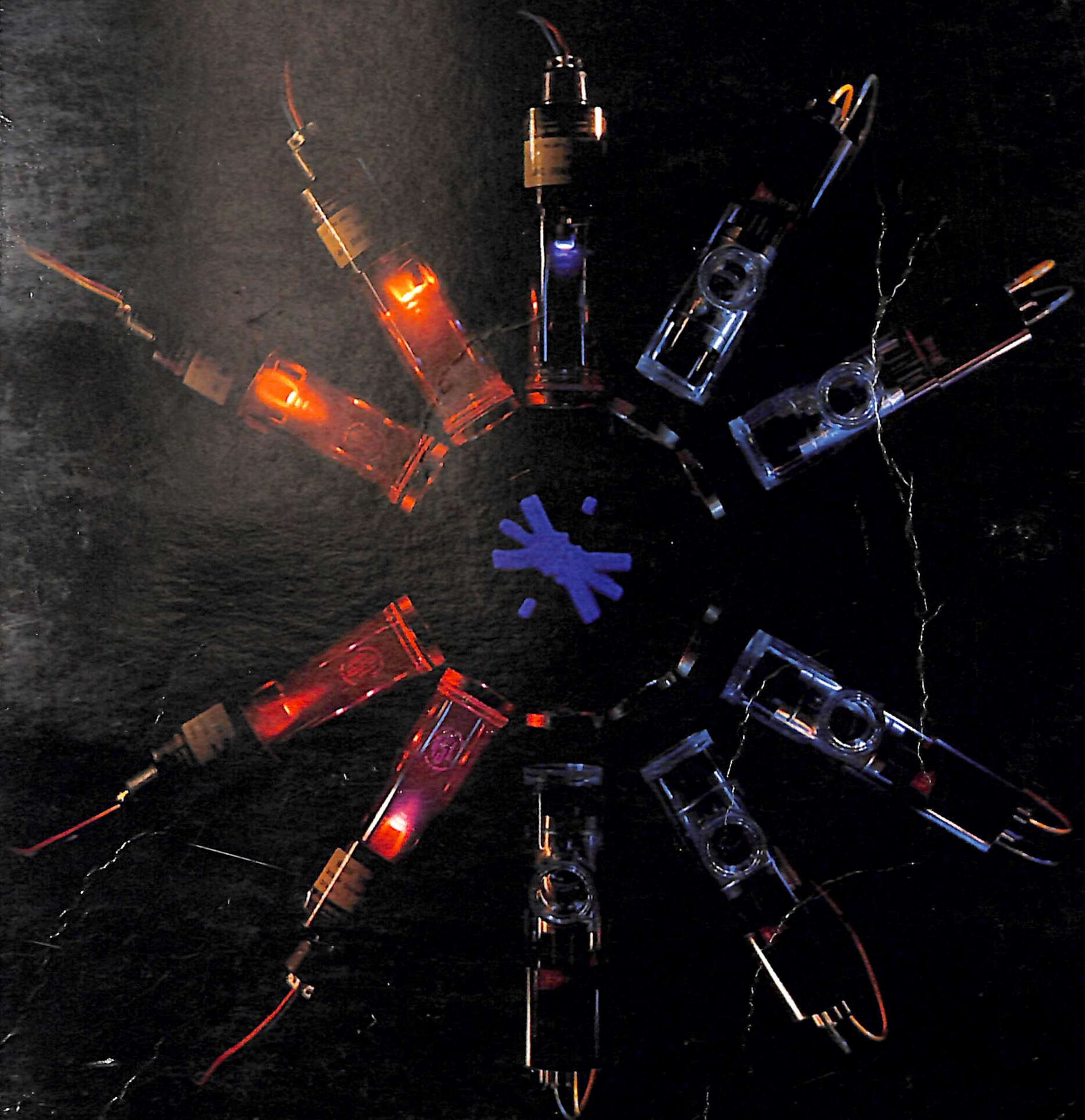
Commonwealth Scientific and Industrial Research Organization, Australia

CSIRO Twentieth Annual Report 1967-68



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Atomic absorption apparatus for the simultaneous determination of copper, zinc, silver, nickel, and lead in mineral samples (see story on page 70).

Solutions of the samples being analysed are sprayed into the flame of a special burner. In this picture the flame is seen from above and appears as a series of intersecting blue lines.

Detectors at right measure the amount of light, from lamps at left, absorbed in the flame by the sample.

CSIRO, the Commonwealth Scientific and Industrial Research Organization, 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 for the promotion of primary and secondary industries in the Commonwealth and its Territories;

- 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 Commonwealth standards of measurement;

- the dissemination of scientific and technical information;

- the publication of scientific and technical reports.

General review

One important criterion by which the research programme of CSIRO must be judged is that of its practical benefit to the community. Chapter 2 of this report gives examples of some of the benefits of scientific research already achieved.

However, CSIRO's contribution to scientific research would be unduly limited if its programmes were selected only because of their short-term practical outcome.

The expense of maintaining CSIRO is now considerable. This expenditure would not be warranted if it produced only a series of recipes for applying existing knowledge to the problems of primary and secondary industry. Because the Annual Report is confined largely to recording the practical results of some of CSIRO's research, it can only reveal in part the high quality and originality of the scientific programmes in progress, or the complex and continuing interchange between science and technology.

In addition to the scientific background research required to answer many of the defined day-to-day practical problems, a national research organization such as CSIRO has a responsibility to develop areas of science that may be expected to open up new opportunities of national interest.

Such 'basic' research in areas that are selected because of their potential practical value forms an important part of the CSIRO programme. Through it CSIRO is better able not only to apply existing scientific knowledge to Australia's problems, but also to keep Australia in the forefront of new scientific achievements. A few examples must suffice.

Animals are known to communicate with one another through the medium of specific chemical substances. A study of the detailed chemistry of these substances, leading to their identification and to understanding of the roles they play, can be expected to provide new approaches to insect control and to overcome some of the dangers and difficulties in the use of chemical pesticides.

Unforeseen opportunities may emerge from studies of the behaviour of solids at very low temperatures. The physics of semi-conductors has already opened up new electronic industries; superconductivity and other intriguing aspects of solids at low temperatures offer wide potential interest.

Chemical reactions at very high pressures have already provided new industrial processes but wider opportunities will undoubtedly emerge from further study.

The far-reaching nature of discoveries concerning genetic inheritance makes it essential that studies in molecular biology be included in CSIRO's research programme, for it can confidently be expected that understanding the complex mechanism of inheritance will lead to means of deliberate modification of plants and animals.

The validity of new scientific discoveries is tested when they are published in the scientific journals. They then receive the most critical scrutiny by those best able to judge and it is on this that the community must rely for its assessment of achievements in basic science.

The choice of a particular research programme must be made by scientists. The objectives of CSIRO will be well served if this programme leads to new practical opportunities.

Experience has shown that support for basic scientific work is essential if CSIRO is to continue to produce results of value to the community and to contribute to the advance of national development.

Top left: His Royal Highness Prince Philip, Duke of Edinburgh, addresses guests at the opening of Clunies Ross House, incorporating the National Science Centre, in Melbourne on May 30, 1968. Prince Philip, who performed the opening ceremony, is Patron of the Clunies Ross Foundation, which was established nine years ago to commemorate the late Sir Ian Clunies Ross, Chairman of CSIRO from 1949 to 1959.

Bottom left: Lady Clunies Ross and the Chairman of CSIRO, Sir Frederick White, in the foyer of Clunies Ross House. Behind them is a mural depicting the life and work of Sir Ian.
The mural was commissioned by the Australian Veterinary Association and painted by Mr. Robert Ingpen of CSIRO.

Science and Industry Research Act

In June 1968 the Commonwealth Government passed a Bill to amend the Science and Industry Research Act 1949–1966. The main purpose of the amendments was to allow CSIRO to adopt similar financial arrangements to those of other Commonwealth statutory corporations.

During an examination of trust accounts the Parliamentary Joint Committee of Public Accounts considered the need for the continued existence of the Science and Industry Trust Account established under Section 25 of the Science and Industry Research Act 1949–1966. The Committee decided that this Trust Account no longer served any useful purpose and recommended that the Account be closed. The Committee stated:

> 'One of the main problems of a governmental research organization is to retain a flexibility so vital to successful research while still obtaining the funds so necessary to the conduct of research. Your Committee sympathises fully with the desire of the Organization to preserve this freedom of action in so far as research activities are concerned.'

During his Second Reading Speech on the Bill in the House of Representatives, the Minister for Education and Science, Mr. M. Fraser, said:

> 'The success which CSIRO has achieved in serving the needs of Australia through scientific research can be attributed to the responsibility which the Executive has been given to exercise its scientific and practical judgment in the selection of a programme of work and in the appointment of scientific and other staff to carry through this programme.'

> 'The financial provisions now proposed give the Executive and the Minister with necessary safeguards the same degree of responsibility and flexibility as are inherent in the other provisions of the Act.'

Under the new Act, which became effective as from July 1, 1968, the Science and Industry Trust Account has been closed. Funds to be provided out of the Consolidated Revenue Fund for the use of CSIRO will appear as a one-line entry in the Appropriation Acts and will be paid over to CSIRO for use in accordance with approved estimates of expenditure. CSIRO now

Mr. M. Fraser succeeded Mr. J. G. Gorton as Minister for Education and Science in February 1968, following the appointment of Mr. Gorton as Prime Minister.

operates its own bank accounts and issues its own cheques and is responsible for its own accounting arrangements subject to audit by the Auditor-General.

In addition to its financial provisions, the Act contains several other minor amendments which allow the Executive to appoint without obtaining approval from the Minister persons whose salary does not exceed $10,073, and with the approval of the Minister to appoint in exceptional cases a senior scientist who does not meet the normal requirements of physical fitness. The amendments also increase the quorum of the Advisory Council to twelve.

New Divisions

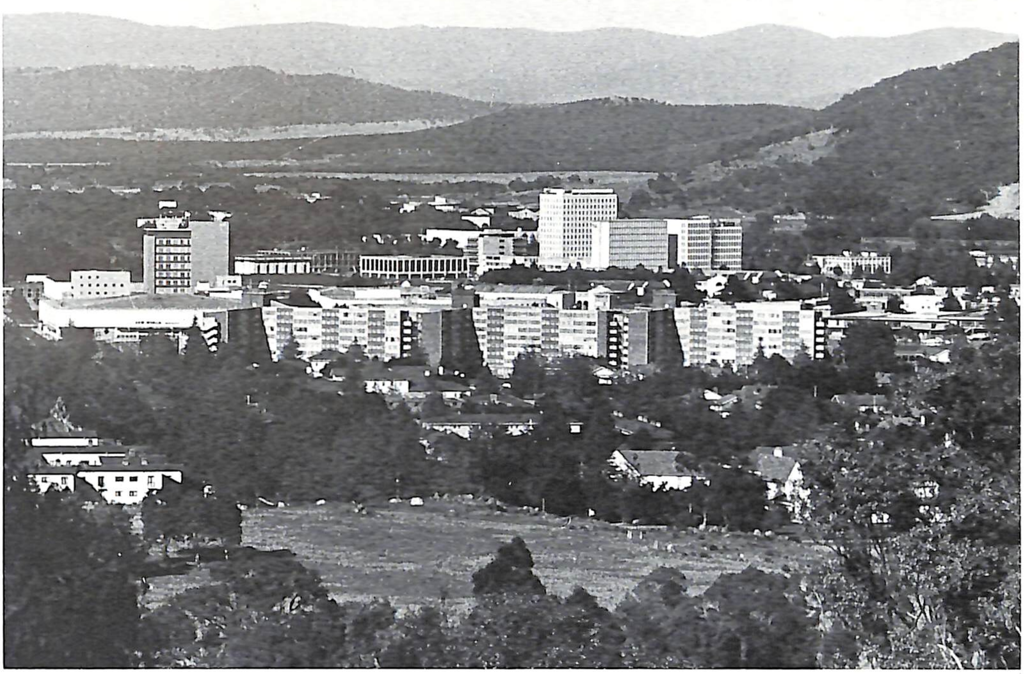
Four CSIRO Sections were given the status of Division during the year. The new Divisions and their Chiefs are:

COMPUTING RESEARCH
Dr. G. N. Lance

HORTICULTURAL RESEARCH
Dr. J. V. Possingham

IRRIGATION RESEARCH
Mr. E. R. Hoare

SOIL MECHANICS
Dr. G. D. Aitchison



In May 1968, the Government approved the building of a new Head Office for CSIRO in Canberra. The building will be constructed by the National Capital Development Commission using funds under its control and is expected to be ready for occupancy by December 1970. This picture is taken looking south-west across the proposed Head Office site. The site, which is a few hundred yards north-west of the Australian War Memorial, occupies an area of about 10 acres and is bordered by Quick Street, Limestone Avenue, and Campbell High School.

Buildings

Treasury funds for capital works increased from \$2·9 million in 1966/67 to \$3·08 million in 1967/68.

In addition funds from industry committees and other contributory sources amounted to \$800,000.

Several major projects were begun during the year. These include a group of buildings to rehouse the DIVISION OF CHEMICAL ENGINEERING at Clayton, Melbourne, at a cost of \$1·4 million and a structures testing laboratory for the DIVISION OF BUILDING RESEARCH at Highett, Melbourne, at a cost of \$180,000.

A grant of \$150,000 by the Australian Dairy Produce Board has enabled a start to be made on an extension to the main laboratory of the DIVISION OF DAIRY RESEARCH at Highett. A further \$150,000 is being provided by Treasury.

A contract has been let for Stage 2 of the Meat Research Laboratory of the DIVISION OF FOOD PRESERVATION at Cannon Hill, Brisbane. The Meat Research Committee has provided \$405,000 for this project and the Australian Meat Board and Treasury \$112,500 each.

Tenders have been let for an extension to the DIVISION OF TEXTILE PHYSICS laboratory at North Ryde, Sydney. The Australian Wool Board has provided \$140,000 for the extension.

Above left
Headquarters building for the Division of Mathematical Statistics at Glen Osmond, Adelaide.

Below left
Stage II of the Division of Land Research laboratory at Black Mountain, Canberra.

The largest project completed during the year was a new laboratory for the DIVISION OF RADIOPHYSICS. The building cost \$1,520,000 and will accommodate a staff of 200. It is located on a 17-acre site at Epping, Sydney, and has a total floor area of about 80,000 square feet including associated workshops and service space.

Stage II of a laboratory for the DIVISION OF LAND RESEARCH has been completed at Black Mountain, Canberra, at a cost of \$543,000. The whole of the Division's Canberra staff is now housed in the one laboratory. Previously some of the Division's staff were located several miles away at Manuka in quite unsuitable rented accommodation.

Since 1953 the DIVISION of METEOROLOGICAL PHYSICS has been housed in a prefabricated aluminium building and a double-storey brick wing at Aspendale near Melbourne. The completion of a new \$100,000 extension to the brick wing has helped to relieve over-crowding and to provide accommodation for an additional ten members of staff.

A building to house the headquarters of the DIVISION OF MATHEMATICAL STATISTICS has been completed at Glen Osmond, Adelaide, at a cost of \$90,000. This is the first time the Division has had a building of its own. The headquarters of the Division was previously in part of the laboratory of the Division of Nutritional Biochemistry in Adelaide.

An extension costing \$70,300 has been added to the main laboratory of the DIVISION OF HORTICULTURAL RESEARCH at Glen Osmond, Adelaide. The extension, which has a floor area of 5700 square feet, almost doubles the facilities available to the Division and will enable it to cope more adequately with an expanded programme of research.

Preliminary planning of the NATIONAL

STANDARDS LABORATORY project is almost complete and it is hoped to start work on the building during 1969/70. It will be by far the biggest and most complex building operation that CSIRO has undertaken. The first stage of the project will involve moving the DIVISION OF APPLIED PHYSICS from its present site in the grounds of the University of Sydney to a new site at Bradfield Park. This stage is expected to cost about $7 million. The second stage, moving the DIVISION OF PHYSICS, is expected to cost about $2 million, and should follow a few years later.

Other major projects completed during the year include:

ANIMAL GENETICS—Modifications to main laboratory and fitting out of laboratories in upper floor of animal house, North Ryde, Sydney. **$172,000**

TEXTILE INDUSTRY—Extension to machinery building, Geelong, Vic. **$170,000**

PHYSICS and RADIOPHYSICS—Observers' quarters, Solar Observatory, Culgoora, N.S.W. **$100,000**

TROPICAL PASTURES—Staff houses, single men's quarters, and farm buildings, Narayen Research Station, Mundubbera, Qld. **$90,000**

ANIMAL HEALTH—Cattle tick isolation pens, Indooroopilly, Brisbane. **$57,000**

PLANT INDUSTRY—Field laboratory and extension to animal house, single men's quarters, and workshop store building, Yalanbee Experiment Station, Baker's Hill, W.A. **$52,000**

APPLIED MINERALOGY—Workshop at Floreat Park, Perth. **$51,000**

SOILS—Radioactive rooms, Glen Osmond, Adelaide. **$47,000**

Industry grant for fibreboard research

The Australian Fibreboard Containers Manufacturers' Association (AFCMA) has entered into a contract with CSIRO to support research on the manufacture of corrugated and solid fibreboards and their conversion into containers. Under the contract, the Association will provide the DIVISION OF FOREST PRODUCTS with a minimum sum of $35,000 a year for five years. As a preliminary to drawing up a programme of research, the Division is conducting a survey to determine the most urgent technical problems facing the industry and to obtain some assessment of their economic significance.

On behalf of its members, the Association intends applying to the Commonwealth Government for a grant towards the cost of the research programme under the Industrial Research and Development Grants Act of 1967. The Act provides for grants of 50% of 'eligible' expenditure up to $50,000 in any year to companies incorporated in Australia, subject to various conditions. To be eligible for a grant, the research work need not be undertaken by the industrial company itself but can be carried out under contract by an approved research organization. CSIRO has been approved for the purposes of the Act.

Since the Act was passed CSIRO has entered into contracts with a number of individual companies, but the contract with the AFCMA is the first with an industrial association.

Rangelands research

Three-quarters of Australia is too dry for cropping or pasture improvement to be economic. In this vast area agriculture is limited to the grazing of stock on natural pastures. Although about half the area is unoccupied and stocking rates on the remainder are low, these arid and semi-arid rangelands carry a third of Australia's sheep and cattle and earn an export income of more than $400 million a year.

Because of the harsh climate, the native vegetation of the rangelands is in a state of delicate balance with the environment. Grazing can easily upset this balance and lead to deterioration of the vegetation and the land surface. Particularly in the more arid areas such changes can be irreversible and it may be impossible to revegetate these areas economically once they have been degraded.

Because of the short history of settlement in Australia, the condition of large areas of rangeland is better than it might otherwise have been. But in the absence of scientifically based methods of management the pastoral industry is exploitative and tends to mine the land and vegetation resources on which production depends. Some properties have been exploited by short-term leaseholders wanting quick profits, but in most cases resources are being depleted because both graziers and scientists know so little about the long-term effects of different management practices.

Most rangelands are beginning to show signs of damage and some have already deteriorated badly. In many areas pastoral production per square mile has declined to well below the peak that usually occurred soon after the land was settled.

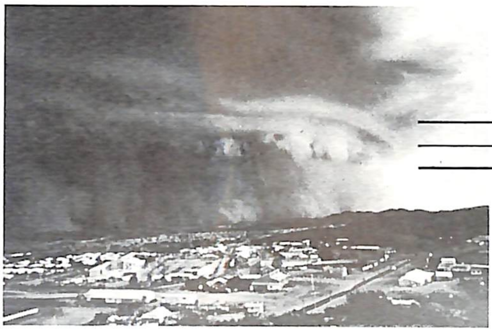
Unless Australia learns to manage her rangeland resources so as to ensure their permanent productivity, they will deteriorate to unproductive waste land that cannot be restored.

A number of individual scientists have studied various aspects of rangelands in the past, but there has been little concerted scientific effort. As a first step towards overcoming this lack of coordinated research and to obtaining the scientific information on which proper maintenance and use of rangelands can be based, the Executive has set up an interdivisional organization called the Rangelands Research Programme. The Programme, which involves scientists from the DIVISIONS OF LAND RESEARCH, PLANT INDUSTRY, and WILDLIFE RESEARCH, is managed by a committee on which each participating Division has a representative. Other Divisions are likely to take part later. The Chairman of the Committee is responsible to the Executive for the planning and implementation of the programme of research.

The Programme has its headquarters in Canberra. There is an active field centre at the Riverina Laboratory, Deniliquin, in the winter-rainfall semi-arid region, and a developing field centre in the summer-rainfall arid region at Alice Springs where scientists from both CSIRO and the Northern Territory Administration are working in collaboration. Other field centres representative of winter-rainfall arid and summer-rainfall semi-arid conditions will be required in the future.

The task of providing a scientific knowledge of Australia's rangelands is tremendous, and will take many years. No single organization can hope to tackle the many important problems involved, but CSIRO will seek collaboration with other organizations by making its facilities available to them for rangelands research and talks with the universities have already begun.

The rangeland pastoral industries can be considered as a climate–soil–vegetation–animal system, which must be maintained in some sort of equilibrium if it is to remain productive. Falling rain causes both erosion and an increase in soil moisture, soil moisture and sunlight produce plant growth, plant

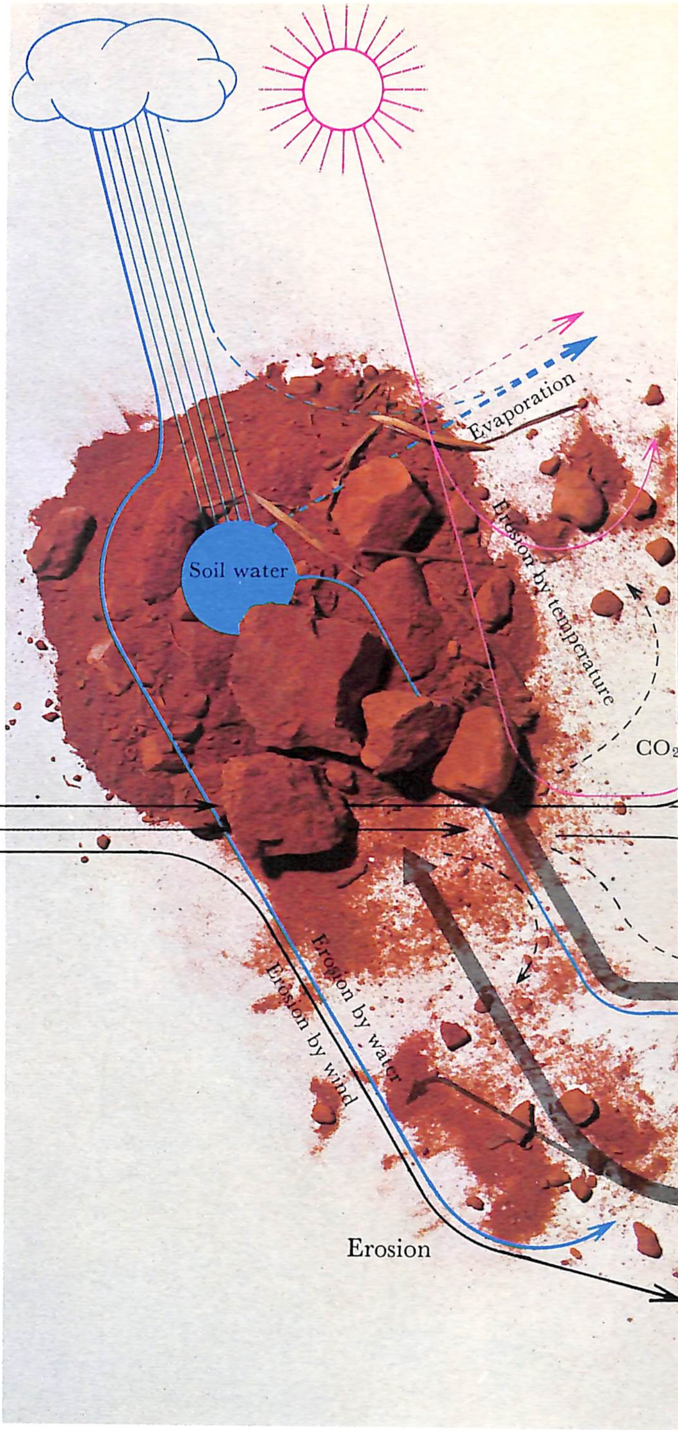


Dust storm approaching Alice Springs

growth helps to protect the soil from erosion and provides forage for animals, and animals grazing the vegetation reduce its protective effect on the soil but produce wool and meat.

Viewed in this way, the needs of the land, including its vegetation, are more important to the stability of the system than the needs of the animals. Land can be regarded as the long-term resource, animals as short-term devices for harvesting production from that resource.

The climate–soil–vegetation–animal system is complex, and a good deal of long-term research on the processes operating in it will be needed before proper management practices can be designed.



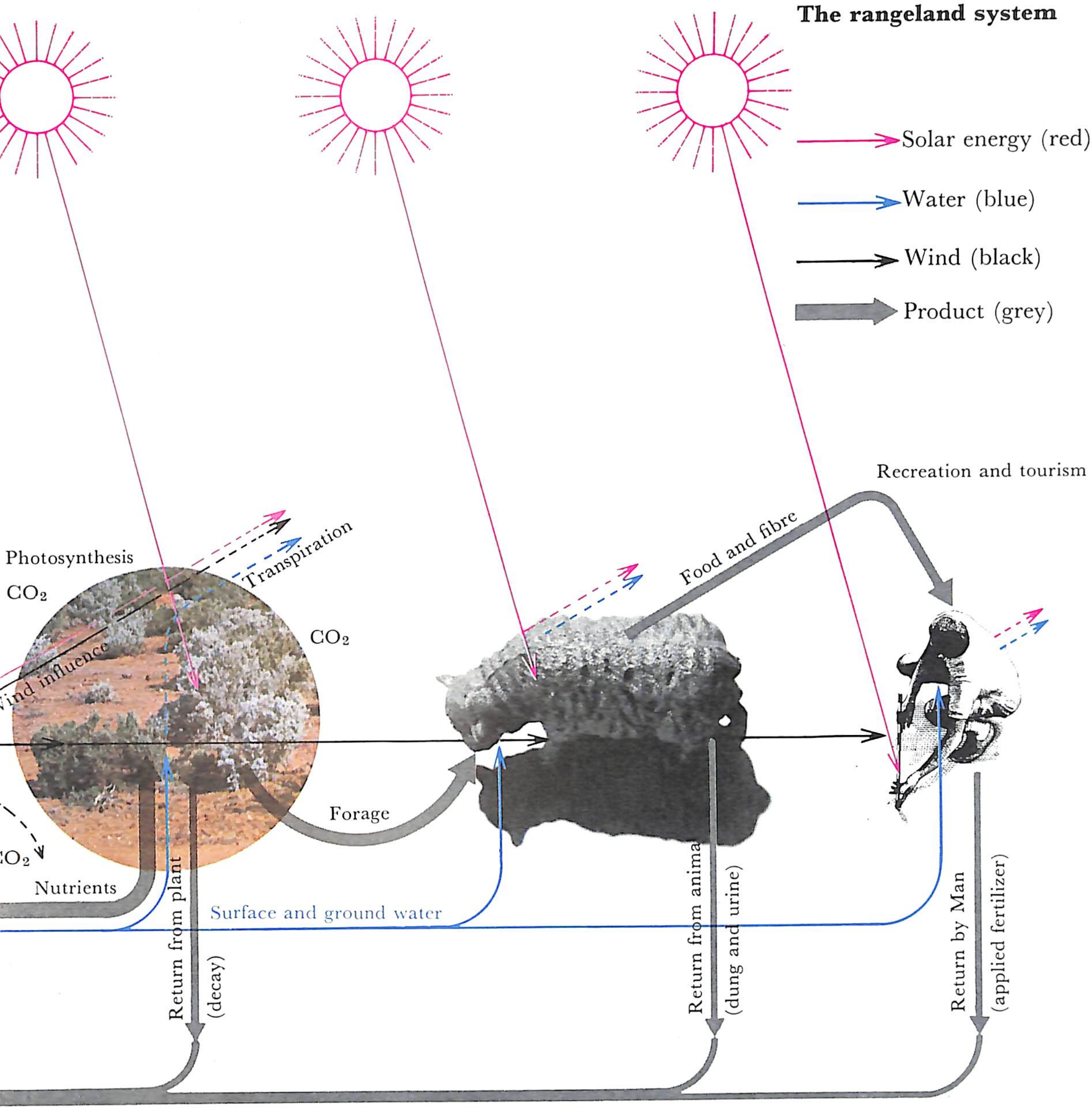
Climate

The rangeland area (map, p.22) can be divided into four climatic zones: summer rainfall arid, summer rainfall semi-arid, winter rainfall arid, and winter rainfall semi-arid.
Scientific disciplines
Agroclimatology, microclimatology, environmental physics

Land

The land is mainly level to gently undulating.
The soils are generally of ancient origin and infertile, the most extensive are red sands, red earths and cracking clays
Scientific disciplines
Geology, geomorphology, pedolog soil physics, soil chemistry, microbiology, hydrology

The rangeland system



Plants

ARID Scrub (mulga, gidgee), spinifex, shrublands (saltbush, bluebush), grasslands (Mitchell grass)

SEMI-ARID Scrub (mulga, belah, cypress pine), shrublands (saltbush, bluebush), grasslands (Mitchell grass, *Danthonia*)

Scientific disciplines

Ecology, physiology, agronomy, genetics and breeding, taxonomy

Animals

Domestic animals are confined to the scrub, shrub, and grasslands. Beef cattle, sheep, marsupials, rabbits, predators and pests

Scientific disciplines

Ecology and behaviour, genetics and breeding, physiology, taxonomy, nutrition, health and husbandry,

Man

Conservation, production management, engineering

Value of CSIRO research

In 1966 the CSIRO Patents Committee suggested that Head Office should attempt to assess the economic benefits that Australia has derived from CSIRO's research. As a first step towards this the Industrial and Physical Sciences Branch of Head Office conducted a pilot survey in 1967 to obtain a better appreciation of some of the problems that such an undertaking would entail. The survey was confined to the benefits from those CSIRO research results that have been patented and licensed to Australian firms for at least two years. This selection represents only a very small part of the Organization's total research output, but it offered several practical advantages. The survey, which covered 16 manufacturing firms, also provided an opportunity for re-examining the effectiveness of CSIRO's patent and licence practice.

The first conclusion from the survey was that a total evaluation of the economic benefits from CSIRO's research was not possible at present, even in the limited field covered by patent licence agreements. Firstly, there is the problem of finding suitable methods of measuring benefits. In those cases where the licences relate to improvements in products or processes it is not always easy to determine how much of the increase in productivity is due to CSIRO's contribution. A second problem is the difficulty of identifying and measuring the value of secondary benefits. For example, Amalgamated Wireless (A/asia) Ltd. has made, under licence to CSIRO, aircraft navigation equipment valued at over $5½ million. The benefit to the community, and to the Australian economy as a whole, goes much further than the increased employment and development of new skills that resulted from the actual production of these instruments. To some extent at least, the high standards of aircraft safety in Australia are a direct result of the early adoption of the CSIRO equipment.

Atomic absorption spectroscopy provides another example of important secondary benefits. Between 1962 and 1967 Techtron Pty. Ltd. manufactured atomic absorption apparatus valued at over $4 million. The value of secondary benefits is less easily assessed but is very much greater than this. For example costs of geochemical analysis have been reduced to about a quarter and in some cases a tenth of their former levels by atomic absorption. These low cost levels and the simplicity and speeds of the determinations have made possible geochemical surveys which otherwise would not have been attempted. Hospital laboratories are using atomic absorption for the routine analysis of blood serum samples for elements such as calcium and magnesium; this would not have been practicable by earlier methods.

A second conclusion from the survey was that CSIRO's patent and licensing practice was basically sound. Several minor suggestions for changes in practice were made by manufacturers and these changes have been accepted and put into effect in recent licence agreements.

As a result of the experience gained from the pilot survey it was decided to attempt further assessments of the economic benefits of CSIRO's research work. Accordingly, the Industrial and Physical Sciences Branch in collaboration with the DIVISION OF CHEMICAL PHYSICS has begun a study of atomic absorption spectroscopy, using the technique of cost-benefit analysis, to determine the value of atomic absorption to the Australian economy.

Treated proteins for sheep and cattle

Last year's Annual Report (pages 32–3) described a programme of research by the DIVISION OF ANIMAL PHYSIOLOGY which has shown that remarkable increases in wool growth can be obtained when proteins or certain amino acids are put into the fourth stomach (abomasum) of a sheep. When a sheep is fed by mouth, the food is fermented by bacteria in the rumen and often only a small amount of the protein in the food gets through to the fourth stomach. The Division has been investigating different ways of treating food which make the protein in it resistant to bacterial attack and so allow more protein to reach the abomasum.

This work, together with related research by the University of Melbourne on fat lambs, may have far-reaching consequences for both the sheep and cattle industries. The research is now at the stage where some guidance is desirable on the types of agricultural production that are likely to benefit most from feeding treated proteins to sheep and cattle. The Division wants to know, for example, whether the potential value of the technique is greatest during drought or in a normal season, and whether the technique will be applied in semi-arid areas before the higher-rainfall areas.

The Executive has therefore made a grant to the University of Melbourne to study the economic implications of the Division's research. Although the study is expected to take up to three years, it is hoped that sufficient information will become available in the early stages to provide the Division with guidelines for directing its research efforts to those areas where the application of the technique will have most impact.

David Rivett Memorial Lecture

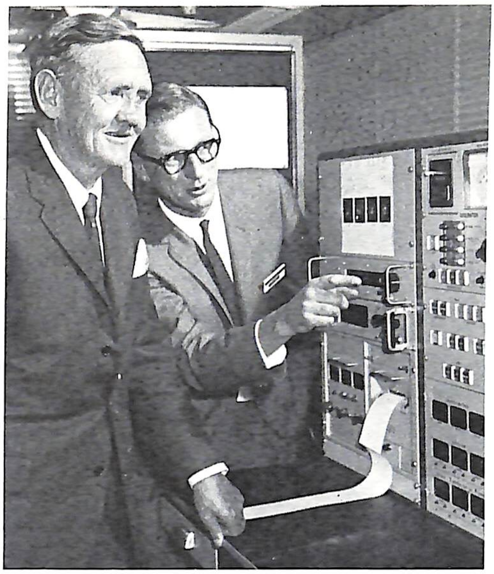
Dr. Maurice Ewing, Director of Lamont Geological Observatory, Columbia University, delivered the third David Rivett Memorial Lecture at the University of New South Wales on July 6, 1967. His subject was the sediment cover of the deep sea floor. Dr. Ewing also spent four weeks visiting laboratories in Australia and New Guinea, and took part in a two-week oceanographic voyage to study the Coral Sea plateau.

The Rivett Lectures commemorate the name of the late Sir David Rivett, who was Chief Executive Officer and later Chairman of the Council for Scientific and Industrial Research, the forerunner of CSIRO. They are given every second year by men who have reached the highest ranks of achievement in scientific research. Previous Memorial Lecturers were Lord Adrian and the late Lord Florey.

Solar Observatory, Culgoora

On September 22, 1967, Mr. J. G. Gorton, then Minister for Education and Science, opened the CSIRO Solar Observatory and commissioned its radioheliograph. The Observatory, which occupies a 3000-acre site at Culgoora, halfway between Narrabri and Wee Waa in northern New South Wales, is operated by the DIVISIONS OF RADIOPHYSICS and PHYSICS.

The radioheliograph, a unique instrument for obtaining continuous



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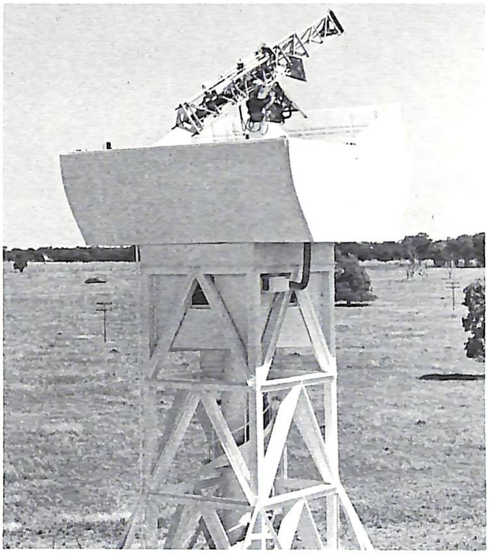
1. Mr. J. G. Gorton inspects the radioheliograph control room with Dr. J. P. Wild of the Division of Radiophysics. The radioheliograph was conceived and designed by Dr. Wild and his colleagues.



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'radio pictures' of the Sun, consists of a huge ring of 96 dish-shaped radio aerials, each 45 feet across, equally spaced around the perimeter of a circle nearly 2 miles in diameter. Each of the radioheliograph's aerials is automatically steered to follow the Sun. Radio signals from the Sun are picked up by the aerials and fed to a central observatory. Here the signals are passed into a complex of electronic circuits and computers and finally displayed as detailed pictures on a television screen at a rate of one every second. Before the radioheliograph came into operation the fastest radio pictures of the Sun took about 45 minutes to compile.

Construction of the radioheliograph was made possible by a grant of $563,000 from the Ford Foundation of America. In addition, some $533,000 has been contributed by the Commonwealth Government for the capital cost of works associated with the radioheliograph and the Observatory.

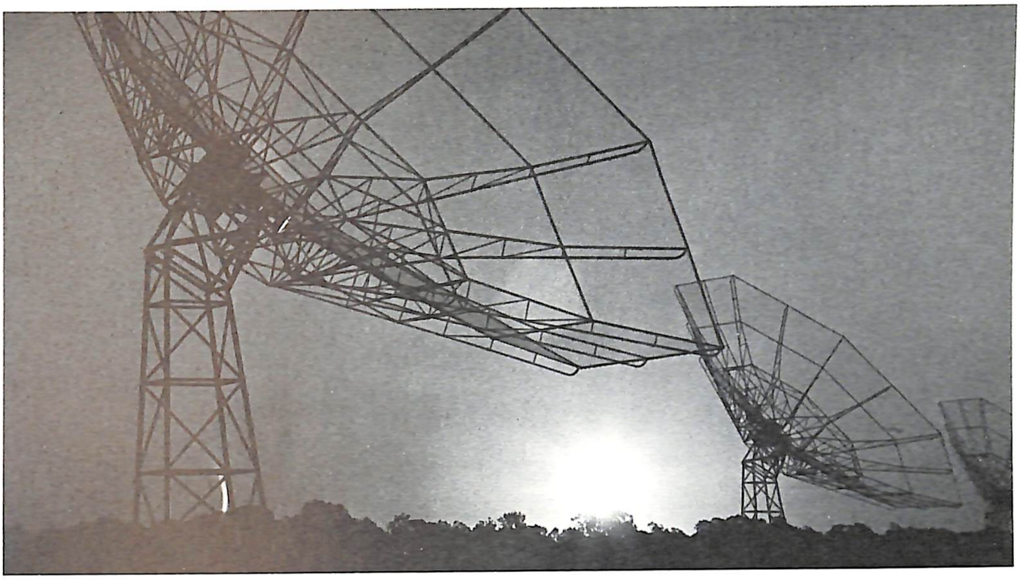
Near the centre of the ring of radioheliograph aerials are the optical telescopes operated by the DIVISION OF PHYSICS. The main optical instrument is a 12-inch high-resolution telescope capable of seeing details of the Sun's surface as small as 450 miles in diameter. It is mounted on a 50-foot tower to avoid turbulent currents of heated air which interfere with the solar image and prevent the observation of fine detail. The telescope dispenses with the conventional dome, which itself can be a source of damaging thermal currents. Instead, it is provided with a canopy

2. The 12-inch optical telescope operated by the Division of Physics at Culgoora. The telescope is mounted on a 50-foot tower.

3. Section of the circle of radioheliograph aerials. They are uniformly spaced 100 yards apart around the perimeter of a circle which measures nearly 6 miles.

4. This picture of a sunspot taken with the 12-inch telescope shows the fine detail that can be obtained. The dark core of the sunspot is about 11,000 miles wide.

3



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that can be fully retracted into the supporting structure when the telescope is being used. The telescope itself is of open lattice-work construction so that it remains in full thermal equilibrium with the surrounding air. As a final aid to thermal control, all parts of the telescope directly exposed to the Sun's rays are cooled by an elaborate air suction system. In operation, the telescope is completely automatic; even the decision to take an exposure at a given instant is made by an electronic device that continuously monitors the image quality.

In addition to the 12-inch telescope the DIVISION OF PHYSICS operates a smaller telescope provided by the United States Environment Science Services Administration for recording flares and other solar disturbances. This is part of an international programme and reports on solar activity are sent regularly to World Data Centres in France, Russia, and the United States.

The Observatory is the only one in the world with facilities at the one site for making high-resolution radio and optical observations of the Sun. These facilities are enabling scientists to see the Sun in much greater detail than before and to obtain a better understanding of the processes taking place on the Sun and of phenomena such as sunspots and solar flares.

Library

The publications held by the CSIRO Library constitute the largest single collection of literature on science and technology in Australia. CSIRO's library system differs from that of most other libraries in that its holdings are not housed together in one single collection. Instead they are housed in some fifty different libraries throughout the Organization. In this way CSIRO ensures that the literature is located close to the scientist who is most likely to use it. At the same time the Central Library keeps a record of each publication and where it is held, so that each associated library can draw readily on the resources of the others.

The Organization's holdings now number more than half a million and are growing at a rate of some 50,000 items a year. The most important part of the Library is its collection of serial publications. CSIRO has 8000 serial title subscriptions and an additional 15,000–18,000 exchange titles. The control of something in the order of 25,000–30,000 title sets, including duplicates, from every country and the renewal of subscriptions involves a good deal of routine administrative and clerical work. Computer-based methods of subscription control and renewal have been developed and together with mechanized methods of ordering publications have helped free the Organization's librarians for more productive work. Computer techniques are now being developed to simplify the processing and distribution of publications as they are received.

A problem common to all libraries today is that of locating the information stored in them. Before suitable computer-based systems of information retrieval can be developed the stored information needs to be catalogued as unambiguously as possible. As a first step towards this, the Library has compiled a list of 13,500 scientific and technical words which can be used as a carefully controlled vocabulary of indexing terms. The list should be useful not only to CSIRO but to all other groups dealing with information retrieval in similar fields.

Post-graduate studentships

Each year CSIRO awards a number of studentships to graduates of Australian universities as part of its policy of providing opportunities for research training. Half of these studentships are awarded to persons wishing to work in certain nominated fields of specific interest to CSIRO.

There is no obligation on studentship holders to seek employment in CSIRO, but the Organization does encourage them to develop close contacts with appropriate CSIRO laboratories. Holders of overseas studentships must give an undertaking to return and work in Australia for at least three years upon completion of their course.

Local pre-doctoral studentships

These are awarded for two years initially to persons who have completed at least one year of full-time post-graduate study. Under certain circumstances they may be extended for a further two years. There were 257 applications. The 26 candidates awarded studentships are listed below with their universities.

Besley, L. M.	(Western Australia)
Boyd, P. D.	(Tasmania)
*Bromley, A. G.	(Sydney)
Canty, A. J.	(Monash)
Corrie, J. E.	(Sydney)
Dobson, J. F.	(Melbourne)
Gardner, J. L.	(Adelaide)
*Gray, C. M.	(Adelaide)
*Hockey, B. A.	(Sydney)
Hodgeman, D. K.	(Adelaide)
Kikkert, J. N.	(Adelaide)
*Kinnear, J. F.	(Melbourne)
*Linden, P. F.	(Flinders)
Lowy, D. N.	(Melbourne)
Martin, L. R.	(Adelaide)
*Muirhead, R. J.	(Adelaide)
O'Brien, R. S.	(Adelaide)
Ord, M. J.	(Melbourne)
*Ratcliffe, D.	(Adelaide)
Slobbe, J.	(Western Australia)
*Smith, G. B.	(New England)
*Starr, J.	(Melbourne)
Taylor, D. E.	(Monash)
Urch, I. H.	(Adelaide)
*Watson, R. K.	(Melbourne)
*Williams, A. F.	(Melbourne)

Overseas pre-doctoral studentships

All overseas pre-doctoral studentships are awarded in areas of specific interest to CSIRO and their tenure overseas is fixed, bearing in mind the most appropriate place of study. Awards were made to the following:

*Bacskay, G. B.	(Melbourne)
*Brent, R. P.	(Monash)
*Webb, J. M.	(Melbourne)

Overseas post-doctoral awards

These are awarded to post-doctoral scientists to enable them to proceed overseas for one year to work with leaders of research in their special field of interest. During the year 42 applications were received and 11 awards were made to the following:

Allison, G. B.	(Adelaide)
Blagrove, R. J.	(Adelaide)
Casey, B. A.	(Adelaide)
*Gawthorne, J. M.	(Western Australia)
Jackson, M. B.	(Adelaide)
Lipa, J. A.	(Western Australia)
*Mayo, O.	(Adelaide)
*Oitmaa, J.	(New South Wales)
*Polya, G. M.	(Tasmania)
*Summerfield, W. C.	(Flinders)
*Tomas, F. M.	(Western Austraial)

* Awards made in the following areas of specific interest to CSIRO: Morphogenesis and differentiation, ruminant physiology, mathematical statistics, geochemistry, geophysical fluid dynamics, solid state chemistry and physics, astrophysics, numerical analysis, engineering systems analysis.

Headquarters of CSIRO Divisions and Sections

Melbourne
Head Office
Division of Animal Health
Division of Applied Chemistry
Division of Applied Mineralogy
Division of Building Research
Division of Chemical Engineering
Division of Chemical Physics
Division of Dairy Research
Division of Forest Products
Division of Mechanical Engineering
Division of Meteorological Physics
Division of Mineral Chemistry
Division of Protein Chemistry
Division of Soil Mechanics
Division of Tribophysics
Editorial and Publications Section
Ore Dressing Laboratory
Physical Metallurgy Section

Geelong
Division of Textile Industry

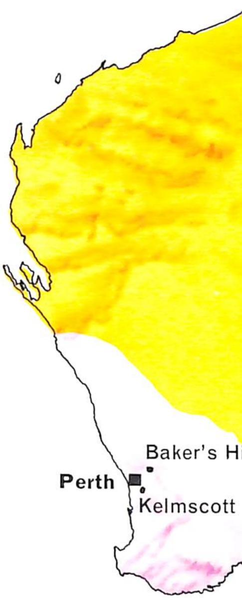
Griffith
Division of Irrigation Research

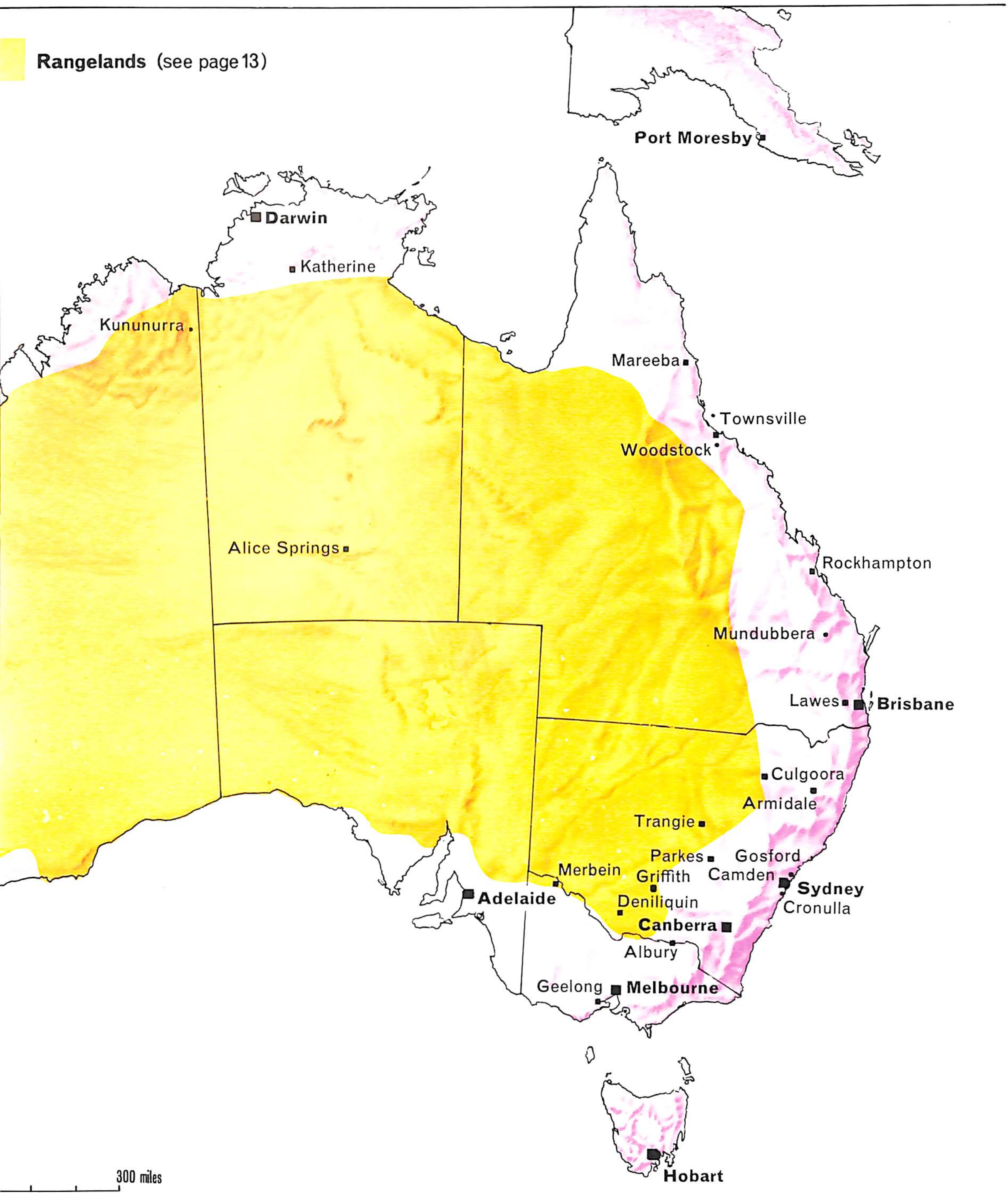
Brisbane
Division of Tropical Pastures

Sydney
Division of Animal Genetics
Division of Animal Physiology
Division of Applied Physics
Division of Fisheries and Oceanography
Division of Food Preservation
Division of Physics
Division of Radiophysics
Division of Textile Physics
Upper Atmosphere Section
Wheat Research Unit

Canberra
Division of Computing Research
Division of Entomology
Division of Land Research
Division of Plant Industry
Division of Wildlife Research

Adelaide
Division of Mathematical Statistics
Division of Nutritional Biochemistry
Division of Soils
Division of Horticultural Research





Rangelands (see page 13)
Port Moresby
Darwin
Katherine
Kununurra
Mareeba
Townsville
Woodstock
Alice Springs
Rockhampton
Mundubbera
Lawes
Brisbane
Culgoora
Armidale
Trangie
Parkes
Gosford
Merbein
Griffith
Camden
Sydney
Adelaide
Deniliquin
Cronulla
Canberra
Albury
Geelong
Melbourne
Hobart
300 miles

Research

The first of the functions of CSIRO, as defined in the *Science and Industry Research Act*, is to carry out scientific research 'in connexion with, or for the promotion of, primary or secondary industries . . .' Over nine-tenths of the Organization's resources are committed to carrying out research.

CSIRO has always been decentralized and today it has nearly forty Divisions and Sections spread throughout the Commonwealth in more than one hundred laboratories and field stations. As envisaged in the Act, the Organization's work has spread to Australia's Territories and several Divisions are conducting research in Papua and New Guinea.

To give a full account of all the research going on in CSIRO would fill a volume many times the size of this Report. This chapter includes only one or two items of interest from each Division and Section. Anyone wanting more comprehensive information on the work of the Organization should consult the separate annual reports of the individual Divisions and Sections and the annual lists of 'Papers, Books, and Patents by Members of the Staff of CSIRO' and 'Serial Publications, Monographs, and Pamphlets issued by CSIRO'.

Taken together, the items in this chapter show something of the tremendous range of the Organization's activities and the relevance of CSIRO's research to Australia's primary and secondary industries. Individually, however, each item describes only a few aspects of the work of a particular Division, so that the reader may be left with an incomplete view of what that Division does. To help overcome this and to restore some sort of perspective, a series of tables has been included in the chapter. The purpose of these tables is to show for each Division and Section the location of its laboratories and field stations; its size in terms of staff and finance; the sources of its finance; the composition of its staff in terms of research scientists, other professional staff, and supporting staff; and the main fields of research in which it is engaged. It is hoped that in this way the reader will be able to see each item within the broader context of CSIRO's overall research programme.

Division of Soils

Location: Glen Osmond, Adelaide, with laboratories in Brisbane, Canberra, Hobart, Perth, and in Townsville, Qld.

Finance: $1,404,694 (Treasury $1,273,583, contributory $131,111)

Staff: Research scientists 61, other professional staff 32, supporting staff 82

Fields of research:

Soil fertility—physical, chemical, and biological properties of soils in relation to plant growth

Soil water—hydrology and salinity, water use by plants

Soil mineralogy and geochemistry—mineral forms of nutrient elements, changes in weathering, clay minerals

Nutrient and toxic elements—chemistry, factors affecting availability, measurements of availability, design of fertilizers ●

Organic matter—chemical nature; formation and decomposition and effect on this of soil microorganisms, ants, and termites; toxic factors in soil

Tillage—effects of cultivation on physical properties of soil and on plant growth

Formation, distribution, and classification of soils—micromorphology, transport of sediment ●

● A black dot against a research programme indicates that one of the items which follow deals with that area of research.

Division of Meteorological Physics

Location: Aspendale, Melbourne

Finance: Treasury $498,665

Staff: Research scientists 20, other professional staff 11, supporting staff 42

Fields of research:

Development and movement of weather systems

Upper atmosphere—circulation patterns

Exchange of heat, water vapour, and momentum between atmosphere and Earth

Meteorology and plant growth

Solar, atmospheric, and terrestrial radiation

Maintenance of radiation standards, calibration of anemometers and radiation instruments

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Division of Land Research

Location: Canberra, with laboratories and field stations at Alice Springs, Katherine, and Coastal Plains, N.T., and at Kununurra, W.A.

Finance: $1,314,931 (Treasury $1,058,746, contributory $256,185)

Staff: Research scientists 37, other professional staff 27, supporting staff 99

Fields of research:

Land resources surveys in Australia and Papua–New Guinea

Regional assessment of land use potential at Kimberley Research Station, Katherine Research Station, and Coastal Plains Research Station

Rangelands research at Alice Springs

Crop–environment relations

Hydrology—ground water and catchment studies

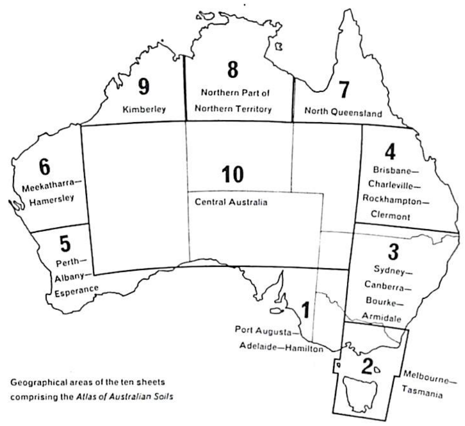
Atlas of Australian Soils

Australia has a great variety of soils, extending as they do from the alpine Kosciusko plateau to the tropical Cape York Peninsula and from the friable black clays of the Darling Downs to the sand plains of Western Australia. Soil maps of particular areas of Australia have been prepared at one time or another by survey teams from CSIRO and from various government departments and universities, but different survey teams have used different systems of soil classification. Some teams have surveyed areas in great detail, others have recorded only the most general information.

For the last ten years, scientists in the DIVISION OF SOILS have been conducting further soil surveys to fill in the enormous gaps which exist in our knowledge of Australia's soil resources. They have also been attempting to combine this new information with that obtained from earlier surveys and to present it all in a unified form.

The result of this project has been the 'Atlas of Australian Soils', a series of ten maps which together provide the most detailed picture yet available of our soils and their distribution. The first map in the series was issued in 1961 and the last in 1968. Each map is drawn to a scale of 1 : 2,000,000 (roughly 1 inch to 32 miles) and is accompanied by a booklet which describes in detail each soil referred to in the map. During the preparation of the Atlas, the Division developed a completely new system of classifying soils known as the 'factual key'. This classification is based solely on those soil properties that can be determined in the field by observation and simple test.

The Atlas makes it possible to compare and contrast soils from different parts of Australia. For example, it shows that the soils of the Esperance plains in Western Australia and of the Pilliga scrub in New South Wales are similar to those of parts of the south-east of South Australia. This means that the results of research on soil properties in one of these areas is relevant to the other areas as well. Soil relationships revealed by the maps should provide research workers with a valuable guide for planning further work on soil properties and plant growth.



Geographical areas of the ten sheets comprising the *Atlas of Australian Soils*

Biosuper

At the DIVISION OF SOILS, scientists have devised a novel way of turning low-grade rock phosphate into a more useful fertilizer which they have named 'biological superphosphate' or 'biosuper'. This fertilizer could be a suitable alternative to superphosphate in much of northern Australia where there are deposits of rock phosphate and where the cost of bringing in superphosphate is high. Biosuper is made by pelleting rock phosphate with sulphur and certain bacteria called thiobacilli. When biosuper is added to the soil, the thiobacilli slowly convert the sulphur into sulphuric acid. The acid then acts on the rock phosphate, changing it into a soluble product resembling superphosphate and gradually releasing sulphur and phosphorus for plant growth.

Biosuper is essentially a slow-acting, long-term fertilizer. Where a quick response is wanted, for example during pasture establishment, superphosphate is better. But biosuper could provide a reasonable alternative to superphosphate in northern Australia in those situations where it is intended to apply large amounts of fertilizer at infrequent intervals. Field trials are now being carried out in the Northern Territory to test the value of biosuper on rice, sorghum, and Townsville lucerne pastures. Biosuper might have advantages over superphosphate on certain sandy soils where phosphorus is easily dissolved and washed away, and on lateritic soils where phosphorus tends to become fixed in the soil and unavailable to plants.

Project Wangara

The low-level westerly winds of temperate latitudes would be brought to a halt within a few days by the braking effect of the Earth's surface if they were not constantly supplied with energy. This energy is transported downwards from the jet streams found at heights of 6 to 8 miles, but the means by which this is done, particularly in the lowest few thousand feet of the atmosphere, is imperfectly understood.

In July and August 1967, a team of 35 observers from the DIVISION OF METEOROLOGICAL PHYSICS and the Commonwealth Bureau of Meteorology conducted an extensive field experiment to find out more about the mechanism by which this transfer of energy takes place. The experiment, which was dubbed Project Wangara after an aboriginal word for west wind, covered an area of 2500 square miles around Hay, in the Riverina district of New South Wales.

Four field stations were set up, each about 25 miles from Hay, while a fifth station was set up near the town. Every hour balloons were released from each station and tracked to determine wind speed and direction up to 7000 feet. This routine was maintained day and night for six weeks. In addition, balloons carrying instruments to radio back information on temperature and humidity at different heights were released from the control station every three hours, and a continuous record was kept of meteorological observations near the ground.

The Division is now using the information collected during Project Wangara to calculate the vertical speed of the air in the lowest few thousand feet of the atmosphere. By relating vertical speed to variations in westerly winds the Division expects to gain a better understanding of the process of energy transfer. Meteorologists will then be able to refine the complex mathematical models they have constructed to describe the atmosphere and processes of weather formation.

Plant growth and environment in northern Australia

In sunlight, plants make their tissues out of water from the soil and carbon dioxide from the air. At Katherine in the Northern Territory, the DIVISION OF LAND RESEARCH is trying to find out the contribution carbon dioxide, water, and sunlight each make to plant growth.

Two 10-acre blocks, one of Townsville lucerne and one of bulrush millet, are being studied. The environment in which these plants grow is not uniform: some leaves receive less sunshine than others because they are shaded or hang at different angles; the carbon dioxide content of the air above a crop is very different from that within the crop, and so on. Many measurements at different levels in the crop need to be made, therefore, if the plant's environment is to be defined adequately. Every few minutes some 200 separate measurements of humidity, temperature, sunlight, and carbon dioxide concentration are automatically recorded for the Townsville lucerne crop, and more than 300 for the taller bulrush millet crop. This information is punched on a computer tape as each measurement is made. A number of other measurements such as yield of dry matter, water content of leaves, soil moisture, and patterns of root distribution are made at less frequent intervals.

All this information is being analysed in a computer so that mathematical equations which describe in detail how plant growth is related to environment can be established. Agriculturists may then be able to use these equations to predict how well Townsville lucerne or bulrush millet might perform in different environments in Australia or overseas. These equations could also provide plant breeders with an additional guide to the sort of characters they should select for when breeding varieties to suit a particular environment.

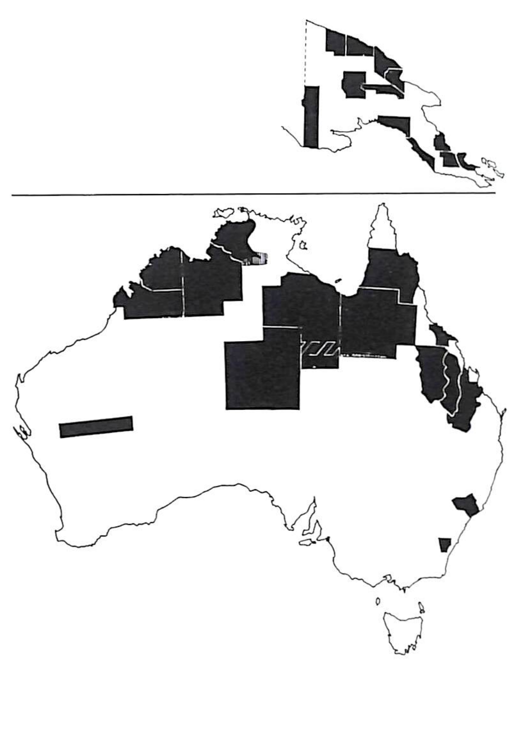
Surveying Australia's land resources

In the last 22 years the DIVISION OF LAND RESEARCH has described and mapped the agricultural potential and land resources of some 845,000 square miles of country in Australia and New Guinea. The basic unit of mapping has been the 'land system'. This is an area of land with a recurring pattern of topography, soils, and vegetation. The preparation of these maps involves the extensive use of aerial photography together with ground surveys by teams of specialists in geology, botany, climatology, soil science, plant ecology, and geomorphology (the study of land forms).

The capacity of the Division to collect information for classifying land systems has increased greatly in recent years and is continuing to increase. Instruments have been invented in CSIRO and elsewhere which can be left unattended in remote areas for months at a time and which will keep a continuous record of such things as rainfall, temperature, humidity, and stream flow. Aerial photography has also become much more sophisticated and can be supplemented by other 'sensing' techniques. There is now a variety of cameras and other sensing devices that can be operated from aeroplanes and satellites to take pictures of land using visible light, infrared radiation, radar, and gamma rays.

To provide a test area for new instruments and techniques in land resources surveys, the Division has surveyed a 3300-square-mile area just east of Canberra by the survey methods that it employs in northern Australia and New Guinea.

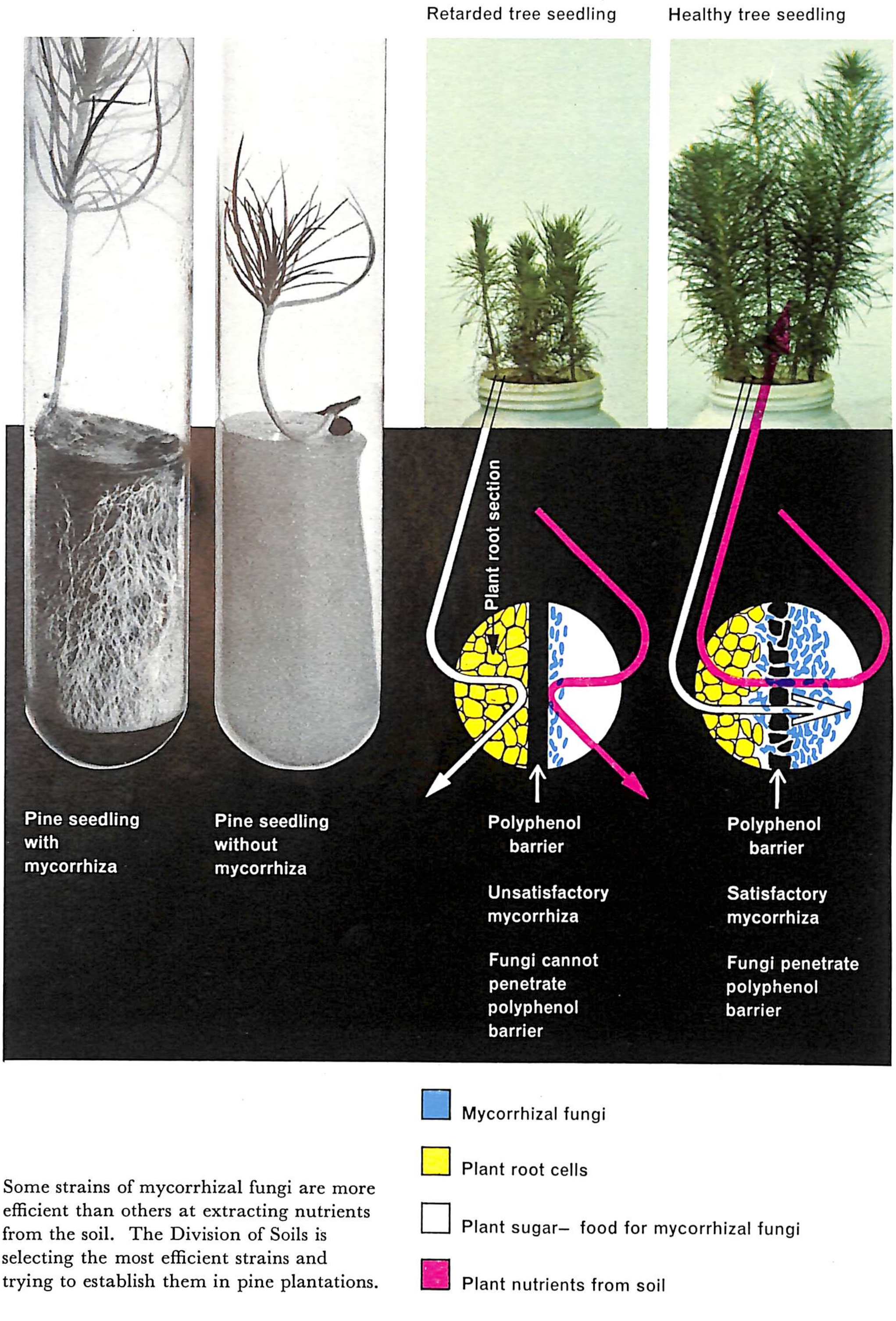
The Division is using this area to learn what it can about the processes that shape landscapes and determine their vegetation, and to study the relationship between soil characteristics and land form. Observations of seasonal changes in vegetation are being made along a 10-mile strip of the Shoalhaven valley by aerial colour photography. The Division is also developing computer methods to simplify and speed up the storage, retrieval, and interpretation of the rapidly increasing amounts of information on land resources that are coming from these new instruments and techniques.



Areas where the Division of Land Research has conducted natural resources surveys.

Forest trees have certain fungi associated with their roots. The fungi extract nutrients from the soil and convey them to the roots. In return the trees supply the fungi with sugars. The association of fungus and root is called a mycorrhiza.

The Division of Forest Products, working with the Victorian Forests Commission, has shown that some tree seedlings fail to thrive because their roots produce polyphenols which prevent the satisfactory establishment of a mycorrhiza. Douglas fir, which cannot be grown economically in Victoria, produces many polyphenols and few strains of fungi can cope with them. *Pinus radiata* produces few polyphenols and most strains of fungi can cope with them.



Some strains of mycorrhizal fungi are more efficient than others at extracting nutrients from the soil. The Division of Soils is selecting the most efficient strains and trying to establish them in pine plantations.

Crops and pastures

Division of Plant Industry

Location: Canberra, with laboratories in Brisbane, Deniliquin, N.S.W., Hobart, and Perth, and field stations and experimental farms at Canberra, Deniliquin, N.S.W., Baker's Hill, Kelmscott, and Pinjar, W.A., and the Tobacco Research Institute at Mareeba, Qld.

Finance: $3,442,105 (Treasury $2,283,856, contributory $1,158,249)

Staff: Research scientists 117, other professional staff 64, supporting staff 317

Fields of research:

Pasture improvement and utilization—plant introduction, breeding, selection, establishment, evaluation, and management ●

Nutrition of plants—soil fertility, fertilizers, physiology of nutrient uptake, nitrogen fixation ●

Plant–environment interactions—ecology and management of native vegetation; weed control; biophysics—interactions with physical environment, particularly energy and water

Biochemical and physiological processes in plants

Plant diseases—host–pathogen interactions

Tobacco agronomy and breeding

Division of Horticultural Research

Location: Glen Osmond, Adelaide, with a branch laboratory and field station at Merbein, Vic.

Finance: $417,156 (Treasury $381,747, contributory $35,409)

Staff: Research scientists 17, other professional staff 2, supporting staff 38

Fields of research:

Grape vines—genetic improvement, viruses, crop management, fruit processing, vine physiology and biochemistry ●

Fruit trees—physiology, orchard ecology

Parasitic nematodes (eel-worms) of vines and fruit trees—physiology, ecology, methods of control ●

Division of Tropical Pastures

Location: St. Lucia, Brisbane, with laboratories at Townsville and Lawes, Qld., and field stations at Mundubbera, Samford, and Townsville, Qld.

Finance: $1,303,216 (Treasury $1,051,888, contributory $251,328)

Staff: Research scientists 37, other professional staff 16, supporting staff 150

Fields of research:

Pastures for tropical and subtropical regions of Australia

Evaluation of new pasture species, plant breeding and genetics ●

Establishment, nutrition, and utilization of pastures ●

Nitrogen—legume bacteriology, nitrogenous fertilizers

Plant ecology and control of regrowth of woody species

Division of Irrigation Research

Location: Griffith, N.S.W.

Finance: $413,981 (Treasury $395,263, contributory $18,718)

Staff: Research scientists 10, other professional staff 10, supporting staff 48

Fields of research:

Water utilization by irrigated plants: soil–plant–water–atmosphere interactions

Agronomy of irrigated crops—citrus, cotton, rice ●

Climatology, hydrology of irrigated basins

Stocking rates and superphosphate

Much of the increase in pastoral production in the high-rainfall areas of southern Australia since the turn of the century has been brought about by the use of superphosphate and subterranean clover to improve pastures. Most of these pastures are under-utilized and further increases in production would be possible with more intensive grazing. Recent work by scientists in the DIVISION OF PLANT INDUSTRY suggests that less superphosphate may be needed when pastures are heavily grazed.

The scientists found that lightly grazed pastures which had received moderate amounts of superphosphate in previous years produced more herbage when superphosphate was added. On the other hand, similar pastures subjected to heavy grazing showed much less response to dressings of superphosphate. Laboratory tests showed that soil from the heavily stocked paddocks contained more available phosphorus than soil from the lightly stocked paddocks. Earlier research suggested that as grazing pressure is increased the amount of phosphorus in the herbage rises. The animals therefore eat more phosphorus in their food and excrete more phosphorus in their dung. In addition, more of the phosphorus excreted is probably available to plants. Such soil effects could therefore provide at least part of the reason for the smaller response of heavily grazed pastures to fertilizer phosphorus.

But a more important explanation concerns the effect of heavy grazing on the capacity of pasture plants to produce more herbage. Under conditions of high stocking, pasture plants are defoliated frequently and suffer a check. Their reserves are depleted and must be replenished before the plants can start to grow again, so that even though there are ample phosphorus and other nutrients, the plants are unable to respond with vigorous growth. At low stocking rates, however, more herbage is produced even though much of it remains uneaten and the pasture needs more phosphorus.

The Division's work shows that the fertilizer requirements of a pasture on a particular soil depend on the rate of stocking. The higher the stocking rate, the less fertilizer the pasture needs. The common practice in agricultural research of calculating fertilizer response on ungrazed plots does not necessarily give a true guide to the fertilizer requirements of the pasture under grazing.

New clover for soil conservation

In 1958 most of the high country in the alpine regions of New South Wales was withdrawn from grazing because of its importance as a source of water for irrigation and hydroelectric power and its almost negligible value for grazing. In most cases protection from fires and livestock is leading to satisfactory recovery, but in the worst-eroded areas, particularly those above 6000 feet, soil reclamation measures have been necessary. The DIVISION OF PLANT INDUSTRY, in association with the Soil Conservation Service of New South Wales, has therefore been trying to develop a hardy pioneering legume for revegetating country above the tree-line where varieties of white clover will not persist.

Thirty years ago the Division introduced varieties of a clover, *Trifolium ambiguum*, from the Caucasian mountains and these have been used as the basis for selecting lines which will grow, persist, and fix nitrogen under alpine conditions. The breeding programme was held up for some time because of difficulties with nodulation but more suitable strains of nitrogen-fixing bacteria have now been developed. *Trifolium ambiguum* can persist through winter because of its large root reserves and its pronounced winter dormancy. Some other species of clover show this persistence too, but *Trifolium ambiguum* has deeper roots and many underground stems or rhizomes and is therefore better able to survive the destructive effects of soil heave during periods of heavy frost.

Promising lines have been selected from experimental sites in the Snowy Mountains and are now being grown in Canberra to provide adequate stocks of seed for release to soil conservation authorities. One of the lines is less suitable for soil conservation work in the alpine areas but it may be a useful pasture species in cold tableland areas with a high rainfall such as Krawaree in the upper Shoalhaven catchment where white clover is not always successful.

Better vine rootstocks

Australia's annual production of sultanas would be much higher if infestation of grape-vine roots by parasitic nematodes could be prevented. The main pests are the root knot nematode and the citrus nematode. These nematodes are tiny semi-transparent worms which infest the roots and interfere with the plant's ability to take up water and nutrients from the soil.

At Merbein, Vic., the DIVISION OF HORTICULTURAL RESEARCH has been testing various rootstocks for their resistance to nematodes and for such things as improved yield and vigour and increased tolerance to salt. Several of the rootstocks tested not only produced high-yielding sultana vines in nematode-infested land: because of their other desirable characters, they also performed better than self-rooted vines on many nematode-free soils. Most of the stocks significantly reduce chloride uptake so that damaging concentrations of salt are less likely in vines grafted on them than in ungrafted vines.

The Victorian Department of Agriculture, with financial support from the Australian Dried Fruits Association, is now growing vines of the best rootstock varieties to provide cuttings for distribution to sultana-growers in Victoria and New South Wales.

Cutting sultana harvesting costs

The cost of harvesting grapes by hand is more than 25% of the total cost of production. Scientists in the DIVISION OF HORTICULTURAL RESEARCH have therefore been trying to devise new methods of harvesting which involve less labour. As a preliminary step they have developed a pre-harvest treatment in which the canes that bear most of the fruiting shoots are severed from the vine at harvest time to allow the fruit to dry while still supported by the trellis wires. The fruit is then sprayed with a dipping emulsion of potassium carbonate and oil. This hastens drying and produces golden-coloured fruit. Finally the fruit is shaken from the vines by hand. Fruit produced in this way dries at the same rate as fruit picked, dipped, and rack-dried by conventional methods and the quality of the fruit is just as good.

The Division is now investigating mechanical methods of shaking the dried fruit from the vines. It will also study mechanical harvesting of fresh grapes both for drying and for wine-making.

Pastures for the Wallum

Between Coff's Harbour in New South Wales and Bundaberg in Queensland is a narrow coastal strip of country known as the Wallum. Its soils are highly deficient in phosphorus, nitrogen, cal-

Above right
Bench grafting vines at the Merbein Laboratory of the Division of Horticultural Research.

Below right
Scientists from the Division of Plant Industry establishing a clover evaluation trial on Mt. Kosciusko.

cium, potassium, copper, and sulphur, and slightly deficient in zinc and molybdenum. In its uncleared state the country provides very little grazing, but the excellent rainfall, a good road system, and closeness to markets favour development of the region, particularly for beef cattle.

Research by the DIVISION OF TROPICAL PASTURES at Beerwah, 40 miles north of Brisbane, has led to the development of improved pastures which will carry one beast to 1 acre continuously on land which in the virgin state will not maintain livestock in a healthy condition even at one beast to 50 acres. These results apply to some 1 million acres of country in the 50–70-inch rainfall country of the southern Wallum.

More recently the Division has been studying the 750,000 acres of Wallum country between Maryborough and Bundaberg. Although this country differs from the southern Wallum in a number of ways and has an annual rainfall of only 40 to 45 inches, there appear to be excellent prospects for improved pastures. Many of the pasture species which do well at Beerwah can be used in the north as well as the CSIRO-bred legume Siratro and various grasses belonging to the genera *Panicum* and *Setaria*.

At Howard, just north of Maryborough, cattle grazing experimental pastures at a stocking rate of one beast

Unfertilized Wallum soil **Improved Wallum soil**

The development of a fertile surface layer high in organic matter follows the establishment of legumes in the sandy Wallum soils.

to the acre gave liveweight gains of 230 pounds an acre in the 9 months between February and December 1967. While the northern Wallum has the same fertilizer needs for pasture development as the southern Wallum, there are some problem soils. Between the Isis and the Elliott Rivers, for example, there are many thousands of acres of salt-affected soils where the growth of grass is very much reduced and where legumes fail completely. There are also large areas of soils with silty surfaces that become powdery when dry and tightly packed when wet. These present difficulties in pasture establishment but once the difficulties are overcome, pastures grow well.

Aluminium and legumes

On many soils the growth of legumes can be affected by too much aluminium or manganese and too little calcium or molybdenum, as well as by the acidity of the soil itself. The DIVISION OF TROPICAL PASTURES has been studying different pasture legumes to find out why it is that many tropical species grow well on soils that would be too acid for temperate legumes. This work has shown that tropical legumes are generally more tolerant of high levels of aluminium in the soil than temperate legumes, although the tropical legume *Glycine javanica* and the temperate legume white clover fall roughly between the main tropical and temperate groups in their ability to tolerate aluminium.

As well as reducing total yield, aluminium toxicity slows down the uptake of certain nutrients and affects their distribution within the plant. By selecting for tolerance to aluminium, the Division hopes to extend the use of legumes such as lucerne and *Glycine javanica* to relatively acid soils.

Cotton for the M.I.A.

Cotton can be successfully grown on the Murrumbidgee Irrigation Area provided it can be harvested before the autumn gets too cold. It is a high-value crop well suited to irrigation and adds to the agricultural diversity of the district. However, temperature places some restrictions on cotton-growing in the M.I.A. and varieties that can be sown late to avoid low spring temperatures and that will mature before the advent of low temperatures and frosts in autumn are needed.

At Griffith, the DIVISION OF IRRIGATION RESEARCH is crossing Russian and American early-flowering lines of cotton in an attempt to breed high-yielding varieties that will mature three weeks earlier than existing introduced varieties. The new varieties are being developed for their ability to produce 1-inch cotton, which is in short supply on the Australian market, but longer staples of up to $1\frac{1}{8}$ inches are also included in the breeding programme as this class of cotton has an export potential for south-east Asian markets.

In addition to its plant breeding work, the Division is experimenting with different cultural practices which could shorten the growing season. One method being examined is planting cotton 'broadcast': the crop is sown in rows 7 inches apart instead of the usual 40 inches in order to produce smaller plants with fewer bolls, each boll having a chance to mature while temperatures are favourable. Although there are fewer bolls per plant, there are five times as many plants per acre, so that the overall number of mature bolls is increased. This method of planting could shorten the growing season by three weeks.

Another possible way of achieving an earlier season is by ratooning, that is by leaving the cotton stubs remaining in the ground after harvest to provide new growth in the following season. Some form of mulching or covering by soil is necessary to protect the stubs against frost. Ratooned cotton could bring on maturity about a month earlier and it should be possible to ratoon for two or three years in succession.

By breeding varieties for early flowering, by planting broadcast, and by ratooning for further earliness, the Division hopes to overcome the climatic disadvantages of the Murrumbidgee Irrigation Area for cotton-growing.

Livestock

Division of Animal Genetics

Location: North Ryde, Sydney, with a laboratory and field station at Rockhampton, Qld., and field stations at Armidale and Badgery's Creek, N.S.W.

Finance: $1,153,369 (Treasury $770,626, contributory $382,743)

Staff: Research scientists 32, other professional staff 25, supporting staff 108

Fields of research:

Basic studies—molecular biology and genetics, genetics and physiology of morphogenesis, statistics

Genetics in relation to the breeding and selection of beef cattle, dairy cattle, sheep, and poultry ●

Myxomatosis—genetics of myxoma virus, genetics of rabbit resistance, transmission by rabbit fleas ●

Division of Animal Health

Location: Parkville, Melbourne, with laboratories in Sydney, Brisbane, and Townsville, Qld., and field stations at Werribee, Vic., Badgery's Creek, N.S.W., and Jimboomba, Qld.

Finance: $1,478,258 (Treasury $1,098,437, contributory $379,821)

Staff: Research scientists 41, other professional staff 21, supporting staff 175

Fields of research:

Infectious diseases of livestock—contagious bovine pleuropneumonia, bovine tuberculosis, infertility of cattle, foot diseases of sheep and cattle, mycotic dermatitis of sheep, virus diseases ●

Cattle tick and tick fever ●

Worm parasites of sheep and cattle

Animal viruses—basic studies and transmission by insects ●

Immunology

Division of Nutritional Biochemistry

Location: Adelaide, with a field station at O'Halloran Hill, S.A.

Finance: $551,235 (Treasury $359,852, contributory $191,383)

Staff: Research scientists 19, other professional staff 12, supporting staff 63

Fields of research:

Digestion and fermentation in the rumen

Mineral nutrition of ruminants—role of major elements—calcium, magnesium, phosphorus, sodium, potassium; role of trace elements—copper, cobalt, molybdenum, selenium; tolerance and adaptation of sheep to saline waters

Tissue biochemistry—pathways in energy metabolism ●

Nutritional disorders—phalaris staggers, heliotrope poisoning

Organic chemistry—carbohydrates, plant alkaloids, chelating complexes in plants

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Division of Animal Physiology

Location: Prospect, N.S.W., with a laboratory and field station at Armidale, N.S.W., and the Beef Cattle Research Unit at Brisbane

Finance: $1,575,269 (Treasury $207,216, contributory $1,368,053)

Staff: Research scientists 47, other professional staff 40, supporting staff 175

Fields of research:

Physiological basis of productive functions in ruminants—reproduction, body growth, wool growth ●

Animal production from pasture—temperate and tropical regions

Nutrition and animal production—sheep and cattle ●

Influence of climate on ruminants

Metabolic disorders of ruminants

The Divisions of Animal Genetics, Animal Health, Animal Physiology, and Nutritional Biochemistry comprise the ANIMAL RESEARCH LABORATORIES.

Testing for swine fever

Swine fever is a serious virus disease of pigs. It is widespread throughout the world and highly infectious, but strict quarantine precautions have helped to keep Australia relatively free from the disease. However, in 1960 an outbreak occurred in New South Wales. Although infected pigs showed few if any symptoms, they gave a positive reaction when their blood was tested for the presence of swine fever antibodies. The virus responsible for the outbreak was isolated and shown to be a much milder strain than usual. But since there is always a danger that a mild strain will revert eventually to a more virulent form, the quarantine authorities adopted the only policy practicable, that of slaughtering all affected animals. Blood tests were used extensively in the eradication campaign.

However, some doubt came to be cast on the validity of these tests when pigs with positive reactions were found a long way from the original outbreak area. These pigs showed no symptoms of swine fever. Furthermore, a study of herd histories revealed that there was little likelihood of their ever having been in contact with infected pigs. The eradication campaign was therefore modified to place less emphasis on blood tests and more on other veterinary evidence.

Research by the DIVISION OF ANIMAL HEALTH has helped explain this situation. The Division has found that a virus which causes mucosal disease in cattle can also infect pigs under natural conditions. Pigs which are infected with the mucosal disease virus show no obvious symptoms, but they produce an antibody which makes them resistant to subsequent infection with swine fever virus. These animals give misleading positive reactions for swine fever when subjected to the blood tests which were used during the 1960 eradication campaign. As a result of these findings, the Division has been able to develop a new blood test which distinguishes between pigs infected with mucosal disease virus and those infected with swine fever virus.

Tick resistance in cattle

Cattle pick up ticks from pastures as 'seed' larvae. The larvae moult on the cattle to become nymphs which in turn moult to become adults. The adults then mature, mate, and eventually drop off. Cattle vary a lot in their susceptibility to infestation with ticks. Animals on which few ticks reach maturity are said to be tick-resistant. In general, breeds such as Zebus and Afrikanders are more resistant than British breeds, but within any one breed individuals can be found which are more resistant than others. The DIVISIONS OF ENTOMOLOGY and ANIMAL GENETICS have found that resistance to ticks is strongly inherited and both Divisions are now studying the problems involved in selecting and breeding cattle for this character.

It seems likely that the ability of

The vaccine and the diagnostic test used in the highly successful State–Commonwealth campaign to eradicate contagious bovine pleuropneumonia were developed by the Division of Animal Health. Over a million doses of the vaccine are produced by the Division every year. Each batch of vaccine is tested before release by vaccinating cattle and then infecting them with pleuropneumonia organisms. The picture shows lungs from vaccinated test cattle being sampled to determine whether any pleuropneumonia organisms are present.

cattle to become resistant to ticks is inherited and is due mainly to some sort of immune response acquired as the result of previous infestation, but the exact nature of the mechanism involved is not yet clear. The DIVISION OF ANIMAL HEALTH has been able to show that resistance is directed mainly against the attachment of 'seed' larvae, and to a lesser extent against the attachment of nymphs and adults when they emerge from moulting.

Fleas against the rabbit

Although myxomatosis still kills a lot of rabbits, the level of kill is much lower than when the disease was first released in 1950. The main reason for this has been the emergence of less virulent strains of myxoma virus. A rabbit infected with one of these weaker strains is sick for a week or so, but once it recovers, it is immune to further infection. On the other hand, a rabbit infected with a lethal strain dies quickly. There is therefore a much greater chance of a mosquito's biting a rabbit infected with a weak strain and transmitting it to other rabbits than there is of its biting a rabbit infected with a lethal strain. Because the weaker strains are spread more readily by mosquitoes, there is always a percentage of the rabbit population which is immune to myxomatosis as a result of earlier infection.

In an effort to lower the percentage of immune rabbits, the DIVISION OF ANIMAL GENETICS has enlisted the aid of the European rabbit flea, which was the main agent responsible for the spread of myxomatosis in Britain and Europe. The main advantage of the flea over the mosquito is that once its host dies, there is a mass exodus of fleas onto other rabbits. Strains of virus which kill quickly are therefore spread more widely by the flea than strains which kill slowly. A further advantage of the flea over the mosquito is that it is always present irrespective of seasonal conditions. The Division has been selecting more virulent strains of myxoma virus and hopes in collaboration with State authorities to use the flea to spread these strains among rabbits.

In 1967 the Division imported fleas from Britain and bred them in Sydney for twelve months under strict quarantine. Extensive tests confirmed that the fleas were harmless to wildlife, domestic animals, and man, and in January 1968 the quarantine authorities of the Commonwealth Department of Health approved the release of the fleas for field testing.

The flea will not breed on any animal but the rabbit. Moreover, its breeding cycle is completely dependent on that of the female rabbit. Ten days before her litter is due, the fleas become aware of the doe's state and flock to her. Hormones in the blood sucked from the rabbit rapidly induce sexual maturity in the female fleas. The fleas then lay their eggs in the rabbit's nest soon after the litter is born.

Glucose production in the sheep

As part of its research on how the sheep converts pasture plants into wool and meat, the DIVISION OF NUTRITIONAL BIOCHEMISTRY is studying the chemical pathways involved in the production of glucose. Only a small amount of the glucose needed by the adult sheep for its energy requirements is absorbed directly from the digestive tract. The rest is manufactured in the sheep's body from other substances. Normally, the sheep manufactures a large part of its glucose from propionic acid which is produced in the rumen in large quantities by the bacterial fermentation of the sheep's food. The propionic acid is absorbed from the digestive tract and passes into the blood stream. It is then transported to the liver and converted to glucose.

When a sheep is starved, propionic acid is no longer produced in the rumen and the sheep must obtain its glucose by some other means. One way is to break down body proteins into amino acids, which can be used as a source of glucose. Many animals do this when starved. Another way is to draw on reserves of body fat. These contain glycerol which can be converted to glucose. When starved, the sheep appears able to conserve its body protein better than many other animals and to obtain some of its glucose from glycerol. However, when glycerol is released from fat, fatty acids are also produced; these can accumulate in the liver and interfere with its normal functioning.

The Division is therefore trying to find out the conditions in the sheep's environment which cause one mechanism of glucose production to be brought into play rather than another. It is also trying to determine whether the production of glucose from glycerol is efficient when food is short and whether it can lead to disorders such as pregnancy toxaemia.

Measuring hormones

Hormones play an important part in controlling wool growth in sheep, in regulating growth, nutrition, and reproduction in livestock, and in helping livestock adapt to sudden changes in climate.

Research into the hormonal mechanisms involved has been hampered in the past by the lack of suitable methods for measuring the very low concentrations of hormones circulating in the blood. However, the DIVISION OF ANIMAL PHYSIOLOGY has now developed highly sensitive radioassay techniques for measuring blood concentrations of several protein and steroid hormones and hopes to develop similar techniques for a number of other hormones as well. The Division has used these techniques already to examine hormonal changes in the ewe and cow during the oestrous cycle and pregnancy, and to study the effect of cold stress on the functioning of the adrenal glands in sheep.

These techniques should permit new approaches to a variety of field problems such as predicting threatened abortion, early diagnosis of pregnancy, and early detection of twins.

Heat production in livestock

Sheep use some of the energy in their food for growing wool and meat, but much is dissipated as heat. A knowledge of the amount of heat produced by a sheep can therefore help the scientist in devising ways of improving the efficiency with which the sheep utilizes its food.

Although scientists can measure the heat production of a sheep accurately in the laboratory by confining the sheep in a cage and using complicated apparatus, they have been unable to make the same sort of measurements on a sheep grazing in a paddock. Instead they have had to estimate the probable heat production of a grazing sheep on the basis of laboratory findings, taking into account such things as climate and the amount of walking the sheep does during grazing. Scientists of the DIVISION OF ANIMAL PHYSIOLOGY and the University of New England are now working together on a new technique that should make it possible to determine heat production in both grazing animals and laboratory animals almost as a matter of routine. The technique is based on the fact that an animal's heat production is related to its carbon dioxide production.

A weak solution of radioactive sodium bicarbonate is infused into a vein and becomes evenly distributed throughout the body tissues and fluids, where it is diluted by non-radioactive bicarbonate produced by the body cells. The concentration of radioactivity in a sample of body tissue or fluid, such as blood, is then inversely proportional to the rate of bicarbonate production, and from this both carbon dioxide production and heat production can be estimated. Only small and safe amounts of radioactive material are needed and the equipment is simple and portable.

Insects, fish, and wildlife

Division of Entomology

Location: Canberra, with laboratories in Brisbane, Perth, and Sydney, and field stations at Townsville, Qld., at Armidale, Trangie, and Wilton, N.S.W., and at Hobart, and biological control units at Ascot, England, and Montpellier, France

Finance: $1,853,096 (Treasury $1,450,285, contributory $402,811)

Staff: Research scientists 57, other professional staff 28, supporting staff 141

Fields of research:

Genetics, physiology, biochemistry, and behaviour of insects as a basis for new methods of control—sterile male techniques, meiotic drive, lures ●

Ecology and control of insect pests—cattle tick, locusts and grasshoppers, pasture insects, forest insects, orchard insects, bushflies, sheep blowflies, insect pests of stored products ●

Insecticides—insect resistance, toxicology

Insect transmission of viruses

Biological control of insect pests and weeds

Taxonomy and maintenance of National Insect Collection

Division of Wildlife Research

Location: Canberra, with a laboratory at Helena Valley, W.A.

Finance: $675,855 (Treasury $444,633, contributory $231,222)

Staff: Research scientists 15, other professional staff 10, supporting staff 72

Fields of research:

Biology of animals of economic importance—rabbits, kangaroos, dingoes, mice, ravens, black cockatoos, wedge-tailed eagles ● ●

Biology and surveys of native fauna in relation to management and conservation

Bird banding and bird migration

Fundamental studies in population ecology, physiology, and animal behaviour

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Division of Fisheries and Oceanography

Location: Cronulla, Sydney, with laboratories in Brisbane, Melbourne, and Perth

Finance: $706,925 (Treasury $695,868, contributory $11,057)

Staff: Research scientists 21, other professional staff 18, supporting staff 70

Fields of research:

Biological and population studies of prawns, tuna, Western Australian crayfish, and Australian salmon; population studies of trawl fish ●

Primary productivity of marine environments ●

Structures and circulation of ocean waters

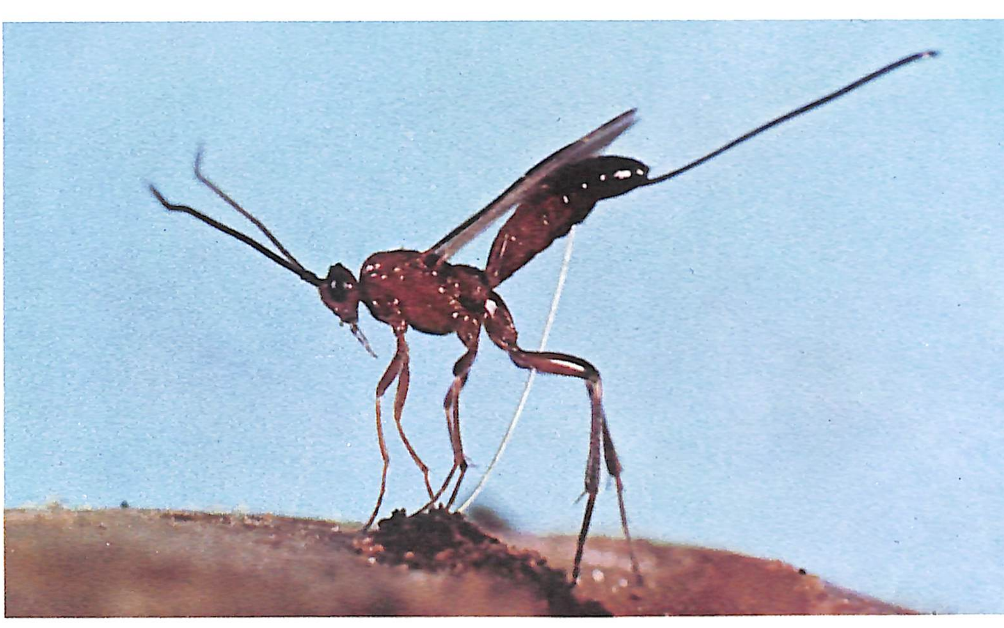
Distribution and abundance of zooplankton

Oceanography in relation to fisheries

Metabolism of single-celled algae

High-pressure studies of organic sea-water systems

A parasitic wasp, introduced from South America by the Division of Entomology, laying its eggs in a grub of the potato tuber moth inside a potato. The Division is testing several parasites as possible agents for the biological control of the moth.



Pine-trees and Sirex

The Sirex wood wasp was first discovered in Australian softwood plantations in 1952 at Pittwater, Tasmania. In 1961 it was found in Victoria, but prompt action and a continual programme of search and destroy operations by the Victorian Forests Commission reduced its spread and so far have kept it out of the State's main pine forests. Nevertheless, the Sirex wasp remains a potentially serious pest of softwood plantations in south-eastern Australia.

When Sirex lays its eggs in pine-trees, it infects the wood with a fungus. Some trees can confine the spread of the fungus. Others cannot and are killed. But not all trees are attacked; the female wasps seem to prefer to lay their eggs in trees which are weak or sick.

The DIVISION OF ENTOMOLOGY has shown that pine-trees can be made highly attractive to Sirex females if they are pruned to a height of 15 to 20 feet and ringbarked at a height of 12 to 15 feet. The Victorian Forests Commission has found this a useful method for determining whether or not Sirex is present in a particular area. Crude extracts from the bark of these 'trap' trees will attract Sirex females and the Division is now attempting to isolate and identify the chemical compound or compounds concerned and to see whether chemical attractants can be developed for use in Sirex control.

Sex attractants and fruit flies

Several years ago the DIVISION OF ENTOMOLOGY showed that the Queensland fruit fly could be controlled successfully in orchard areas of New South Wales by using a combination of a male attractant and a food lure to entice fruit flies to poisoned baits. This avoided the disadvantages usually associated with spraying with insecticides.

Both the male attractant and the food lure were substances which were discovered, largely by trial and error, to be attractive to fruit flies; they were not natural compounds produced by the fruit flies themselves. Recently the Division has found that the male Queensland fruit fly secretes and stores a substance which it releases at dusk and which attracts virgin female fruit flies. The Division is now examining the composition of this attractant and the part it could play in control measures.

Smell and social behaviour in rabbits

The most effective methods of pest control are usually those based on a thorough understanding of the biology of the pest concerned. For example, research undertaken some years ago by the DIVISION OF WILDLIFE RESEARCH on social behaviour in the rabbit has led to more efficient techniques for poisoning rabbits. This work showed that rabbits display a distinct social structure during the breeding season, organizing themselves into small communities or groups, each of which occupies its own well-defined territory. It also showed that rabbits smear objects in their territory with a secretion from scent-producing glands under their chins as a warning to would-be trespassers from other territories.

More recently the Division has been studying the function of another set of scent glands, found in the anal region of the rabbit. The rabbit can use these glands to coat its dung pellets with a strong-smelling secretion, but it does not do this indiscriminately. If it is engaged in social activities, such as examining a strange object carrying the scent of another rabbit, it drops pellets which have the characteristic strong 'rabbity' smell of the anal gland secretion. Pellets produced while the rabbit is engaged in non-social activities smell less strongly. The stronger-smelling pellets are also deposited in the dunghills which are a regular feature in rabbit territories. These dunghills serve as a warning to strangers invading foreign territory and as an assurance to occupants of the territory.

The biggest and most active anal glands are found in the socially dominant bucks, who are mainly responsible for territorial defence and demarcation of boundaries. The intensity of the smell of the secretion varies from rabbit to rabbit, it increases with age, it is stronger in bucks than in does, it is reduced in castrated bucks, and it changes from season to season. Young rabbits in the nest can distinguish between the reassuring smell of the secretion produced by their mother and the frightening smell of strangers.

A knowledge of the part played by smell in the social behaviour of rabbits and of the chemical nature of the secretions involved could lead to new methods of rabbit control, methods based perhaps on the use of chemical attractants.

Plagues of mice

The house mouse is a serious pest in grain-growing districts and in grain stores as well as being a nuisance in houses. Scientists of the DIVISION OF WILDLIFE RESEARCH have been looking into the problem of house mice in South Australian wheatfields to find out why mice breed up to plague proportions in some years but are so scarce in others. They have found an annual movement of mice to and from the wheatfields. In winter the wheatfield soils become too waterlogged for the mice, but a few mice survive in better-drained soils along vegetated banks of streams. From these winter refuges mice invade the fields each summer and shelter in cracks in the soil. If the weather is dry, many mice die from lack of water caused by breathing air that is too dry. Mice are unable to burrow in the fields unless good rains fall. When the soils are soft enough to burrow in and there is sufficient food, the mice begin breeding. Under favourable conditions, which occur rarely, they can increase from around 5 an acre to 200 an acre in four months. If the food then runs out, or if rain falls or farmers plough, the mice leave their homes and invade farm dwellings in hundreds, and a plague is declared.

The Division's study indicates that conditions are suitable for a plague if enough rain falls in winter to provide moist subsoil throughout summer, if spring is long and cool and plenty of seed sets, if hot weather cracks the soil in summer, if mice invade the fields, and if one or two storms yielding about an inch of rain fall in mid to late summer to moisten and soften the soil. But if any one of these conditions is not met, if too much or too little rain falls, for example, or if the rain falls at the wrong time, there will be no plague.

As a result of this investigation, it may be possible to devise suitable measures for dealing with mice plagues, perhaps even for preventing them. It should also be possible to predict plagues three or four months in advance, giving the farmer time to prepare for them.

The work on house mice helps explain the plagues of native rodents that occur from time to time in the arid and semi-arid inland. For example some 10,000 square miles of cattle country in the Barkly Tablelands of the Northern Territory have been infested recently with a large native rat known as the plague rat (*Rattus villosissimus*). Its habitat, vast open plains of black cracking soil dominated by Mitchell grass, is equivalent to the wheatfields of the mouse. These plains are drained by a complex of rivers, all of which have permanent waterholes and swamps along them, corresponding to the mouse's winter refuges. In good seasons, such as the last two in the Northern Territory, the Mitchell grass produces lots of large seeds and the black soils are moistened to a considerable depth, supplying the rats with plenty of good sites for their homes. Instead of being restricted to the swamps, therefore, the rats are able to invade the open plains and to multiply rapidly.

In the rice-growing areas around Humpty Doo near Darwin, another native rat (*Rattus colletti*) has also reached plague proportions. This rat was once quite rare, but has been present in large numbers ever since rice-growing started. Presumably rice paddies provide suitable conditions for burrowing all year round, even in the dry season when the black cracking soils usually bake hard and dry.

Upwelling and sea fertility

The high productivity of many fisheries in the tropical and subtropical waters of the world is due largely to the upward movement of nutrient-rich waters from the deeper layers of the sea to the surface layers. Until recently there was little evidence of any such upwelling in Australian coastal waters. But in 1966, studies by the DIVISION OF FISHERIES AND OCEANOGRAPHY of a 50-mile coastal belt off Evans Head in northern New South Wales revealed what appeared to be a 6-weekly cycle of upwelling. In 1967 the Division set up a small field laboratory at Evans Head and began a detailed programme of plankton sampling and hydrological measurements. The Division found that the upwelling was preceded by a swing towards shore of the swift-flowing southward core of the East Australian Current and that this change of direction could be used to predict upwelling. The first upwelling cycle, predicted for August, was upset by flood waters discharging into the sea, but the second cycle, due in the third week of September, occurred just as predicted.

This upwelling of waters rich in nutrients brings about changes in the plankton population. At first the plankton consist mainly of microscopic plants (phytoplankton). Then microscopic animals (zooplankton) appear and eat the phytoplankton. Finally carnivorous zooplankton appear and eat the grazing zooplankton. The Division now plans to trace the dispersal and mixing of the upwelled water to the south of Evans Head and to study the effect of the upwelling on the coastal prawn population.

Guide for tuna fishermen

Bluefin tuna schools favour waters with surface temperatures between 62°F and 68°F, and particularly regions where there are sharp discontinuities, or fronts, in the surface temperature. Fishermen locate these fronts by looking for changes in the colour of the water or by keeping a constant check on sea temperatures.

In recent years, the DIVISION OF FISHERIES AND OCEANOGRAPHY has helped fishermen in New South Wales by supplying them with maps showing sea surface temperatures and other conditions favouring the appearance of tuna at the surface. These maps take only two or three days to prepare and are based on temperature measurements made with an infrared radiation thermometer mounted in an aircraft.

In 1967 these maps were supplied regularly throughout the fishing season, and proved to be a valuable guide to where to look for tuna schools. Use of the maps resulted in an estimated 20% increase in catch worth about $100,000.

The Division is now preparing an atlas of surface temperatures and salinities for Australian waters as a basis for scientific work on further prediction of the regions where tuna are most likely to be found. The atlas will consist of a series of maps showing how temperature and salinity vary from place to place during the year. The maps are based on data obtained from oceanographic cruises.

Textiles

Division of Protein Chemistry

Location: Parkville, Melbourne

Finance: $895,620 (Treasury $44,929, contributory $850,691)

Staff: Research scientists 41, other professional staff 23, supporting staff 66

Fields of research:

Composition and chemistry of wool proteins
Electron microscope and X-ray studies of fibre structure
Proteins from wool and the influence of breed and nutrition
Shrink resistant processes
Mechanism and prevention of sunlight yellowing
Vacuum pressing of wool
Sheepskin processing and new uses for wool
Leather manufacture and hide proteins
Enzymes and muscle proteins

Division of Textile Industry

Location: Geelong, Vic.

Finance: $993,948 (Treasury $12,416, contributory $981,532)

Staff: Research scientists 19, other professional staff 25, supporting staff 161

Fields of research:

Scouring and related processes
Spinning, other mechanical processes
Dyeing and whitening of wool
Shrinkproofing and other treatments
Setting and prevention of wrinkling
Cotton processing

Division of Textile Physics

Location: Ryde, Sydney

Finance: Contributory $794,873

Staff: Research scientists 21, other professional staff 21, supporting staff 89

Fields of research:
Wool testing methods and equipment
Properties of fabrics, felting, shrinkproofing, setting, wrinkling
Wool structure and physical properties
Wool pressing and sampling
Wool drying and dyeing
Operations research into wool textile manufacture

The Divisions of Protein Chemistry, Textile Industry, and Textile Physics comprise the WOOL RESEARCH LABORATORIES.

Vacuum pressing of wool

In 1961 the DIVISION OF PROTEIN CHEMISTRY developed a vacuum method for pressing wool bales. In this method, fleeces were placed in a large plastic bag inside a tall box. Air was pumped from the bag and the pressure of the atmosphere compressed the wool. The bag of compressed wool was then lifted into a conventional jute pack, bale fasteners were inserted, and air was allowed to return slowly to the bag. As this happened the wool expanded to fill the jute pack, forming a bale of conventional size and improved shape.

Although vacuum pressing had many advantages, it could not be adopted until recently because of the tendency of vacuum-pressed bales to burst during dumping. Dumping is the mechanical compression of bales to reduce their size before shipment overseas. After research by the DIVISIONS OF PROTEIN CHEMISTRY and TEXTILE PHYSICS revealed the reasons for this bursting, the DIVISION OF PROTEIN CHEMISTRY was able to develop a modified dump which constrained the bales during dumping and prevented bursting. One advantage of the modified dump is that it produces bales with a volume of 15½ cubic feet instead of the usual 18½ cubic feet, so that less shipping space is needed. In October 1967, following successful tests with the new dump, the Australian Wool Board gave its approval for the use of vacuum pressing by the wool industry.

Whiter and brighter wool

Wool is not popular for white garments such as babywear because of its tendency to turn creamy yellow when exposed to sunlight. This change in colour can also cause changes in shade of dyed wool garments. For some years, the DIVISION OF PROTEIN CHEMISTRY has been trying to develop a treatment that will whiten wool and prevent yellowing. In the early 1960s the Division found that treatment with thiourea and formaldehyde reduced the rate of yellowing, but the effect of the treatment was partly lost when the wool was washed. This problem has now been largely overcome by controlled heating of the fabric during and after treatment.

Although fluorescent brightening agents can be used to make wool look whiter, they also increase its susceptibility to yellowing. Fortunately, some brightening agents cause less discoloration than others. Moreover, the thiourea and formaldehyde treatment retards yellowing of the wool fibre and limits the yellowing effect of the brightener. The Division has therefore been able to develop a process which involves partially bleaching the wool with hydrosulphite, adding a fluorescent brightening agent to make the wool whiter and brighter, and treating the wool with thiourea and formaldehyde to stabilize its appearance by retarding yellowing. The process was adapted for commercial use by the DIVISION OF TEXTILE INDUSTRY and has now been adopted by several wool textile mills.

Research is continuing in an effort to find out the detailed mechanism of sunlight yellowing. When this is known it should be possible to devise even more effective anti-yellowing treatments.

Wool testing

There is an increasing demand from textile manufacturers for accurate descriptions of the wool they buy in terms of yield and fibre diameter. Testing of wool in Australia is expanding, and over 10% of the clip is now tested. A good deal of wool testing is also carried out overseas. Although the methods used give fairly satisfactory results, they are usually slow and expensive. The current charge by the Australian Wool Testing Authority for a yield certificate is $10 plus 35 cents a bale. No matter where the test is carried out, it is all part of the cost of delivering wool to the user.

The DIVISION OF TEXTILE PHYSICS is trying to find quicker and cheaper methods of wool testing. Some years ago, for example, the Division devised a hand-operated coring tool for taking wool samples from bales and an instrument called the direct-reading regain tester which measures the moisture content of wool.

Scientists in the Division are now working on a system that will measure the yield and fineness of wool samples semi-automatically. The samples are first weighed and washed. Wool and vegetable matter are then separated, dried, and weighed to give yield and percentage of vegetable matter. Fineness is measured on the clean wool.

The Division is also looking at sampling methods to find out the smallest number of samples which need to be taken if the characteristics of all the wool in a particular lot are to be measured with the required degree of precision.

Jet scouring

The usual method of scouring wool is to agitate it in baths of either soap–soda solutions or synthetic detergents. This causes considerable tangling of the wool fibres and many of the fibres become broken in the combing and carding processes that follow later. Several years ago the DIVISION OF TEXTILE INDUSTRY developed a new scouring process in which the wool is passed under a series of jets which spray it with either an organic solvent or a detergent solution. Jet scouring greatly reduces tangling and subsequent breakage of fibres during processing and so produces a more valuable product; the equipment occupies only one-third the space of conventional machinery, it is easier to operate, and output is higher.

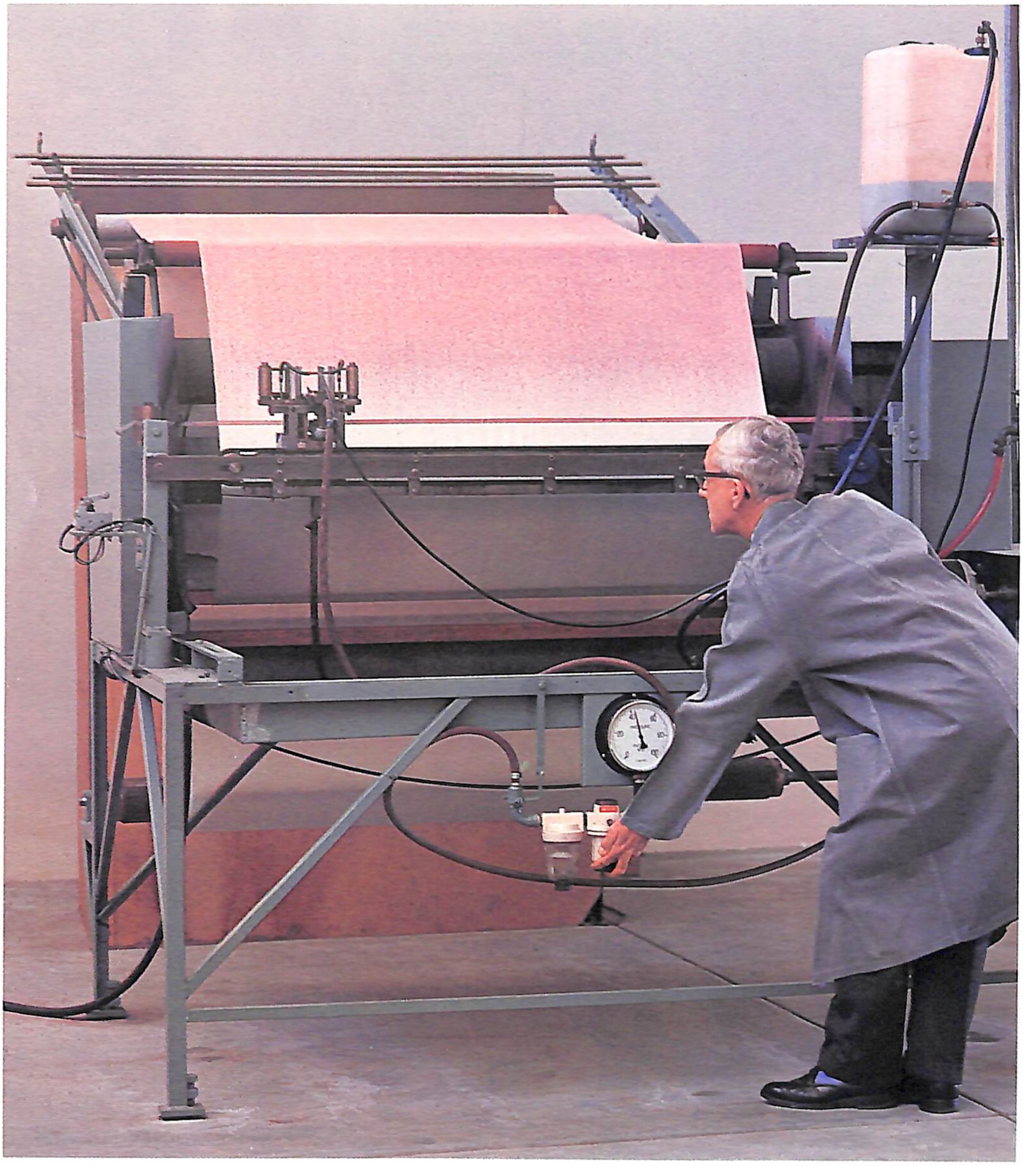
Jet scouring plants are operating successfully in Britain, Belgium, and Australia and a machine will soon be installed in Italy. A full-scale machine built by the Sydney firm of Wessberg and Tulander has also been installed at the DIVISION OF TEXTILE INDUSTRY's Geelong laboratory to provide scoured wool for the Division's research programmes and to act as a demonstration plant for industry. In addition, the machine has several modifications which enable it to be used for research on other processes such as dyeing and shrink-proofing.

Spray printing of wool fabrics

A new method of applying dye to wool fabrics is being developed by the DIVISION OF TEXTILE INDUSTRY. Special dye solution is sprayed through a fine wire mesh onto the fabric as it travels through the machine. The air pressure at the spray head determines the size of the spray droplets and can be varied to give different patterns. The dye solutions are similar to those used in the rapid continuous method of top dyeing described in last year's Annual Report. After being dyed, the sprayed fabric is steamed and scoured to remove chemicals and loose dye.

Spray printing can be used to produce unique marl and mottle patterns. It can also be used to impart a melange appearance to fabrics. Melange fabrics are usually made by blending different-coloured wools before spinning. With the new technique, textile manufacturers should be able to keep stocks of undyed fabric and spray-dye them as needed to give a wide range of shades and patterns.

Below
Experimental equipment developed by the Division of Textile Industry for spraying dye onto wool fabrics.



Food processing

Division of Food Preservation

Location: North Ryde, Sydney, with the Meat Research Laboratory at Cannon Hill, Brisbane, and a laboratory at Gosford, N.S.W.

Finance: $1,385,271 (Treasury $1,159,367, contributory $225,904)

Staff: Research scientists 49, other professional staff 53, supporting staff 113

Fields of research:

Effect on quality of the storage, processing, transport, and packaging of food with special reference to fruit, vegetables, meat, fish, and eggs ● ●

Physical and chemical properties of food

Physiology, including post-harvest physiology, of fruit and vegetables

Microbiology of food-spoilage organisms

Division of Dairy Research

Location: Highett, Melbourne

Finance: $465,899 (Treasury $293,160, contributory $172,739)

Staff: Research scientists 13, other professional staff 9, supporting staff 49

Fields of research:

Cheese—mechanization of cheddar manufacture, cheese starters, enzymology of cheese ripening

Casein and other milk proteins—fundamental chemistry, commercial manufacture ●

Flavour chemistry ●

Drying of dairy products, recombined products ●

New foods

Oxidative deterioration of butter-fat in stored dairy products

Superficial scald in apples

Unless special precautions are taken, many varieties of apples kept in cool stores can develop superficial scald. This disorder, which is characterized by a brown discoloration of the skin, reduces the value of the fruit and can cause heavy losses. Granny Smiths are particularly prone to it.

For more than fifty years scientists have been trying to find the cause of superficial scald. In 1919, a group of scientists in the United States found that there was less chance of apples being affected if each apple was wrapped in oiled paper or if the flow of air over the fruit was increased. They suggested that superficial scald was caused by volatile substances from the fruit. In 1956, again in the United States, it was shown that scald could be controlled more effectively by applying diphenylamine to the surface of the fruit. However, many countries that import Australian apples will not accept diphenylamine-treated fruit, so that oiled wraps are still the standard method used in Australia for preventing scald in fruit for export.

The cause of superficial scald remained obscure until a few years ago when scientists in the DIVISION OF FOOD PRESERVATION isolated from the natural waxy coating of apples a substance which they later identified as α-farnesene. It was the first time this compound had been detected in plants. The scientists found that α-farnesene, a moderately volatile hydrocarbon, was present in the atmosphere in apple cool stores. They also found that it was readily absorbed by oiled wraps, that it oxidized rapidly in air, and that its oxidation was delayed by diphenylamine.

The Division is now studying the oxidation products of α-farnesene, as they seem to be the most likely cause of scald. The Division also hopes to use quick chemical tests to screen different substances for their ability to prevent the oxidation of α-farnesene. Those substances which appear most promising will then be tested in long-term fruit storage experiments to see if any of them will control scald and provide an acceptable alternative to diphenylamine.

Keeping pears fresh

Apples and pears are kept in cool stores because the low temperatures reduce respiration and so keep the fruit fresh for much longer. The DIVISION OF FOOD PRESERVATION, in collaboration with the New South Wales Department of Agriculture, has shown that pears keep much better in cool storage when packed in boxes lined with bags made from polyethylene film. The method has proved valuable in storing fresh pears for the local market and consignments of Australian 'Poly-pack' pears have been well received overseas.

Shrivelling due to evaporation of water from the fruit is prevented, so that the pears keep their fresh appearance for a long time. If the bags are tightly sealed, the air in them is altered by the natural respiration of the fruit. Some of the oxygen in the air is used up while the carbon dioxide level is increased. This slows down the respiration of the pears and so increases their storage life. The plastic must let enough oxygen diffuse in and enough carbon dioxide diffuse out to prevent the fruit from being damaged by oxygen shortage or excess carbon dioxide. At the cool storage temperatures of 30–32°F these requirements are met by a low-density polyethylene film 15/10,000 of an inch thick. At higher temperatures the fruit respires faster and the bag must be slit when removed from cool storage. For the same reason the pears must be pre-cooled before being packed in the sealed bags and must be returned quickly to the cool store.

Some varieties of pears are more sensitive to carbon dioxide than others. These varieties can be packed either in unsealed bags or, for better results, in bags containing a small packet of carbon dioxide absorbent such as fresh hydrated lime.

Milk proteins for food

About 80% of the protein in milk is casein, the other 20% being made up of various whey proteins. Until recently, casein was recovered mainly for use in adhesives and for coating paper. A small amount of high-grade casein was also used in foodstuffs. Some of the whey protein was used as food for stock and to a lesser extent as food for humans, but most of it was wasted.

In 1965 the DIVISION OF DAIRY RESEARCH developed a simple but efficient process for recovering casein and whey proteins together as a powder known as co-precipitate. The nutritional value of co-precipitate is higher than that of casein alone and there has been a growing demand for the product from Japan as an ingredient in special foods such as those for babies and old people. Co-precipitate also improves the texture and appearance of products such as sausages and tinned meats. In 1967–68 some 2000 tons of co-precipitate were produced in Australia and production could go very much higher as the demand for milk proteins grows.

One of the reasons why casein has not been used widely in foodstuffs in the past is that it has a tendency to develop a gluey flavour. This tendency is less pronounced with co-precipitate, but it can limit the range of foodstuffs in which co-precipitate is used. Scientists in the Division have come a step closer to devising means of preventing this gluey flavour by showing that it is caused by a characteristic reaction between sugars and proteins known as the 'browning' or Maillard reaction. This reaction can result in an array of compounds, some brown and some highly flavoured, and is responsible for such things as the browning of meat in cooking, off-flavours in dried egg, discoloration in dried fish, and the crust colour of bread.

Spray drying milk with natural gas

Powdered milk is made by spraying milk into a stream of hot air. The water evaporates almost instantly and the dried milk powder is collected from the air stream. The air is usually heated to about 300°F with steam coils. Higher temperatures improve the efficiency of drying but are harder to obtain. Heating can be simplified and higher temperatures achieved if a direct flame is used in the air stream, but most fuels are unsuitable for this because they produce compounds which affect the flavour of the powdered milk. One exception is natural gas, but recent work in Australia has shown that although natural gas does not produce off-flavours it can lead to contamination of the powdered milk with small amounts of nitrites or nitrates.

Some spray drying plants in Australia may wish to change over to natural gas as soon as it becomes available. The DIVISION OF DAIRY RESEARCH and the Gas and Fuel Corporation of Victoria have therefore been studying the problem. They have found that contamination can be largely eliminated by introducing steam into the flame to reduce its temperature. Although at a lower temperature, the flame still provides ample heat and drying remains quick and efficient.

Wheat Research Unit

Location: North Ryde, Sydney

Finance: $83,445 (Treasury $21,821, contributory $61,624)

Staff: Research scientists 4, other professional staff 4, supporting staff 3

Fields of research:

Quality of wheat and flour ●

Lipid biochemistry

Improving wheat proteins

Wheat proteins are deficient in some of the amino acids which man needs in his diet, particularly lysine. Scientists from the WHEAT RESEARCH UNIT and wheat breeders from the University of Western Australia are now studying the possibility of breeding varieties of wheat with a high lysine content. As part of this investigation the Unit is analysing the amino acid content of wheats from Australia, North America, India, and Mexico.

Engineering and construction

Division of Mechanical Engineering

Location: Highett, Melbourne

Finance: $520,379 (Treasury $468,701, contributory $51,678)

Staff: Research scientists 15, other professional staff 21, supporting staff 46

Fields of research:

Comfort cooling

Utilization of solar energy

Aerodynamics of fans and ducting

Grain storage and agricultural machinery ●

Design and control by computer

Division of Soil Mechanics

Location: Syndal, Melbourne, with a laboratory in Adelaide

Finance: $320,605 (Treasury $298,907, contributory $21,698)

Staff: Research scientists 9, other professional staff 8, supporting staff 28

Fields of research:

Mechanical properties of soils, soil stabilization, soil fabric

Soil moisture, soil sampling, foundation behaviour of soils ●

Evaluation of land for engineering ●

Division of Building Research

Location: Highett, Melbourne, with an office in Port Moresby

Finance: $764,847 (Treasury $716,873, contributory $47,974)

Staff: Research scientists 22, other professional staff 34, supporting staff 56

Division of Building Research continued

Fields of research:

Building materials—ceramics and ceramic products, concrete, gypsum and gypsum products, paint, organic building materials ● ●
Concrete structures
Architectural acoustics
Heat comfort in buildings
Tropical building
Operational research

Division of Forest Products

Location: South Melbourne

Finance: $1,289,174 (Treasury $1,216,087, contributory $73,087)

Staff: Research scientists 34, other professional staff 44, supporting staff 154

Fields of research:

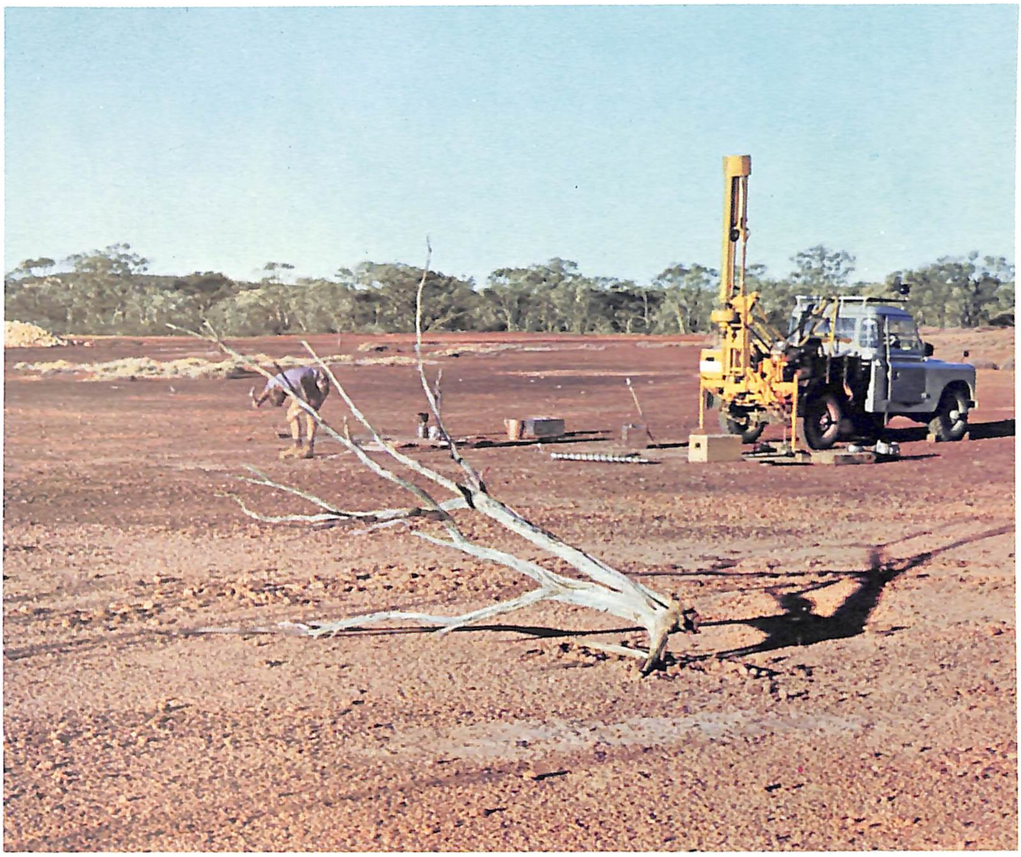
Structure of wood and wood fibres
Conversion of trees to final timber product:
  Solid wood, cutting and seasoning
  Preservation ●
  Wood-based panels
  Operational research
Pulp, paper, and paper products
Engineering of timber structures

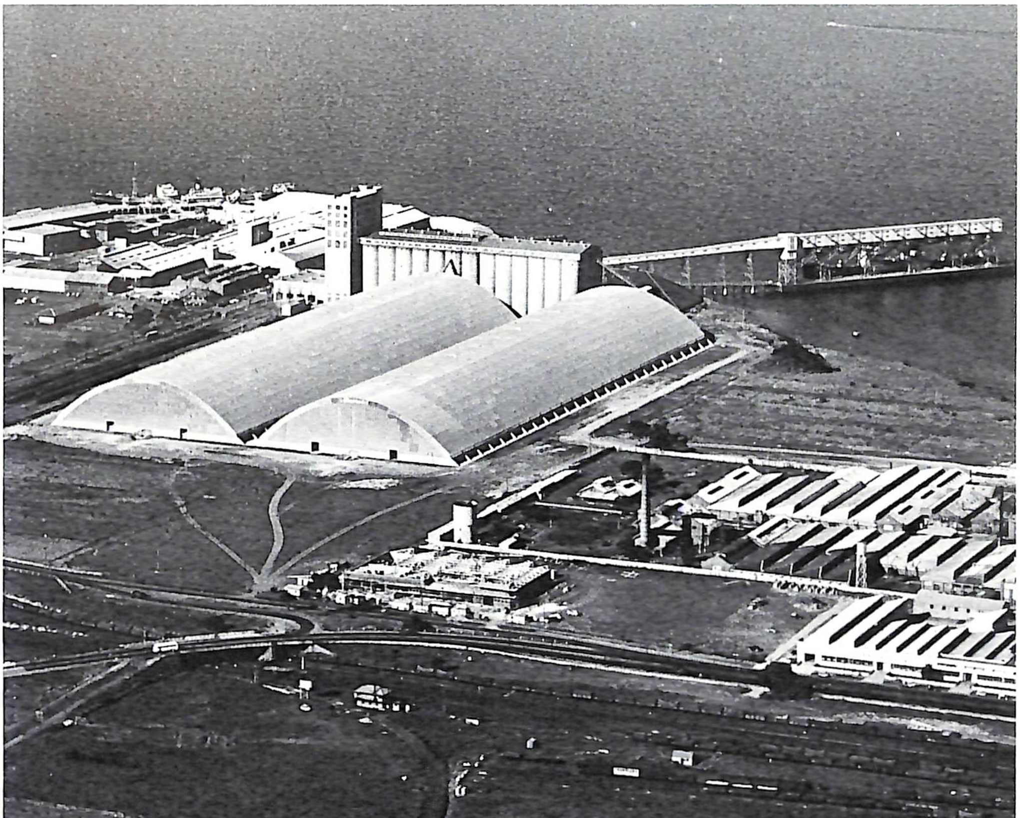
Above right

A survey team from the Division of Soil Mechanics sampling soil in Queensland to test its engineering properties.

Below right

In 1967 the Victorian Grain Elevators Board installed a grain aeration system in these two giant sheds at the Board's Geelong terminal. Between them the two sheds hold 500,000 tons of wheat. The Division of Mechanical Engineering undertook much of the design of the installation and advised on the specifications for the fans.





Controlling insects in wheat

If cool air is drawn through grain, the temperature of the grain is lowered to a point where insects cannot breed at all or can do so only very slowly. Wheat storage authorities in Australia are turning increasingly to aeration to assist in the control of weevils and other insects in storages. With grain aeration there is no hazard to the operator as there is with fumigation, and no risk of insecticide residues as there is with insecticide treatments.

In 1967 the Victorian Grain Elevators Board installed what is believed to be the world's biggest grain aeration system in two giant sheds at its Geelong terminal. Each shed is 1000 feet long and 300 feet wide and between them they hold 500,000 tons of wheat. The system uses 124 fans totalling 1380 horsepower to give an air flow of 590,000 cubic feet a minute. At the request of the Board, the DIVISION OF MECHANICAL ENGINEERING undertook much of the design of the installation and advised on the necessary specifications for the fans. The size, number, and placing of the air ducts were worked out from a model in which an electric current flowing in a suitably shaped tank of water simulated the flow of air through the stored grain. The same model was also used to predict the pressure against which the fans had to work.

The Division has also been considering smaller storage bins of 1000 to 2000 tons, and is developing a completely automatic aeration unit that can be used at isolated country sites without the need for skilled supervision. A prototype installation in Victoria at Raywood, just north of Bendigo, has given excellent results. In this installation an automatic switching device turned the fan on whenever the outside air temperature fell below the grain temperature by 8°F or more. The Division is now trying to develop improved switching devices which will increase the efficiency of the aeration systems.

Grain aeration should work well in most parts of the Australian wheat belt except Queensland where temperatures are generally too high for adequate cooling. The Division has devised a method of rapidly cooling grain with refrigerated air and is testing it in Queensland. Cooling has been satisfactory and the cost appears quite reasonable, but testing will have to continue for some time to find out how effectively insects are controlled by this method.

Measuring soil moisture

As a soil dries out, the remaining water becomes more tightly held in the pores of the soil. The energy needed to remove this water is known as the soil moisture potential. In designing foundations for buildings and other structures, engineers use measurements of moisture potential to help predict the effect of moisture changes on the ability of the soils beneath the foundations to support their loads.

Moisture potentials can be calculated from the humidity of the air just above a soil sample. An instrument designed by the DIVISION OF SOIL MECHANICS to measure this humidity quickly and accurately has provided foundation engineers with an improved technique for determining moisture potentials. Several versions of the instrument have been made. One is a laboratory version which can test nine soil samples simultaneously. Another is a small portable instrument which is being used by the Division to help the South Australian Department of Mines prepare recommended foundation designs for buildings in the Adelaide area. Other instruments have been made in which the humidity sensing device is enclosed in a probe no more than $\frac{1}{16}$ of an inch in diameter.

These probes can be inserted in a soil sample while it is undergoing strength tests in the laboratory, or buried in the ground to give on-site measurements of moisture potential.

Remaking the Birdsville Track

A 300-mile stretch of the Birdsville Track from Marree in the far north of South Australia to the Queensland border is to be reconstructed and sealed shortly to provide an all-weather beef road. The new road will cost $4·6 million and will be built by the South Australian Highways Department.

Before construction work begins, the Department and a firm of consulting engineers are collaborating with the DIVISION OF SOIL MECHANICS in a survey of the country along the Track to determine the best route for the new road and to locate sources of road-making materials. The survey team is using a system developed by the Division for classifying, describing, mapping, and evaluating country as an aid to planning the design and construction of roads and other engineering structures.

Information collected by the survey team will be stored on computer tape according to the Division's classification system so that it will be readily available to future survey teams working in similar types of country.

Protecting marine piling

Timber piles have many advantages for wharf construction: they are cheap, strong, and resilient. But although many Australian timbers have the necessary length, strength, and straightness to make good piles, most of them are susceptible to attack by marine borers and are therefore uneconomical to use. Only a few species such as turpentine are resistant enough to be suitable. Unfortunately the supply of these resistant species is limited, particularly in the longer lengths needed for the construction of wharves in the new ports being opened up in northern Australia.

For many years the DIVISION OF FOREST PRODUCTS has been looking for suitable preservative treatments to protect Australian and imported timbers against attack by marine borers. In a recent series of tests, the Division found that round eucalypts treated with creosote resisted marine borer attack even in tropical waters where the attack is much more severe, while plantation-grown specimens of *Pinus radiata* treated with creosote were susceptible. On the other hand, when a cheaper preservative based on copper, chromium, and arsenic salts was used, the situation was reversed. Pine specimens impregnated with 1·7 pounds of this preservative for each cubic foot of wood remained in even better condition than the creosoted eucalypt specimens, while eucalypt specimens impregnated with the copper–chrome–arsenic preservative were quite inferior to creosoted pine.

The Division has now begun a new series of marine exposure tests at Carnarvon, Port Hedland, Darwin, Weipa, Cairns, Gladstone, Sydney, Port Moresby, Lae, and Rabaul, to study the effect of different preservatives on different timber species under tropical and subtropical conditions. The tests should also help the Division in identifying the different marine organisms which can attack timber in each port.

Cheaper curing of concrete

Manufacturers of precast, prestressed concrete units and concrete masonry commonly speed up the curing of the concrete in its moulds by heating it with steam. After overnight heating and cooling the concrete reaches nearly full strength and the finished product can be removed from the moulds, freeing them for further use.

Investigations by the DIVISION OF BUILDING RESEARCH into the curing of concrete under closely controlled conditions have led to the development of a system of curing based on the use of hot flue gases from a burner intead of steam.

Prototype equipment for converting existing curing chambers was designed by the Division and tested in a Hobart concrete masonry plant in 1967. The results showed that curing with flue gas was just as effective as steam curing and cost much less. A typical fuel bill of $8000 a year could be cut to about $2000, and as a boiler was no longer needed the salary of an attendant was also saved. The capital cost of a flue-gas curing chamber is about $1000, a small fraction of the cost of a steam curing unit.

Glazed concrete masonry

Efforts to produce fired glazes on the surface of concrete masonry have generally been unsuccessful because the high temperatures used for firing weaken the concrete, but now the DIVISION OF BUILDING RESEARCH has developed a range of glazes that fire at temperatures as low as 500 to 600°C. At these temperatures the strength of the concrete is not seriously affected. There is no need to treat the concrete surface specially before glazing, and a variety of colours and patterns is possible. The materials used in the glazes are produced in Australia and are quite cheap.

Glazed blocks can be made durable, easy to maintain, and with non-fading colours. They are much less permeable to water than unglazed blocks and white efflorescent crusts cannot form on their surface. These advantages could offset the extra cost involved in glazing and several firms are now investigating the commercial possibilities of manufacturing glazed concrete blocks.

Chemistry and mineralogy

Division of Applied Chemistry

Location: Fishermen's Bend, Port Melbourne

Finance: $1,040,460 (Treasury $970,760, contributory $69,700)

Staff: Research scientists 37, other professional staff 27, supporting staff 54

Fields of research:

Chemistry of naturally occurring products

Synthesis of potentially valuable compounds

Organometallic chemistry

Thermodynamics and reaction mechanisms

High-pressure chemistry

Crystal nucleation and growth

X-ray crystallography

Homogeneous catalysis

Surface chemistry and physics

Desalting of water

Bush fires

Microanalytical Laboratory

Division of Applied Mineralogy

Location: Fishermen's Bend, Port Melbourne, with branch laboratories in Perth and Sydney

Finance: $651,263 (Treasury $596,352, contributory $54,911)

Staff: Research scientists 26, other professional staff 18, supporting staff 38

The Divisions of Applied Chemistry, Applied Mineralogy, Chemical Engineering, Chemical Physics, and Mineral Chemistry comprise the CHEMICAL RESEARCH LABORATORIES.

Division of Applied Mineralogy continued

Fields of research:

Geology and geochemistry of ores
- Distribution of elements in mineralized areas ●
- Formation of sulphide ores
- Mineralogy and mineragraphy
- Rock drilling

Industrial treatment and use of rock and mineral raw materials
- Cements, concretes, rock aggregates
- Refractories, engineering ceramics, foundry materials ●
- Mineral-organic systems

Division of Chemical Engineering

Location: Fishermen's Bend, Port Melbourne

Finance: $589,762 (Treasury $549,792, contributory $39,970)

Staff: Research scientists 17, other professional staff 17, supporting staff 29

Fields of research:

Chemical engineering processes—grinding, mixing, fluidized beds ●

Metallurgical processes—tin smelting, metal recovery by sulphite processes

Desalting of water

High-pressure chemical reactions

Process evaluation

Division of Mineral Chemistry

Location: Garden City, Port Melbourne, with a Coal Research Laboratory in Sydney

Finance: $1,564,690 (Treasury $1,434,885, contributory $129,805)

Staff: Research scientists 45, other professional staff 54, supporting staff 133

Fields of research:

Chemical aspects of mineral exploration
- Borehole logging
- Coal survey
- Sedimentary ores, sedimentary chemistry

Chemistry of mineral treatment
- Aluminium, carbon, mineral sands
- Hydrometallurgy

Chemical aspects of fuel technology
- Fuel cell
- Combustion, inorganic combustion products
- Metallurgical reductants

Chemistry of solids and surfaces
- Electrode processes
- Plasma processes ●
- Solid state compounds
- Thermochemistry ●

Ore Dressing Investigations

Location: Parkville, Melbourne

Finance: $126,163 (Treasury $111,513, contributory $14,650)

Staff: Research scientists 3, other professional staff 8, supporting staff 6

Fields of research:

Flotation

Hydrometallurgy ●

Physical separation processes—gravity, electrostatic, magnetic

Grinding and sampling

Division of Chemical Physics

Location: Clayton, Melbourne

Finance: $871,995 (Treasury $841,316, contributory $30,679)

Staff: Research scientists 32, other professional staff 10, supporting staff 52

Fields of research:

Spectroscopy
- Atomic absorption and resonance spectroscopy ●
- Diffraction gratings and specialized optical instruments
- Molecular spectroscopy
- Mass spectroscopy

Electron diffraction, electron microscopy, X-ray diffraction

Solid state research

Theoretical chemistry

Designing better insecticides

Without insecticides much of the world's food and fibre could not be harvested. But insecticides have their drawbacks. Insects may develop resistant strains, poisonous residues may accumulate in foodstuffs, wildlife may be affected, and useful insect species may be killed. There is therefore a continuing search going on throughout the world for improved insecticides which do not have these disadvantages.

As part of its research on possible new insecticides the DIVISION OF APPLIED CHEMISTRY is trying to develop alternatives to DDT and other insecticides belonging to the chlorinated hydrocarbon group. The approach to this problem in most laboratories has been to synthesize new compounds which are similar to DDT but not completely identical with it and to see how they perform. This involves the routine testing of thousands of new compounds. Scientists in the Division have adopted a less hit-or-miss approach. They are trying to specify in advance those compounds which on theoretical grounds should be most effective.

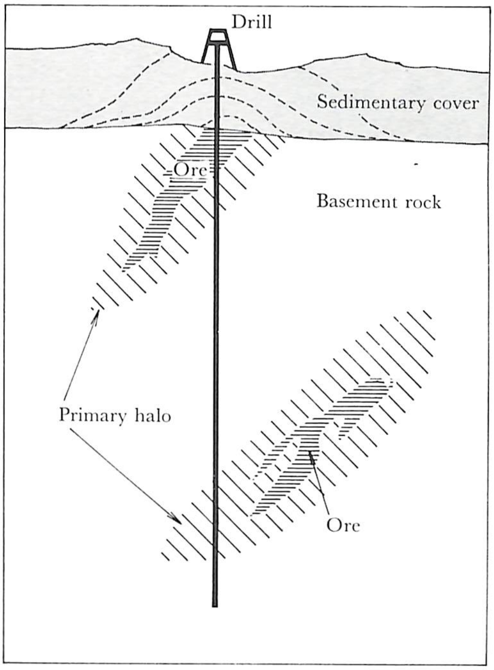
It is known, for example, that DDT acts by interfering with the transmission of impulses in the nerve fibres of insects. One theory is that the DDT molecules occupy 'holes' of a particular shape and size in certain protein molecules in the membrane of the nerve fibre. Suggestions have been made as to the general physical and chemical properties of these 'holes'.

Using this hypothetical picture as a starting point, scientists in the Division have worked out the formula and molecular structure of a variety of new compounds which should fit these holes and exert a similar effect to DDT. At the same time, these compounds have been designed to contain no chlorine, since some of the disadvantages of DDT are due to the chlorine in it. The various compounds have then been synthesized and tested against house flies. By comparing the actual performance of the compounds with their predicted performance, it has been possible to establish more accurate guidelines for the design of further compounds.

The Division now has several unchlorinated compounds, which compare with DDT in their toxicity to flies but which appear relatively harmless to animals. These compounds will have to undergo more extensive testing, but the chance of insects developing resistance to them seems much less than with DDT.

Looking for gold

Modern prospectors rely on all sorts of geological, geophysical, and geochemical evidence in their search for commercial ore bodies. But eventually they must drill a hole through the rock to locate and confirm the existence of the ore body which other evidence suggests is there. Since many ore bodies occur rather sporadically and since the diameter of



the drill hole is normally no more than one or two inches, it is possible for a hole to pass quite close to a body of ore without the operator knowing anything about it. If the operator could tell not only when the hole reached an ore body but when it was near one, the effective target for drilling could be made much larger and less drilling would be involved.

During the formation of an ore body certain elements may move into the surrounding rock. Traces of mercury and arsenic commonly penetrate the rock around regions of gold mineralization and form what are known as dispersion haloes. Another element, tellurium, is often associated with gold at Kalgoorlie, and traces of it in a rock sample could be an indication that gold is nearby.

The DIVISION OF APPLIED MINERALOGY, with financial support from Western Mining Corporation Ltd., has therefore developed a highly sensitive method for determining tellurium in rock samples. The method employs atomic absorption spectroscopy and can detect two parts of tellurium in one hundred million parts of rock. This sensitivity should make it possible to determine whether tellurium spreads out far enough to form useful indicator haloes around gold ores.

Plasma sintering

There is an increasing demand from industry and defence authorities for ceramic materials which can withstand high temperatures and resist corrosion and abrasion. These materials are used for such components as bearings and bushes, drawing and extrusion dies, nozzles, and cutting tools. Oxides of aluminium, beryllium, zirconium, and magnesium are the main materials used. Because of their very high melting points they cannot be fabricated by melting and moulding—the vessel holding them would melt before they did. The usual method of fabricating oxide ceramics, therefore, is to form powdered oxide into the desired shape by pressure, slipcasting, or extrusion. The shape is then heated at a temperature below the melting point of the oxide until the particles join together—a process known as sintering.

Scientists in the DIVISIONS OF APPLIED MINERALOGY and MINERAL CHEMISTRY have devised a new method of sintering in which oxide shapes are heated in a plasma of ionized gas. This is much quicker than normal heating techniques, and greater densities and strengths can be achieved in the final product. The equipment used is reasonably inexpensive for small-scale work. It allows objects to be sintered either in a batch or by a continuous process.

Sizing particles quickly

Most ores must be ground to fine powders before further processing. Since grinding is costly, it should be continued only until the ore particles are fine enough for efficient processing. In the past, the mill operator has had to rely on methods such as slow and inefficient hand sieving to determine whether he is producing particles the correct size. A particle sizer has now been developed by the DIVISION OF CHEMICAL ENGINEERING which will enable him to find this out quickly and accurately.

The instrument, called a cyclosplitter, measures the proportion of a ground material which is coarser than a predetermined size. A sample is suspended in water and pumped into a cylindrical hydraulic cyclone inside which a swirling flow pattern is set up. Centrifugal forces separate the particles of the sample into a coarse and a fine fraction. The coarse particles are returned to the pump for further treatment and the fine particles are gradually removed. The minimum size of particles retained in the coarse fraction can be varied simply by raising or lowering the outlet tube. Using the cyclosplitter, an unskilled operator can process a sample every four minutes. A prototype instrument has given promising results in routine determination of particle size in the grinding section of the ore-pelletizing plant of Hamersley Iron Pty. Ltd. The instrument is now being manufactured commercially by Warman International Pty. Ltd. of Sydney.

Hot ground

In many large mines, both in Australia and overseas, copper is recovered from ore bodies containing copper–iron sulphides. If air can penetrate through cracks and pores, the ore bodies may, under certain conditions, heat up. This can make the work environment unpleasant and difficult and may affect the ore in such a way that less copper can be recovered from it. In extreme cases localized regions of the ore bodies become incandescent.

The DIVISION OF MINERAL CHEMISTRY began investigating this problem of 'hot ground' late in 1966 with financial support from Mount Isa Mines Limited. Extensive research at Mount Isa had already shown that heating of the ore could occur naturally as a result of oxidation by air and the action of water. It had also shown that mining operations which broke up the ore and exposed new surfaces to the air could accelerate this heating, enabling the ore to reach temperatures between 50 and 100°C. However, oxidation by the air failed to explain why some parts of an ore body became incandescent.

With the cooperation of technical staff from Mount Isa Mines Limited the Division was able to show that incandescence was brought about by a reaction between ammonium nitrate and the ore. Ammonium nitrate impregnated with fuel oil is commonly used in mining as an explosive. In the ore body affected at Mount Isa, it is placed in blast holes about $2\frac{3}{4}$ inches in diameter and up to 85 feet long. The ammonium nitrate can react rapidly with the ore, generating heat and accelerating oxidation so that the sulphides and the surrounding rock may become red hot.

These findings provide a basis for possible changes in mining procedures to reduce heating. In addition, the Division found that ammonium hydrogen tetraborate incorporated in the explosive can delay reaction between the explosive and the ore and slow down the reaction if it does start. The same chemical or calcium chloride and aluminium sulphate can be used to inactivate spilt explosive or explosive that has failed to detonate.

Left
The development of hot ground in copper mines can be simulated by blowing air through a mixture of ore and ammonium nitrate.

Recovering more gold

Gold and silver can be extracted from many sulphide concentrates by a process known as cyanidation. Some concentrates can be cyanided directly, others need to be roasted first. The ORE DRESSING INVESTIGATIONS laboratory has been studying a number of concentrates from gold mines in Victoria and the Northern Territory which have been harder to treat. Less than 50% of the gold and silver in these concentrates can be recovered by direct cyanidation. Roasting the concentrate before cyanidation can actually lower the yield.

ORE DRESSING INVESTIGATIONS have now developed a process which will recover more than 90% of the gold and silver from these ores. In this process the concentrate is ground, cyanided, roasted, leached with an acid brine solution, and cyanided again. Further work is needed to define the best operating conditions for each stage, but the process could be useful for several gold producers in Australia.

CRA's vessel 'Craestar', which operates in the Pacific region, carries atomic absorption apparatus. Mineral samples collected nearby can be delivered by helicopter and analysed for eight metals within a day.

Measuring five elements at a time

In 1953 a group of scientists in the DIVISION OF CHEMICAL PHYSICS devised a novel method of chemical analysis known as atomic absorption spectroscopy. With atomic absorption the amount of a metallic element in a sample can be measured quickly and accurately by vaporizing the sample in a flame, passing a beam of light from a specially designed lamp though the flame, and measuring the amount of light absorbed at certain wavelengths. Some 65 metals can be measured in this way, a different lamp being used for each metal.

Atomic absorption has found wide application in industry and research and several hundred locally made absorption instruments have been sold in Australia. Atomic absorption has also caused a revolution in mineral exploration. It is estimated that in 1967 over 50 absorption instruments were used in Australia to analyse more than 500,000 mineral samples.

Over the years, a number of refinements have been made to atomic absorption equipment to improve its accuracy and reliability. One recent refinement is the 'resonance detector', which simplifies the measurement of light absorption at particular wavelengths. Resonance detectors are compact, robust, inexpensive, and require no adjustment. They are particularly suitable where large numbers of identical analyses are wanted.

The development of resonance detectors has also made it possible to design instruments that can analyse for several elements simultaneously. Two such instruments have been made so far. One is being used by the DIVISION OF SOILS for determining calcium, magnesium, sodium, and potassium in soil samples in a national survey. The other, shown on the cover of this report, is being used by Sampey Exploration Services of Midland, Western Australia, for the simultaneous determination of copper, zinc, silver, nickel, and lead in mineral samples. After solutions of the samples have been prepared, one operator with relief during meal break can analyse 2000 samples a day for these five metals, equivalent to 10,000 determinations, at a cost of little more than $1 a sample.

Division of Applied Physics

Location: Chippendale, Sydney

Finance: Treasury \$1,474,408

Staff: Research scientists 36, other professional staff 46, supporting staff 129

Fields of research:

Maintenance and development of standards: direct current, length, mass, power frequency, radio frequency and microwave, vibration, audio frequency ●

Magnetic and dielectric properties of materials

Applied mechanics

Division of Physics

Location: Chippendale, Sydney, with an optical observatory at Culgoora, N.S.W.

Finance: \$855,740 (Treasury \$811,422, contributory \$44,318)

Staff: Research scientists 21, other professional staff 23, supporting staff 56

Fields of research:

Maintenance and development of standards: temperature, humidity, viscosity, light, radiation ●

Solid state physics

Fluid state physics

Solar physics

Physical Metallurgy Section

Location: Parkville, Melbourne

Finance: Treasury \$43,192

Staff: Research scientists 3, other professional staff 2, supporting staff 1

Fields of research:

Grain boundaries in metals

Changes in metals during deformation

The Divisions of Applied Physics and Physics comprise the NATIONAL STANDARDS LABORATORY.

Division of Tribophysics

Location: Parkville, Melbourne

Finance: $392,150 (Treasury $373,042, contributory $19,108)

Staff: Research scientists 22, other professional staff 8, supporting staff 23

Fields of research:

Defects in metal crystals

- Effect on properties such as strength and plasticity ●
- Effect on surface properties such as adsorption and catalysis ●

Upper Atmosphere Section

Location: Camden, N.S.W.

Finance: Treasury $124,694

Staff: Research scientists 5, supporting staff 11

Fields of research:

Physics and chemistry of the ionosphere ●

Division of Radiophysics

Location: Epping, Sydney, with the Australian National Radio Astronomy Observatory at Parkes, N.S.W., and a radio observatory at Culgoora, N.S.W.

Finance: $1,540,587 (Treasury $1,536,553, contributory $4,034)

Staff: Research scientists 38, other professional staff 27, supporting staff 163

Fields of research:

Solar radio astronomy ●

Galactic radio astronomy ●

Experimental cloud seeding

Cloud and rain physics

Liquid densities

A sample of about 50 cubic centimetres is usually needed for the precise determination of the density of a liquid, although samples as small as 10 cubic centimetres can sometimes be used. However, the DIVISION OF APPLIED PHYSICS has now developed a technique for liquids of low viscosity which makes it possible to determine the density of a sample only 1 cubic centimetre in volume with an accuracy of two parts in 100,000.

A small glass float containing a magnet is placed in the test liquid, the mass of the float and the magnet being such that they just sink. If a variable magnetic field is then applied to the magnet in the float, the strength of the field which just holds the float in suspension can be used to calculate the density of the liquid. The technique is particularly useful with scarce biological samples, as very little liquid is lost during measurement.

Measuring humidity

At the surface of liquid water, water molecules are continually leaving the liquid to become vapour molecules. At the same time vapour molecules are continually striking the surface of the liquid. Some of them stick and become part of the liquid, the rest bounce back into the vapour. For many years scientific opinion has differed on the proportion of molecules that stick. About a dozen experimental determinations have been made in various laboratories overseas in the last 40 years. A few of the experiments gave a value of the order of 50%, while the rest gave much lower values, ranging from 0·3 to 4·5%.

Recent work by the DIVISION OF PHYSICS has shown that under normal conditions the figure is about 2%. This work has also provided a better understanding of the theoretical principles underlying psychrometry—the measurement of humidity with dry- and wet-bulb thermometers.

The Division is using this new knowledge to improve the accuracy of humidity measurements and to increase the range of application of psychrometric techniques.

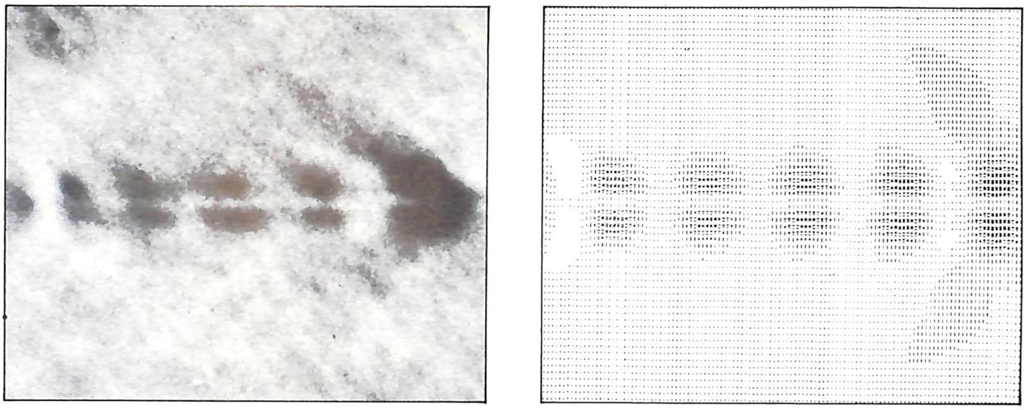
Pictures from computers

The mechanical properties of metals and alloys, such as strength, ductility, and fracture, can be seriously affected by atomic-sized defects in the metal crystals. Electron microscopes are used widely to study these defects, but electron micrographs (pictures obtained with an electron microscope) of crystal defects are not always easy to interpret. They cannot be interpreted intuitively in the way that pictures obtained with an optical microscope can, because the process of image formation is quite different and because the objects are viewed at atomic dimensions.

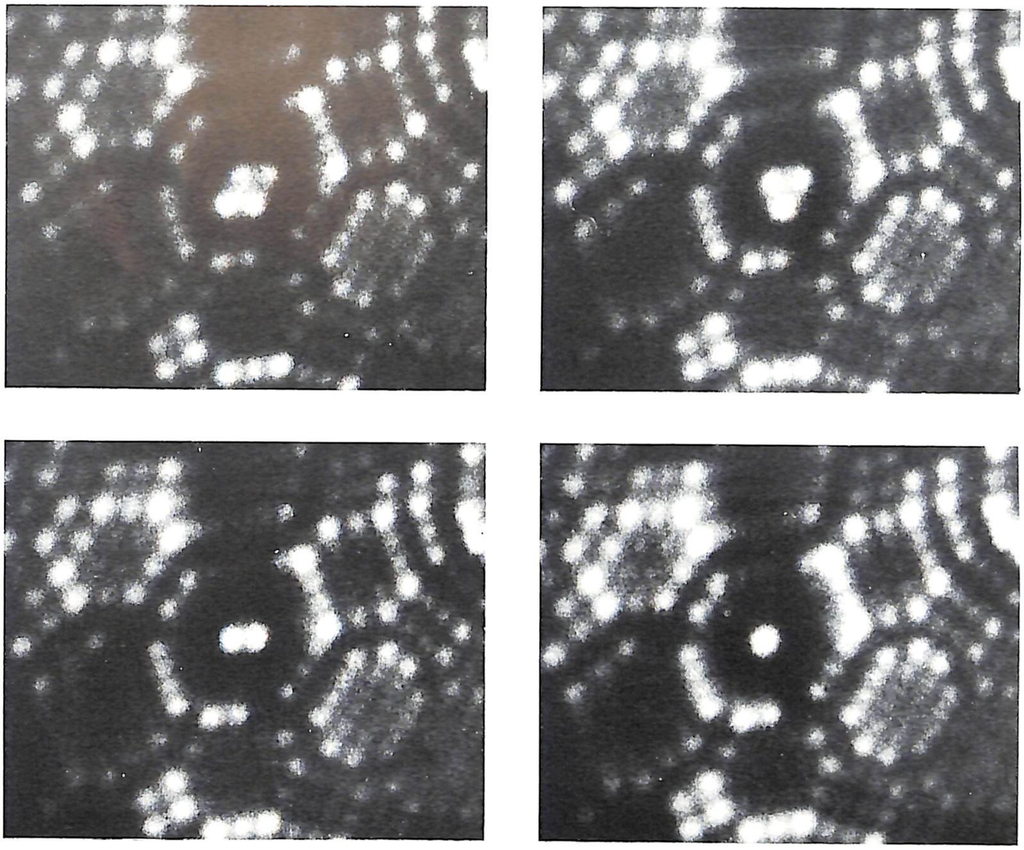
For some years it has been possible for the scientist to predict from theory the sort of image he should obtain for a particular type of defect. But very few predictions of this sort have been made because a large amount of computing is involved and because the results of the computations are presented as tables of numbers or graphs of the brightness at a number of points of the picture. These computations are difficult to compare with actual electron micrographs because they over-emphasize brightness values and disguise the general character of the micrograph as a picture.

The DIVISION OF TRIBOPHYSICS has been able to reverse this emphasis by using the printer of a computer to print a theoretical picture of the computed image. This is done in much the same way as a half-tone in a newspaper where different-sized dots are used to give different shades of grey. The pictures

Screw dislocation in beta-brass.
Left, electron micrograph (magnification 100,000).
Right, as predicted by computer.



The sequence of pictures below shows the evaporation of atoms from a tungsten needle under a high electric field. Each white spot is a tungsten atom.
As the electric field between the tungsten tip and the screen is increased the atoms at the tip of the needle (centre of picture) are stripped off one by one.



opposite show an electron micrograph of a dislocation in beta-brass and its theoretical counterpart. Theoretical pictures like these can be computed in about one minute. Already the Division has computed several thousand pictures and these have proved invaluable in interpreting pictures obtained with electron microscopes. The technique is now being used widely both in Australia and overseas.

Observing atoms

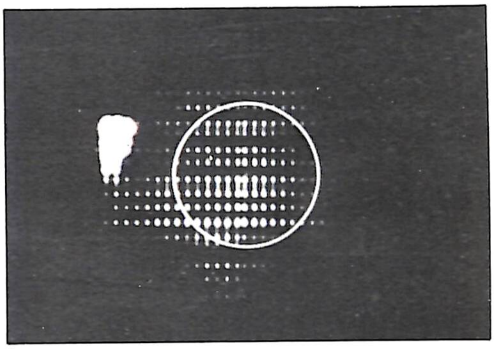
Many important processes in the chemical industry involve chemical reactions on the surface of solid catalysts. In the DIVISION OF TRIBOPHYSICS scientists are using an instrument known as a field ion microscope to study the way solid catalysts work. This instrument can magnify the tip of a fine metal needle about 2,000,000 times. Individual atoms in the needle tip produce a pattern of bright spots on the microscope's fluorescent display tube. By examining these patterns, scientists can find out more about the way in which the atoms are arranged and the forces which bind them to each other.

How big are quasars?

Quasi-stellar objects or quasars are among the most fascinating and mysterious objects in the astronomer's universe. They can be a hundred times brighter than the brightest galaxy but thousands of times smaller. How they produce their tremendous energy is one of the major problems of astronomy today. If the diameter of certain quasars could be measured, their magnetic fields could be assessed. Astronomers would then be in a better

These pictures of solar bursts, taken on September 2, 1967, are among the first obtained with the radioheliograph. The white circle represents the visible disk of the Sun. (1) A burst which occurred near the edge of the Sun's visible surface a little after midday shows up as a bright patch against the much fainter background of radio emission from the Sun's atmosphere. (2) Three and a half minutes later a new disturbance occurs in an entirely different area. (3) A minute later more bursts break out almost simultaneously at both regions.

These pictures showed that individual radio bursts, which from other records appeared to be the same group, could originate in widely separate areas of the Sun. They also showed that remote but active centres could erupt in close succession. This suggests a link between them, probably by means of electron streams already thought to be the source of many solar bursts.



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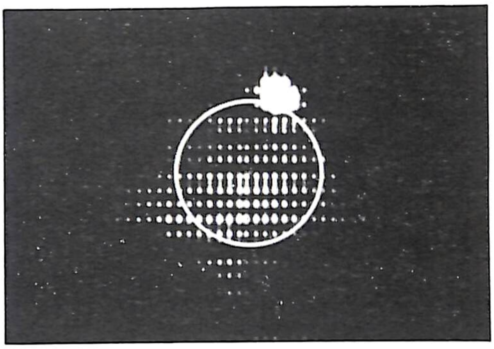

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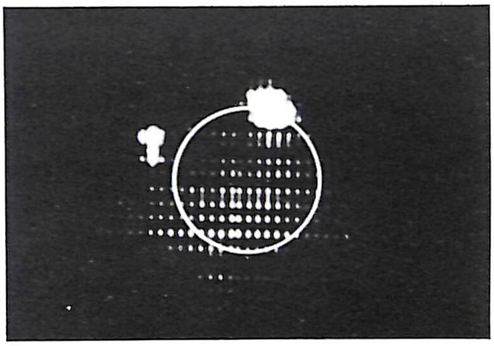

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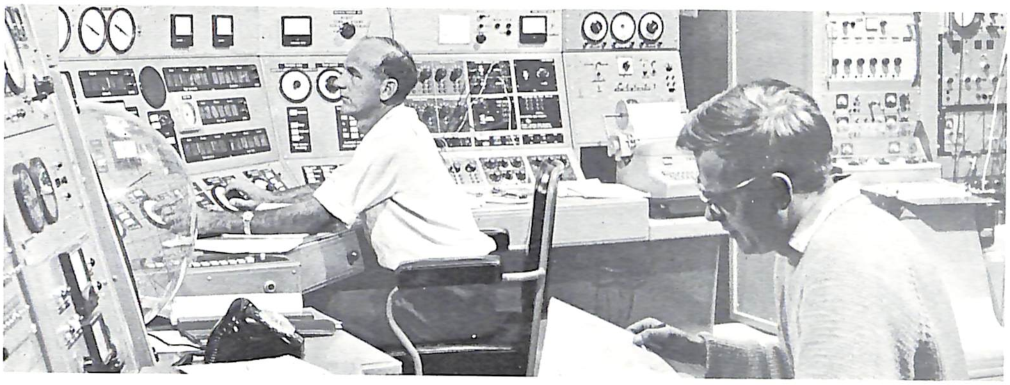


position to discuss the efficiency of energy production by the quasars, their energy reserves, and their stability. They would also know whether they were dealing with one object or with several. A puzzling feature of some quasars is the way in which their output of energy, at both light and radio wave lengths, can change in a matter of months or even weeks. Measurements of the corresponding changes in their size would help astronomers interpret these events.

The diameters of radio sources can be measured by using two radio telescopes a known distance apart. If the two telescopes are directed at the same radio source and if the signals received by each at the very same instant are combined, then the diameter of the source can be calculated from the interference pattern produced. In the case of quasars, their distances from Earth and their diameters are such that they cannot be measured with any degree of accuracy unless the two telescopes are many thousands of miles apart. Radio astronomers from the DIVISION OF RADIOPHYSICS are now planning to join forces with radio astronomers in North America in an attempt to measure for the first time the diameters of some of the more interesting quasars. The 210-foot steerable dish at the Australian National Radio Astronomy Observatory at Parkes, New South Wales, will be used in conjunction with a radio telescope in North America.

Above left
This time exposure of 21 minutes shows the full range of movements of the Parkes radio telescope as the 210-foot diameter dish is moved from a tilted position through 60° to the zenith, rotated 180° in azimuth, then dipped in the opposite direction. **Below left** The control room of the Parkes radio telescope.

Until recently, measurements of quasars using telescopes so far apart were not feasible because of the difficulty of synchronizing observations at two centres many thousands of miles from each other. But now the development of portable atomic clocks so accurate that they gain or lose less than one second in 10,000 years has made it possible for two radio telescopes on opposite sides of the world to record radio signals from the same source at precisely the same time.

Satellites and the upper atmosphere

In Britain, scientists at the Royal Aircraft Establishment, Farnborough, have noticed that the plane of orbit of an artificial satellite tilts gradually as the satellite circles the Earth towards the end of its life. They concluded from this that the upper atmosphere at heights of about 150 miles is rotating faster than the Earth and that there is an overall west wind of more than 200 miles an hour.

A possible explanation of this wind has now been put forward by the UPPER ATMOSPHERE SECTION. Some years ago the Section proved that winds in the Earth's atmosphere at a height of about 60 miles blew the electrically conducting air of the ionosphere across the Earth's magnetic field, thereby generating electric currents. The associated electric voltages penetrated upwards for hundreds of miles where they set the air of the high atmosphere in motion. In other words the atmosphere behaved like a dynamo at 60 miles and like an electric motor at greater heights.

The observations from Farnborough led scientists in the Section to predict that the 'motor' would be more effective by day than by night and that this could result in an apparent overall west–east rotation of the high atmosphere. Subsequent calculations showed that there should indeed be a strong west wind in equatorial regions but a weak overall east wind in middle and high latitudes. It can be shown on theoretical grounds that satellite orbits would be affected mainly by winds near the equator.

Statistics and computation

Division of Computing Research

Location: Canberra, with subsidiary installations at Adelaide, Melbourne, Sydney

Finance: Treasury $809,822

Staff: Research scientists 11, other professional staff 21, supporting staff 47

Fields of research:

Improvement of operating systems

Development of classification methods

Picture interpretation ●

Numerical meteorology ●

Voice digitization

Division of Mathematical Statistics

Location: Glen Osmond, Adelaide, with officers stationed at a number of Divisions and Sections and at the University of Melbourne

Finance: Treasury $385,367

Staff: Research scientists 22, other professional staff 14, supporting staff 35

Fields of research:

Computing with particular reference to statistics

Analysis of climatological data

General distribution theory

Geometrical analysis, multivariate analysis

Statistical inference

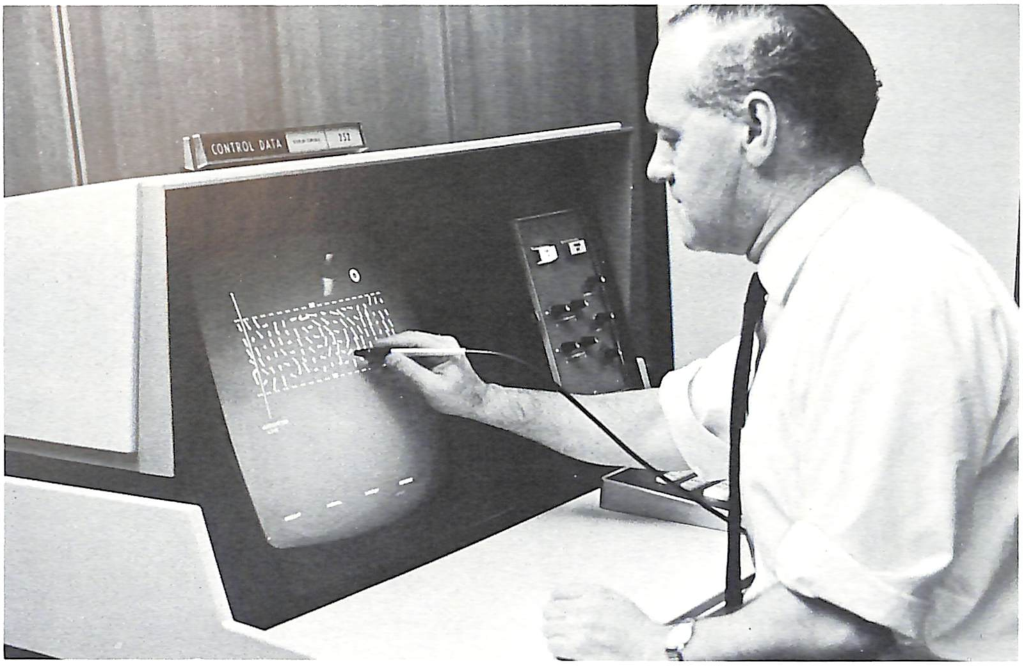
In addition to conducting their own research programmes,
the Divisions of Computing Research and Mathematical Statistics help scientists in other Divisions and Sections in the design of experiments and in the analysis and interpretation of research results.

Communication by pictures

Pictures are often a more convenient form of communication than words. Graphs, maps, flow charts, and circuit diagrams can convey information much better than words or tables of numbers. Display screens linked to computers are being used increasingly to display the output of a computer in pictorial form rather than in numbers. This has led scientists to consider the reverse process—giving information to the computer in pictorial form. For example maps might be fed into the computer and information retrieved from it in answer to such questions as, 'What is the shortest route by road from Canberra to Brisbane?'

As part of its research on the interpretation of pictures by computer, the DIVISION OF COMPUTING RESEARCH has developed a map input system using a 'light-pen'. With this system, a draughtsman can use his light-pen to draw a map on a display screen linked to a computer. He can name regions and locations on his map, make alterations to it, and retrieve information such as the area of a particular region or the distance between two towns simply by asking the computer questions in a combination of verbal and graphical commands.

For this system to operate satisfactorily, the computer must be able to grasp the organization of the graphic in the same way as a human does. To make this possible, new languages have had to be invented by the Division to describe the way in which pictures are organized. The Division is now using these languages to investigate other problems such as the input of programmes to computers in the form of flow charts.



Many experiments in meteorology produce such large quantities of data that high-speed computers are needed to process it all. Even then, the results are often a bewildering mass of numbers. The DIVISION OF COMPUTING RESEARCH has developed programmes which allow the results of meteorological experiments to be displayed on a screen in a more meaningful and readily comprehensible way. In the picture above, one of the Division's scientists is using a Vista display screen and a light-pen to study the eddy structure of a wind. The computer has translated the original data from a mass of numbers into a simple picture which can be altered if necessary with the light-pen.

Staff

Retirement

Dr. J. R. Vickery, O.B.E., M.Sc., Ph.D., has retired from CSIRO after 28 years as Chief of the DIVISION OF FOOD PRESERVATION. He has been regarded for many years as the leader in food science and technology in Australia and as an international authority in this field.

Dr. Vickery graduated M.Sc. from the University of Melbourne in 1926 and completed his Ph.D. degree at the University of Cambridge in 1929 at the Low Temperature Research Station of the British Food Investigation Board. He then became a member of a team of British, Australian, and New Zealand scientists working on the freezing, storage, and transport of lamb. In 1931 he returned to Australia and was appointed Officer-in-Charge of the Food Preservation Section of C.S.I.R. In 1940 the Section became a Division with Dr. Vickery as its Chief.

Dr. Vickery's work has been widely recognized overseas, particularly in the Commonwealth, and he has visited India, Pakistan, and New Zealand to advise on the development of food preservation research in these countries. In 1958 he was invited by the British Government to investigate meat research in Britain and to advise on the establishment of a meat research centre. He has been a member of the World Health Organization's Food Additives Committee, and has been frequently consulted by F.A.O. In 1966 he was chosen by the Food Group of the Society of Chemical Industry, London, to deliver its first international lecture.

Dr. Vickery was a foundation member and later Chairman of the original Australian Section of the International Institute of Food Technologists. He received the I.F.T. International Award in 1960 and the Australian Award in 1966. In 1967 he was created an O.B.E. in the Queen's Birthday Honours and was elected Foundation President of the Australian Institute of Food Science and Technology.

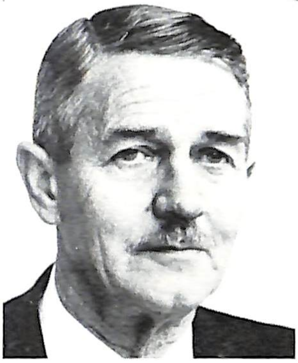
New Chief

Mr. M. V. Tracey, M.A., F.Inst.Biol., was appointed Chief of the DIVISION OF FOOD PRESERVATION following the retirement of Dr. J. R. Vickery.

After graduating M.A. from the University of Cambridge, Mr. Tracey joined the Biochemistry Department at Rothamsted Experimental Station, Britain, in 1945. He was awarded a Royal Society and Nuffield Foundation Commonwealth Bursary in 1955 and spent a year with the Division of Protein Chemistry. In 1958 he returned to Australia to take up an appointment with CSIRO as Leader of the Wheat Research Unit.

Mr. Tracey was admitted to Fellowship of the Institute of Biology in 1966.

Resignation



Associate Professor H. H. Dunkin, B.Met.E., of the Mining Department, University of Melbourne, has resigned after 27 years as Officer-in-Charge of ORE DRESSING INVESTIGATIONS so that he can devote more time to the activities of his Department. Under his leadership, the Ore Dressing laboratory has provided a valuable and effective service to the Australian minerals industry. Professor Dunkin will continue his association with ORE DRESSING INVESTIGATIONS in a consultant capacity.

Officer-in-Charge

Mr. K. S. Blaskett, B.E., F.S.A.S.M., has been appointed Officer-in-Charge of ORE DRESSING INVESTIGATIONS following the resignation of Professor H. H. Dunkin. A graduate in mining engineering from the University of Adelaide, Mr. Blaskett joined ORE DRESSING INVESTIGATIONS in 1946 after 16 years' operational and research experience in the mining and metallurgical industry.

Retirements

Dr. G. Baker, APPLIED MINERALOGY
Mr. J. Fridrichsons, CHEMICAL PHYSICS
Mr. T. Greaves, ENTOMOLOGY
Mr. W. L. Greenhill, unattached
Mr. A. V. Hill, PLANT INDUSTRY
Dr. J. S. Hosking, BUILDING RESEARCH
Mr. L. Medina, APPLIED PHYSICS
Dr. D. S. Riceman, NUTRITIONAL BIOCHEMISTRY
Mr. L. A. Thomas, PLANT INDUSTRY
Mr. A. J. Vasey, unattached
Dr. K. W. Zimmerman, APPLIED CHEMISTRY

Professorships

The following members of the staff have resigned during the year to accept appointment to university chairs.

Dr. S. J. Leach, PROTEIN CHEMISTRY, has been appointed Professor of Biochemistry at the University of Melbourne.

Dr. R. O. Slatyer, LAND RESEARCH, has been appointed Professor of Biology at the Australian National University.

Honours and Awards

Dr. F. J. Bergersen, PLANT INDUSTRY; David Rivett Medal of the CSIRO Officers' Association.

Dr. F. J. Bergersen

Dr. N. K. Boardman, PLANT INDUSTRY; David Syme Research Prize, University of Melbourne (shared).

Mr. J. G. Bolton, RADIOPHYSICS; Britannica Australia Award (shared).

Dr. L. M. Clarebrough, TRIBOPHYSICS; Doctor of Science, University of Birmingham.

Miss J. Conochie, HEAD OFFICE; Fellowship of the Library Association of Australia.

Mr. T. R. A. Davey, CHEMICAL ENGINEERING; Doctor of Applied Science, University of Melbourne.

Dr. A. J. Dyer, METEOROLOGICAL PHYSICS; Doctor of Science, University of Melbourne, and Buchan Prize, Royal Meteorological Society (shared).

Dr. R. C. Gifkins, PHYSICAL METALLURGY; silver medal of the Australian Institute of Metals.

Mr. A. F. A. Harper, PHYSICS; medal of the Royal Society of New South Wales.

Mr. W. Hartley, Scientific Attaché to the Australian Embassy, Washington; Fellow of the Australian Institute of Agricultural Science, and Frank N. Meyer Memorial Medal of the American Genetic Association.

Dr. J. G. Bolton

Dr. E. M. Hutton, TROPICAL PASTURES; Fellow of the Australian Institute of Agricultural Science.

Mr. I. Langlands, BUILDING RESEARCH; President of the Institution of Engineers, Australia, and Fellow of the Australian Institute of Building.

Dr. W. J. Peacock, PLANT INDUSTRY; Edgeworth David Medal of the Royal Society of New South Wales.

Dr. C. H. B. Priestley, METEOROLOGICAL PHYSICS; Vice-President, International Association of Meteorology and Atmospheric Physics.

Dr. E. W. Radoslovich, SOILS; Doctor of Science, University of Adelaide.

Mr. F. N. Ratcliffe, ENTOMOLOGY; Honorary Doctor of Science, Australian National University.

Dr. A. L. G. Rees, CHEMICAL PHYSICS; Vice-President and President Elect of the International Union of Pure and Applied Chemistry, and President of the Royal Australian Chemical Institute.

Dr. J. S. Shannon, ENTOMOLOGY; Doctor of Science, University of Adelaide, and H. G. Smith Memorial Medal, Royal Australian Chemical Institute (shared).

Dr. D. H. Solomon, APPLIED MINERALOGY; Archibald D. Olle Prize of the Royal Australian Chemical Institute.

Mr. W. C. Swinbank, METEOROLOGICAL PHYSICS; Buchan Prize, Royal Meteorological Society (shared).

Dr. A. L. G. Rees

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D. B. Williams, B.Sc.Agr., B.Com., Ph.D. (*seconded to University of Melbourne*)

PRINCIPAL RESEARCH SCIENTISTS
Miss S. H. Allen, B.Sc.
J. C. M. Fornachon, B.Agr.Sc., M.Sc. (*seconded to Australian Wine Research Institute*)

Finance

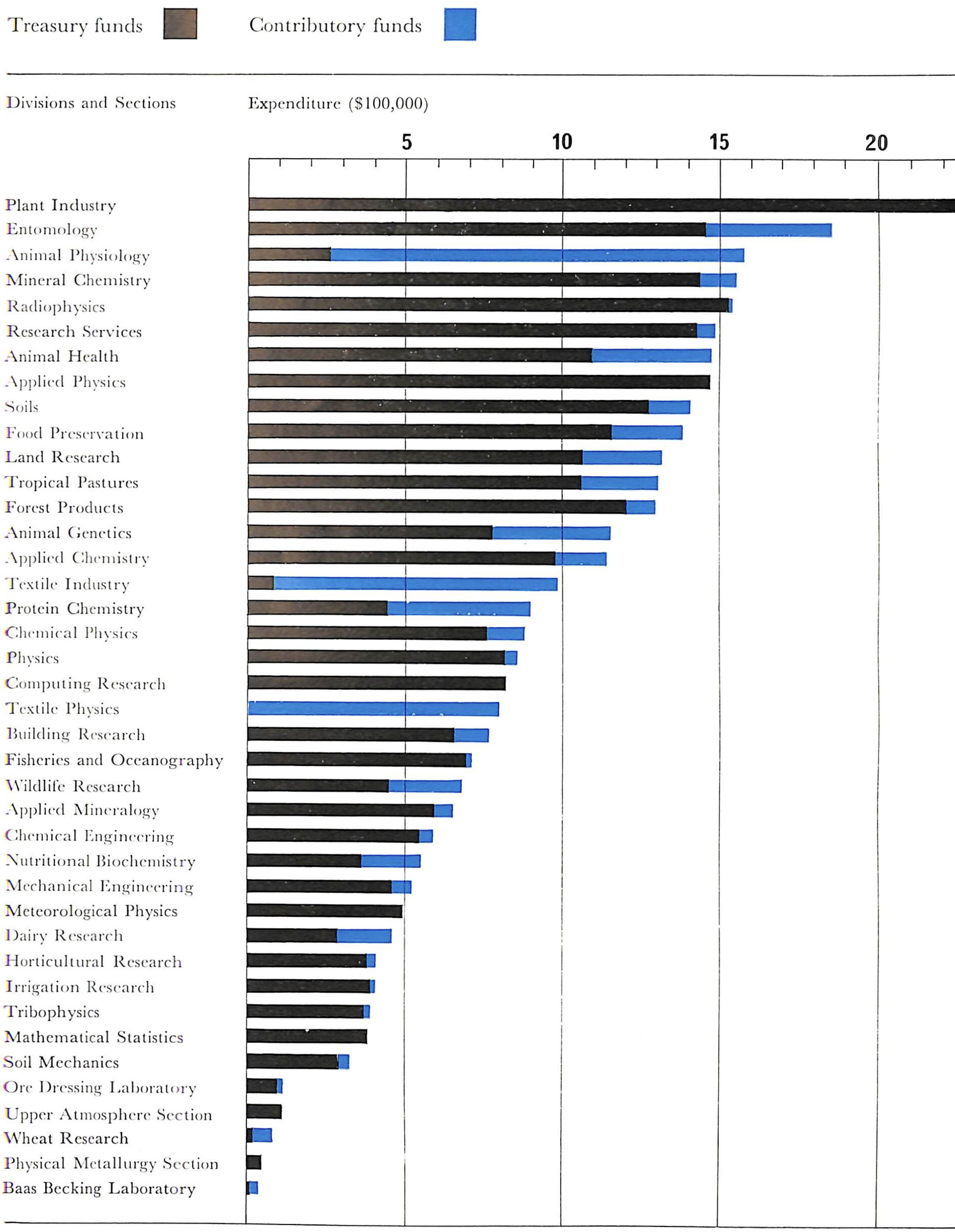
In 1967/68 CSIRO spent \$42·5 million, an increase of \$2·9 million over the previous year's expenditure. Of this amount \$39·2 million was spent on actual research work, including administration and supporting services such as library and publishing. Grants totalling \$1·3 million were made for Studentships and to outside bodies such as the Commonwealth Agricultural Bureaux and the Standards Association of Australia, while \$2·0 million was spent on capital works and services under the control of CSIRO. In addition, the Department of Works and the Department of the Interior spent \$3·7 million on buildings and other works for CSIRO and on the acquisition of land.

About three-quarters of CSIRO's income for 1967/68 was provided directly by the Commonwealth Government. The remainder was contributed by primary industry, individual companies, Australian and overseas government instrumentalities, and private foundations. About four-fifths of these contributory funds came from five Trust Funds set up by primary producer groups representing the wool, meat, wheat, dairying, and tobacco industries. These funds are derived from a levy on produce matched by a Government contribution.

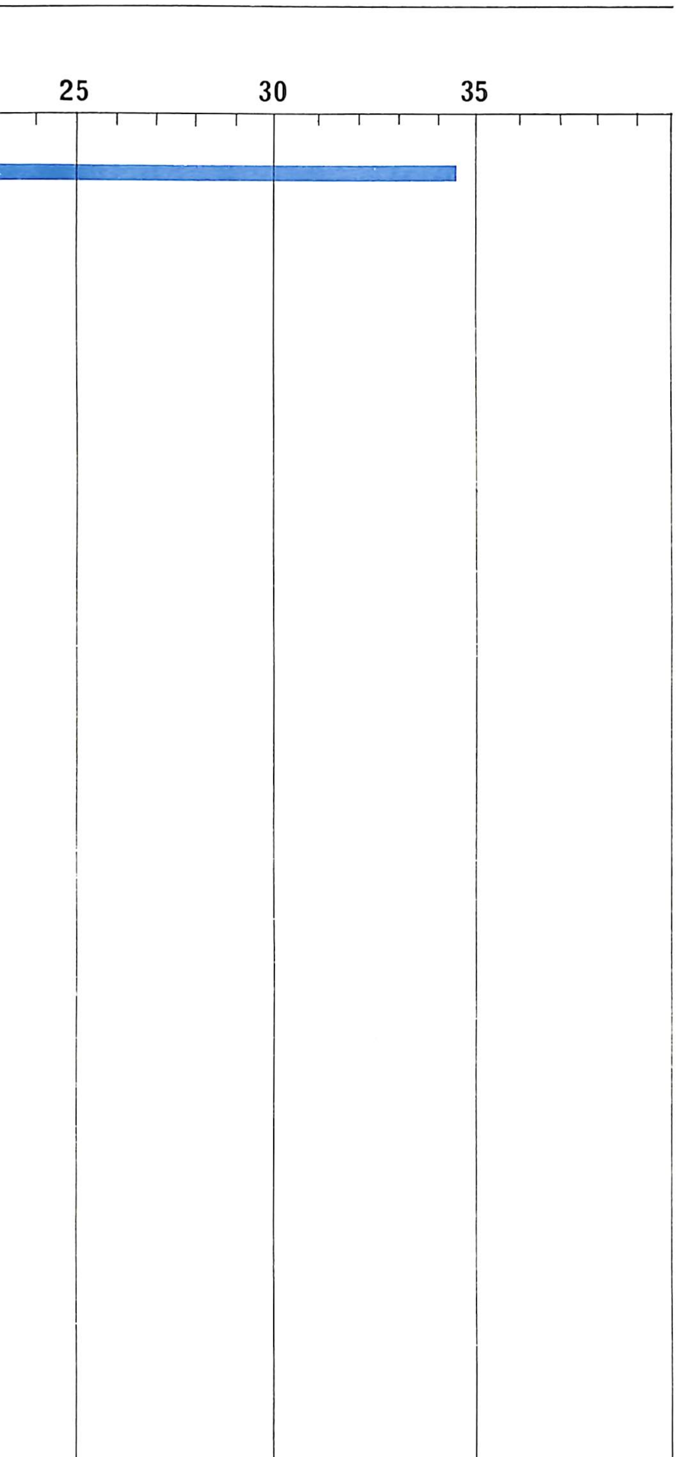
The following table summarizes sources of CSIRO funds and categories of expenditure.

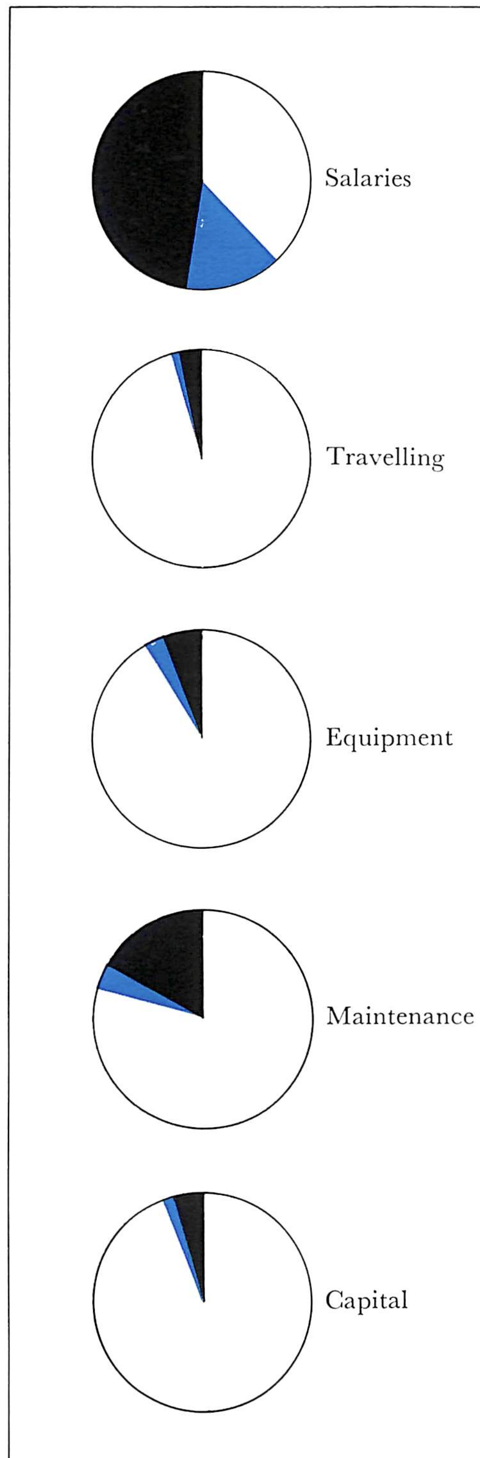
Source of funds	Investigations	Grants for Studentships and grants to outside bodies	Capital works and services	Total
Treasury appropriation	30,409,433	1,329,875	1,412,286	33,151,594
Wool Research Trust Fund	5,631,713		463,054	6,094,767
Meat Research Trust Account	867,263		40,139	907,402
Wheat Research Trust Account	256,550		10,179	266,729
Dairy Produce Research Trust Account	263,172		5,497	268,669
Tobacco Industry Trust Account	197,768		—	197,768
Other contributors	1,512,984		59,951	1,572,935
Total	**$39,138,883**	**$1,329,875**	**$1,991,106**	**$42,459,864**

Expenditure on investigations by Divisions and Sections, 1967/68



Expenditure by CSIRO, 1967/68





Expenditure

The following summary gives details of expenditure by CSIRO Divisions and Sections on other than capital items from July 1, 1967, to June 30, 1968.

DIVISION OR SECTION	**Treasury Funds** ($)	**Contributory Funds** ($)	**Total** ($)
Expenditure on Administration			
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 and Washington, staff and upkeep of State Committees, and general office expenditure.	2,199,512	—	2,199,512
Expenditure on Investigations			
Animal Research Laboratories			
Animal Genetics	770,626	382,743	1,153,369
Animal Health	1,098,437	379,821	1,478,258
Animal Physiology	207,216	1,368,053	1,575,269
Nutritional Biochemistry	359,852	191,383	551,235
Plant Industry	2,283,856	1,158,249	3,442,105
Entomology and Wildlife			
Entomology	1,450,285	402,811	1,853,096
Wildlife	444,633	231,222	675,855
Soils	1,273,583	131,111	1,404,694
Horticulture and Irrigation			
Horticultural Research	381,747	35,409	417,156
Irrigation Research	395,263	18,718	413,981
Tropical Pastures	1,051,888	251,328	1,303,216
Land Research	1,058,746	256,185	1,314,931
Processing of agricultural products			
Food Preservation	1,159,367	225,904	1,385,271
Dairy Research	293,160	172,739	465,899
Wheat Research	21,821	61,624	83,445
Wool Research	12,416	1,802,777	1,815,193
Chemical research of industrial interest			
Chemical Research Laboratories	2,361,868	140,349	2,502,217
Protein Chemistry	44,929	850,691	895,620
Fisheries and Oceanography	695,868	11,057	706,925
Processing and use of mineral products			
Chemical Research Laboratories	2,031,237	184,716	2,215,953
Mining and Metallurgy	162,705	42,779	205,484
Physical research of industrial interest			
National Standards Laboratory	2,285,830	44,318	2,330,148

General physical research			
Radiophysics	1,536,553	4,034	1,540,587
Meteorological Physics	498,665	—	498,665
Upper Atmosphere	124,694	—	124,694
Radio Research Board	40,000	46,231	86,231
General industrial research			
Building Research	716,873	47,974	764,847
Tribophysics	373,042	19,108	392,150
Soil Mechanics	298,907	21,698	320,605
Mechanical Engineering	468,701	51,678	520,379
Processing of forest products	1,216,087	73,087	1,289,174
Research services			
Computing Research	809,822	—	809,822
Mathematical Statistics	385,367	—	385,367
Extramural investigations	103,697	—	103,697
Other services	1,431,663	49,876	1,481,539
Miscellaneous	302,650	68,310	370,960
Expenditure on other services			
Research Associations—Grants	276,500	—	276,500
Research Studentships	330,963	—	330,963
Other grants	702,697	—	702,697
Overseas transactions—June	77,582	29,839	107,421
Total expenditure	31,739,308	8,755,822	40,495,130

Capital Expenditure under CSIRO Control

The table which follows shows expenditure of a capital nature from funds made available directly to CSIRO. It includes expenditure on capital and developmental works and on major items of equipment.

DIVISION OR SECTION	**Treasury Funds** ($)	**Contributory Funds** ($)	**Total** ($)
Administration	7,712	—	7,712
Animal Research Laboratories			
Animal Genetics	40,031	23,887	63,918
Animal Health	40,270	1,698	41,968
Animal Physiology	18,621	5,949	24,570
Nutritional Biochemistry	27,257	—	27,257
Plant Industry	48,528	68,747	117,275
Entomology and Wildlife			
Entomology	47,299	23,310	70,609
Wildlife	6,588	—	6,588

DIVISION OR SECTION	**Treasury Funds** ($)	**Contributory Funds** ($)	**Total** ($)
Soils	81,228	2,663	83,891
Horticulture and Irrigation			
Horticultural Research	4,973	—	4,973
Irrigation Research	4,283	—	4,283
Tropical Pastures	219,349	7,851	227,200
Land Research	701	5,096	5,797
Processing of agricultural products			
Food Preservation	74,290	14,069	88,359
Dairy Research	11,642	3,050	14,692
Wool Research	1,566	341,347	342,913
Chemical research of industrial interest			
Chemical Research Laboratories	111,225	—	111,225
Protein Chemistry	—	42,412	42,412
Fisheries and Oceanography	20,000	—	20,000
Processing and use of mineral products			
Chemical Research Laboratories	51,993	11,584	63,577
Physical research of industrial interest			
National Standards Laboratory	129,084	—	129,084
General physical research			
Radiophysics	130,657	—	130,657
Meteorological Physics	16,409	—	16,409
General industrial research			
Building Research	18,333	—	18,333
Tribophysics	500	—	500
Soil Mechanics	26,901	—	26,901
Mechanical Engineering	26,000	—	26,000
Processing of forest products	33,042	—	33,042
Research services			
Computing Research	189,655	—	189,655
Mathematical Statistics	2,943	—	2,943
Western Australian laboratories	10,866	—	10,866
Miscellaneous	10,340	785	11,125
Total capital expenditure	1,412,286	552,448	1,964,734

Contributions

This table summarizes receipts and expenditure during 1967/68 of funds provided by contributors and recorded in a special account entitled 'Specific Research Trust Fund'. The largest amounts contributed for specific research projects are provided from joint Commonwealth–Industry Funds such as the Wool Research Trust Fund, Meat Research Trust Account, etc. However, sums which are quite substantial in total are contributed by other bodies and industrial organizations, including several United States Government agencies.

DIVISION OR SECTION	**Receipts 1967/68 and balances brought forward 1966/67** ($)	**Expenditure 1967/68** ($)
Animal Genetics		
Wool Research Trust Fund	300,293	288,595
Meat Research Trust Account	59,973	59,871
Other contributors	66,990	58,164
Animal Health		
Wool Research Trust Fund	218,848	212,823
Meat Research Trust Account	158,035	144,615
Dairy Produce Research Trust Account	22,143	17,993
Other contributors	16,766	6,088
Animal Physiology		
Wool Research Trust Fund	1,302,543	1,262,885
Meat Research Trust Account	111,113	103,792
Other contributors	9,998	7,325
Nutritional Biochemistry		
Wool Research Trust Fund	203,197	191,383
Plant Industry		
Wool Research Trust Fund	880,710	823,727
Meat Research Trust Account	37,741	34,228
Wheat Research Trust Account	46,679	41,801
Dairy Produce Research Trust Account	15,086	13,565
Tobacco Industry Trust Account	217,759	197,768
Other contributors	183,736	115,907
Entomology		
Wool Research Trust Fund	75,336	54,416
Meat Research Trust Account	203,720	188,415
Wheat Research Trust Account	47,000	44,877
Other contributors	210,203	138,413
Wildlife		
Wool Research Trust Fund	201,630	194,726
Meat Research Trust Account	16,637	16,569
Other contributors	20,133	19,927

DIVISION OR SECTION	Receipts 1967/68 and balances brought forward 1966/67 ($)	Expenditure 1967/68 ($)
Soils		
Wheat Research Trust Account	50,638	56,131
Other contributors	105,403	77,643
Horticultural Research		
Other contributors	38,726	35,410
Irrigation Research		
Other contributors	47,216	18,718
Tropical Pastures		
Meat Research Trust Account	168,871	157,041
Dairy Produce Research Trust Account	64,819	57,942
Other contributors	74,143	44,196
Land Research		
Meat Research Trust Account	30,548	27,379
Other contributors	253,418	233,902
Food Preservation		
Meat Research Trust Account	220,759	159,594
Wheat Research Trust Account	4,859	5,202
Other contributors	119,787	75,177
Dairy Research		
Dairy Produce Research Trust Account	191,526	175,789
Other contributors	—	—
Wheat Research Unit		
Wheat Research Trust Account	59,684	61,624
Wool Research Laboratories		
Wool Research Trust Fund	2,257,004	2,112,411
Other contributors	51,676	31,713
Chemical Research Laboratories		
Wool Research Trust Fund	48,329	44,927
Meat Research Trust Account	12,507	7,605
Dairy Produce Research Trust Account	7,200	3,380
Other contributors	129,305	84,437
Protein Chemistry		
Wool Research Trust Fund	863,988	849,681
Other contributors	21,978	43,422
Fisheries and Oceanography		
Other contributors	11,203	11,057
Chemical Research Laboratories		
Other contributors	319,220	196,300
Mining and Metallurgy		
Other contributors	114,121	42,779
National Standards Laboratory		
Other contributors	71,516	44,318

Radiophysics		
Other contributors	17,967	4,034
Meteorological Physics		
Tobacco Industry Trust Account	909	—
Radio Research Board		
Other contributors	47,967	46,231
Building Research		
Other contributors	89,108	47,973
Tribophysics		
Other contributors	23,628	19,108
Soil Mechanics		
Other contributors	37,609	21,698
Mechanical Engineering		
Wheat Research Trust Account	49,188	51,678
Other contributors	20,750	—
Forest Products		
Other contributors	102,878	73,087
Mathematical Statistics		
Other contributors	10	—
Agricultural Liaison Unit		
Wool Research Trust Fund	61,973	45,146
Other contributors	3,005	2,503
Film Unit		
Other contributors	5,086	2,227
Miscellaneous		
Meat Research Trust Account	7,000	6,665
Other contributors	403,230	62,430
Overseas transactions—June	—	29,839
Total contributions	10,835,021	9,308,270

Miscellaneous Receipts

During 1967/68, miscellaneous receipts amounting to $764,350 were paid into Consolidated Revenue. Details of the receipts are as follows:

Sale of publications	31,842
Sale of equipment purchased in former years, and other receipts	119,627
Sale of produce	92,407
Royalties from patents	156,125
Testing fees	65,199
Computing charges	269,552
Miscellaneous	29,598
Total	764,350

Photograph acknowledgments

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