Commonwealth Scientific and Industrial Research Organization, Australia

CSIRO Twenty-third Annual Report 1970/71

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This Report of the work of the Commonwealth Scientific and Industrial Research Organization for the year ending June 30, 1971, has been prepared as required by Section 30 of the Science and Industry Research Act 1949–1968.

The Executive gratefully acknowledges the valuable help that CSIRO has received from Commonwealth and State government departments and instrumentalities, the Australian universities, members of primary and secondary industries, private individuals, and overseas institutions.

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

J. R. Price (*Chairman*)
V. D. Burgmann
C. S. Christian
M. F. C. Day
L. Lewis
E. P. S. Roberts
H. B. Somerset
K. L. Sutherland
E. J. Underwood

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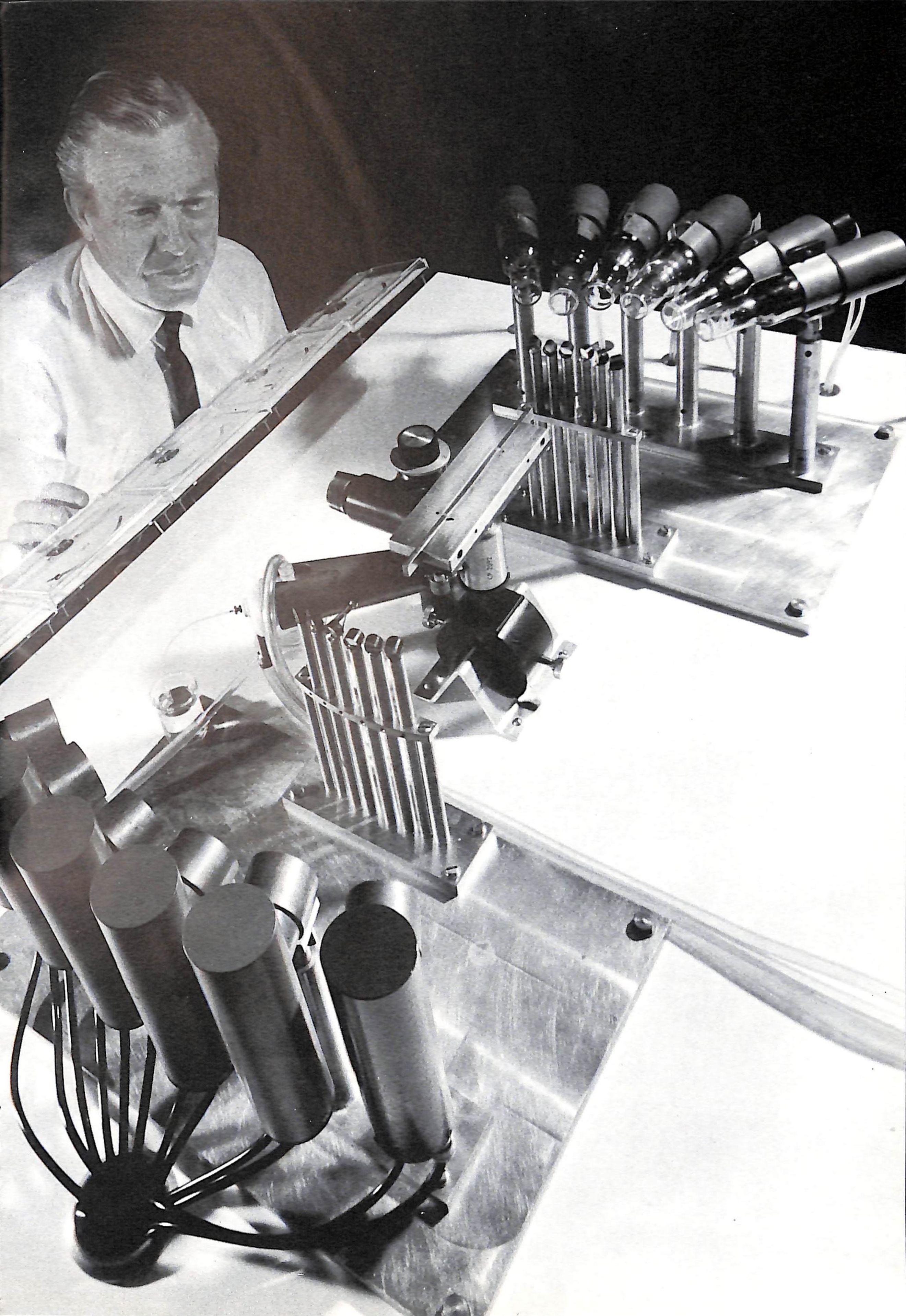
Cover

Examining a weevil with a scanning electron microscope.
Although the maximum magnification that can be obtained with scanning electron microscopes is not quite as great as that obtainable with conventional electron microscopes, and although their resolving power is not as high, they have become an extremely useful and versatile research tool because of their ability to look at the surface of objects rather than through very thin sections.
Even at low magnifications their depth of focus is much greater than is possible with optical microscopes, as can be seen from the image of the weevil on the display screen in the cover picture. The weevil is about 6 millimetres long and 3 millimetres wide.
(*Photograph*: Eric Smith.)

Research by the DIVISION OF CHEMICAL PHYSICS some years ago on the absorption of light by atoms in a flame led to the development of atomic absorption spectroscopy—a method of chemical analysis that enables the amount of a metallic element in a sample to be measured quickly and accurately. Today the elemental analyses carried out by atomic absorption throughout the world probably outnumber those by any other method. Commercial production of atomic absorption equipment began under licence from CSIRO in 1962. Within a few years, annual world sales of these instruments had risen to 1000 and by 1970/71 had exceeded 3000 and were still rising. To date, more than 14,000 instruments have been manufactured under licence from CSIRO and royalties derived from these licences have been in excess of $825,000. Although the basic patent of the instrument expired recently in several countries, continued research has led to improved instruments and to further patents.

The picture at right shows experimental atomic absorption equipment being developed by the DIVISION OF CHEMICAL PHYSICS. This equipment can analyse samples for up to six different elements simultaneously.



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

Introduction

Scientific and technological research is an activity which changes continually as research programmes advance, projects are completed, and new problems appear. The research administrator needs to be able to manage the resources available in a way which takes account of changing circumstances; he terminates projects that have reached a successful conclusion—or those which have failed to live up to early promise—and he redeploys resources into new areas which in his judgment and that of his colleagues warrant support. The judgments on which he makes such changes may be relatively straightforward when concerned with short-term problems, but are much more difficult when research programmes have long-term implications and involve considerable investment in time and money—as, of course, many of them do. Though such programmes should not be subject to pressures resulting from economic fluctuations, the research administrator has to pay attention to changing economic trends; and he must also look a long way ahead since the implications of research, even the implications of so-called short-term research, may be far-reaching both in application and in time.

Economic and social factors necessarily have a marked influence on the research programmes of an organization such as CSIRO. This influence is exemplified by the expansion in recent years of CSIRO's research in support of Australia's mineral industries. The need at this time for examination and possible change is highlighted by the increasing public concern over the less desirable effects of primary and secondary industry on our environment, and by the difficulties facing many sectors of our rural industry as a result of changing economic circumstances. The need to adjust to changing circumstances such as these is probably greater than at any previous period in the Organization's history. Moreover it arises at a time when economic conditions have resulted in a slowing down in the growth of the resources available to the Organization and at a time when the cost of maintaining a fixed level of research activity is rising steeply.

To ensure that Australia obtains the maximum return from its investment in CSIRO, it is essential that in adjusting to changing circumstances the Executive exercises the greatest care in re-determining its priorities. With this in mind, it has been looking at means of improving the effectiveness of its research planning by the increased use of techniques which take greater account of scientific, industrial, economic, and social factors.

During the past year, the Executive has made a number of modifications to the organizational structure of CSIRO. These, described in Chapter 1 of this report, have been made with the aim of ensuring the best use, in the national interest, of the resources available to the Organization. The Executive has also initiated a number of special reviews of the Organization's agricultural research and particularly of its research for the wool industry.

Although most of the money available to the Executive is provided direct from Consolidated Revenue, a significant sum is derived from the various agricultural industry funds, particularly the Wool Research Trust Fund. As a result of reduced returns from the sale of wool, the amount of money available to CSIRO from the Fund will be insufficient to maintain the existing level of research activity. Similar difficulties may be expected to arise with others of the agricultural industry funds.

The problems I have outlined present CSIRO with a considerable challenge, but it is a challenge which will be met.

J. R. Price

Chairman

General review

New Minister

Mr. David Fairbairn succeeded Mr. Nigel Bowen as Minister for Education and Science in March 1971.

Finance

About four-fifths of CSIRO's income for the year was provided directly by the Commonwealth Government. The remainder was contributed by primary industry, individual companies, Australian and overseas government instrumentalities, and private foundations. More than four-fifths of these contributory funds came from five trust funds concerned with the wool, meat, wheat, dairying, and tobacco industries. These funds are derived from a levy on produce matched by a Commonwealth Government contribution. In addition to the money which CSIRO received from the Government and from industry and other contributors, some \$4·8 million was spent by the Commonwealth Departments of Works and the Interior on buildings and other works for CSIRO and on the acquisition of land.

During 1970/71 CSIRO spent \$60·2 million, an increase of \$8·4 million over the previous year's expenditure. Most of the additional money was committed to inescapable increases such as higher salaries and running costs and to new equipment and facilities.

Of the money that remained, \$126,000 was allocated to develop major projects initiated in earlier years. Activities in this category included research on problems of grain storage, research on the biology and ecology of northern Australian wildlife, and investigations connected with the processing of sulphide ores.

After providing for the above commitments, the Executive was able to allocate \$92,000 to commence or expand research in three areas—rock mechanics, mineral physics, and the effects of 1080 poison on wildlife.

During February 1971 the Government placed restrictions on Commonwealth expenditure during the remaining months of 1970/71 as part of its plan to curb inflationary trends in the economy. The Organization's allocation for salaries and general running expenses was reduced by \$179,000, while the allocation for capital expenditure incurred directly by CSIRO was cut by \$104,000.

The Government's decision had a more severe effect on the building programme, the funds for which are under the control of the Department of Works. The total of the CSIRO building programme as originally approved was \$2·8 million. The reductions totalled \$1·7 million, a cut of over 60% on the figure approved at the beginning of the year.

Further details of where CSIRO's funds came from and how they were spent during 1970/71 are given in the finance section of this Report.

Changing research programmes

CSIRO's research programme is kept constantly under review and its direction and emphasis are continually adjusted to meet changes in the scientific and economic prospects of the various investigations concerned.

Some of the more important projects which were completed during 1970/71 are set out below, together with areas of research that have been initiated or expanded by the subsequent redeployment of resources of staff and finance.

NUTRITIONAL BIOCHEMISTRY

Research on utilization by the sheep's liver of compounds derived from the digestion of food in the rumen has now been scaled down in favour of research on aspects of liver deficiencies and the biochemical functions of zinc.

Biophysical instrumentation studies have been discontinued and the resources reallocated to make possible an expansion of work on fermentation by rumen microorganisms.

ENTOMOLOGY

Releases have been made in Australia of parasites of the potato tuber moth. Although there is evidence of parasitism, it is not yet possible to indicate how successful this will be in economic terms. The work will be phased out although periodic field observations will be made. The resources have been transferred to work on the biological control of skeleton weed.

The Sirex Biological Control Unit at Silwood Park in England closed in June 1971. The sirex wasp programme in Australia will continue although reduced to a limited extent. Staff returning to Australia will be transferred to work on the bush fly.

TROPICAL PASTURES

Studies of the effects of salinity and other stresses on the physiology of plant growth have been terminated and the resources reallocated to work on plant nutrition and factors affecting the feeding value of pasture plants.

Research on fodder conserved as silage has been completed and the resources reallocated to a study of factors affecting the efficiency of nitrogen fertilizer use.

APPLIED CHEMISTRY

Basic laboratory investigations of the Sirotherm process of water desalination have been completed and the resources directed to research on water pollution technology. Studies of chemical reactions at high pressures have been terminated and the staff transferred to the DIVISION OF MINERAL CHEMISTRY.

BUILDING RESEARCH

Following the successful development of a plant for the accelerated curing of concrete, resources have been reallocated to work on concrete handling during high-rise building construction and methods of welding reinforcement bars in concrete.

MINERAL CHEMISTRY

Projects concerned with catalysis, fuel cells, and treatment of McArthur River ore have been terminated and the resources directed to a number of other projects concerned with shipment of sulphide concentrates, flotation, electrolytic manganese production, processing lateritic nickel ores, and borehole logging.

The transfer of staff positions from the former UPPER ATMOSPHERE SECTION has enabled the Mineral Physics Section of the DIVISION OF MINERAL CHEMISTRY to commence new projects on geophysical exploration and rock physics.

TRIBOPHYSICS
Research on the physics of organic crystals and on thin metal films has been terminated. Staff and finance have been redirected to investigations into high-temperature and high-hardness inorganic materials for cutting processes and high-temperature applications; to expansion of work on die-casting, surface-finishing of metals, and hard-facing metals; and to studies of catalytic processes in petroleum 'cracking' and oxidation of metals.

Work on foundry sands has ceased and the resources have been directed to work on the mechanics of casting problems.

APPLIED PHYSICS
Projects concerned with the precise measurement of acceleration due to gravity, the development of an a.c. resistance bridge, calibration of vibration detectors, and engineering design analysis have been completed. Staff and finance have been directed to projects concerned with the Josephson effect, the absolute determination of the volt, holographic methods of measuring vibration, and the measurement of dimensional stability of machine tools.

Buildings

As mentioned earlier, the Government's decision in February 1971 to restrict Commonwealth expenditure resulted in the deletion of a number of projects from the Organization's building programme for 1970/71. Their total value was about $1·7 million.

During the year work was started on the site of the new NATIONAL STANDARDS LABORATORY at Bradfield Park, Sydney. Half a million dollars was made available so that contracts could be let for site preparation, road construction and diversion, and other necessary site services. Tenders for the main portion of the project are expected to be called in the first half of 1972.

Construction of the following buildings began during 1970/71:

APPLIED GEOMECHANICS—Rock mechanics laboratory at Syndal, Melbourne. $163,000.

ANIMAL HEALTH—Small-animals building, tuberculosis laboratory, and isolation unit at Maribyrnong, Melbourne. $315,000. Of this amount, some $97,000 was provided from the Meat Research Trust Account.

The main project completed during the year was the new Head Office building in Canberra. Finance for the building, which cost $1·5 million, was provided by the National Capital Development Commission and not as part of the CSIRO building programme.

Other major projects completed during the year include:

PLANT INDUSTRY—Agronomy laboratory and administration building, Canberra. The building cost $830,000, of which $500,000 was provided from the Wool Research Trust Fund.

SOILS—Laboratory at Canberra. $535,000.

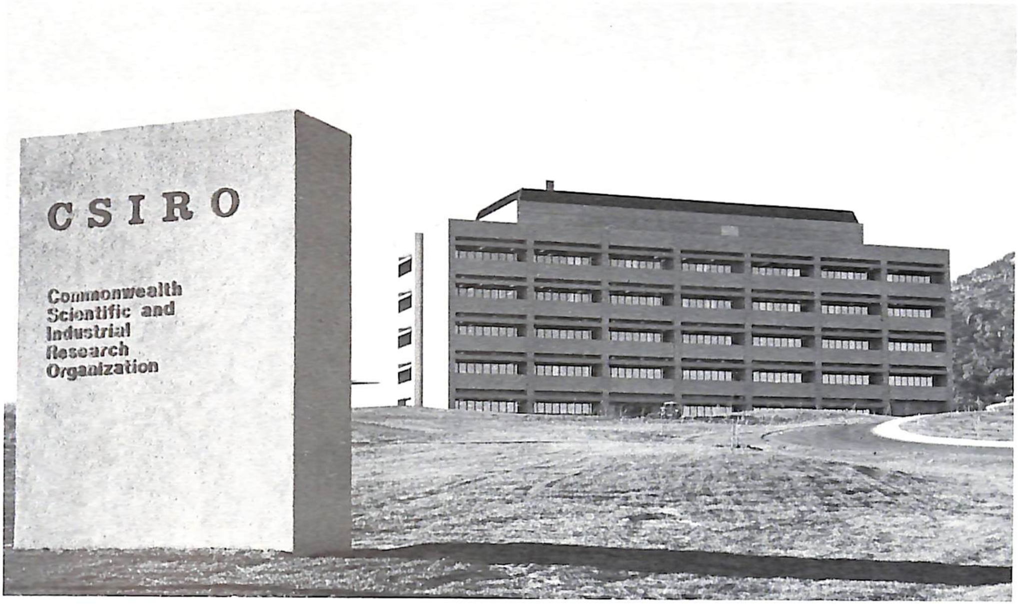
WESTERN AUSTRALIAN LABORATORIES—Extension to the Laboratories at Floreat Park, Perth, to house the Western Australian group of the DIVISION OF MINERALOGY. The headquarters of the Division have been transferred to the new building from Melbourne. $500,000.

PROTEIN CHEMISTRY—Extensions to laboratory at Parkville, Melbourne. The extensions were financed from the Wool Research Trust Fund. $380,000.

WILDLIFE RESEARCH—Laboratory at Canberra. $225,000. Laboratory at Darwin. $217,000.

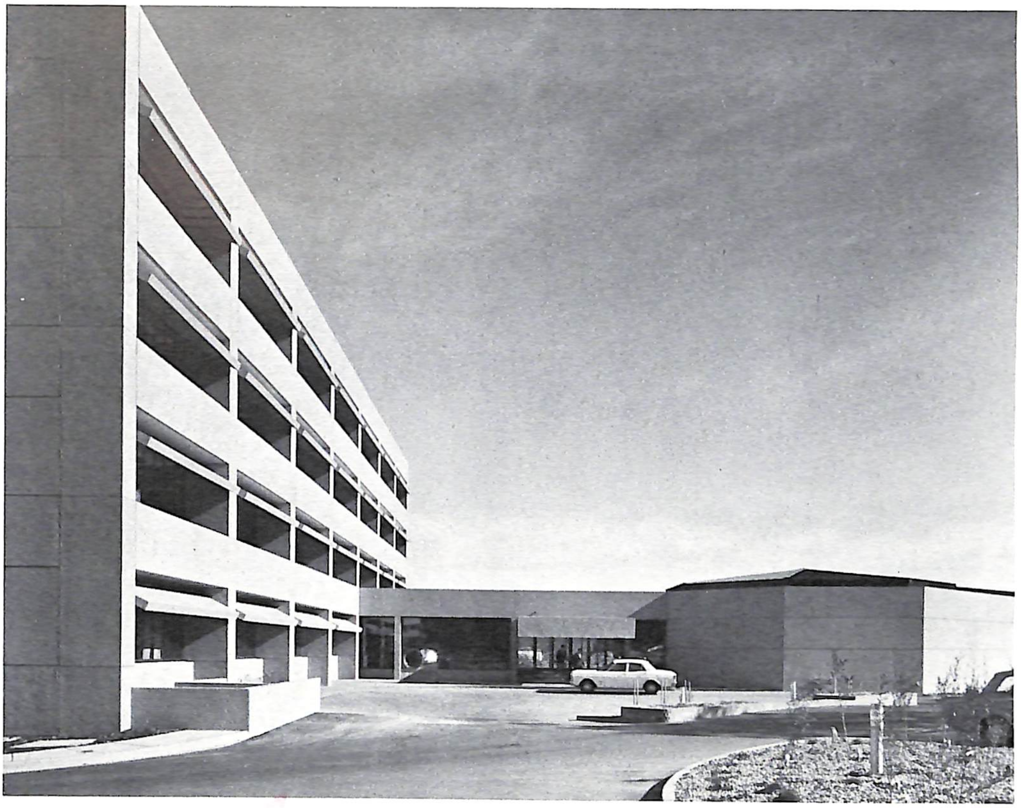
METEOROLOGICAL PHYSICS—Laboratory at Aspendale, Melbourne. $165,000.

ENTOMOLOGY—Workshop, stage 2, Canberra. $155,000.



Above This new Head Office building in the Canberra suburb of Campbell was occupied in January 1971 when a major part of the Head Office staff transferred from Melbourne. The building also houses those Head Office staff who were already located in Canberra and the staff of the Canberra Regional Administrative Office.

Below Head Office building viewed from the entrance courtyard, with the conference area at the right.



HORTICULTURAL RESEARCH—Library and administration building, Merbein, Victoria. $107,000.
TEXTILE PHYSICS—Cloth research laboratory at North Ryde, Sydney. The building was financed from the Wool Research Trust Fund. $30,000.

Organizational changes

CHEMICAL RESEARCH LABORATORIES
The central services group which served the DIVISIONS OF APPLIED CHEMISTRY, APPLIED MINERALOGY, CHEMICAL ENGINEERING, CHEMICAL PHYSICS, and MINERAL CHEMISTRY was disbanded in September 1970. At the same time the term CHEMICAL RESEARCH LABORATORIES, by which the five Divisions had previously been known collectively, was dropped.

FOOD RESEARCH
Following the retirement of Mr. G. Loftus Hills as Chief of the DIVISION OF DAIRY RESEARCH in January 1971, the Division was amalgamated with the DIVISION OF FOOD PRESERVATION to form a single DIVISION OF FOOD RESEARCH. Mr. M. V. Tracey, Chief of the DIVISION OF FOOD PRESERVATION was appointed Chief of the new Division, which comprises the Food Research Laboratory, Sydney, the Meat Research Laboratory, Brisbane, and the Dairy Research Laboratory, Melbourne.

MINERALS RESEARCH
In January 1971 those Divisions concerned with research for the mineral industries were re-organized and grouped together as the CSIRO MINERALS RESEARCH LABORATORIES, a complex comprising the DIVISIONS OF CHEMICAL ENGINEERING, MINERAL CHEMISTRY, and MINERALOGY. Mr. I. E. Newnham, formerly Chief of the DIVISION OF MINERAL CHEMISTRY, was appointed Director of the Laboratories, and Mr. A. J. Gaskin, formerly Chief of the DIVISION OF APPLIED MINERALOGY, was appointed Chief of the new DIVISION OF MINERALOGY, the headquarters of which are located in Perth.

The DIVISION OF MINERALOGY consists of the following groups:

- the group from the former DIVISION OF APPLIED MINERALOGY laboratory located in Western Australia;
- the staff at the Baas Becking laboratory, Canberra, from the former DIVISION OF APPLIED MINERALOGY;
- the Geochemistry Section of the DIVISION OF MINERAL CHEMISTRY located at Sydney.

The remaining staff of the former DIVISION OF APPLIED MINERALOGY were relocated as follows:

- the engineering ceramics group, the refractories group, the foundry sands group, and appropriate technical services staff were transferred to the DIVISION OF TRIBOPHYSICS to form an inorganic materials research group;
- the cement groups from Fishermens Bend and Sydney were transferred to the DIVISION OF BUILDING RESEARCH.

A small microscopy group was formed in the DIVISION OF MINERAL CHEMISTRY by transferring appropriate staff from the DIVISION OF BUILDING RESEARCH.

MARINE BIOCHEMISTRY UNIT
A MARINE BIOCHEMISTRY UNIT was established in April 1971. Dr. G. F. Humphrey, formerly Chief of the DIVISION OF FISHERIES AND OCEANOGRAPHY, was appointed Officer-in-Charge of the Unit which will conduct research on the biochemistry of phytoplankton.

FOREST PRODUCTS
Following the retirement of Mr. I. Langlands as Chief of the DIVISION OF BUILDING RESEARCH in May 1971, the Division's activities were integrated with that part of the DIVISION OF FOREST PRODUCTS concerned with wood as a structural material. Dr. R. W. R.

Muncey, formerly Chief of the DIVISION OF FOREST PRODUCTS, was appointed Chief of the new Division, which has retained the name DIVISION OF BUILDING RESEARCH. The remaining part of the DIVISION OF FOREST PRODUCTS, which was concerned with research for the pulp and paper industries, was integrated with the DIVISION OF APPLIED CHEMISTRY.

PLANT INDUSTRY
A number of changes in the structure of the DIVISION OF PLANT INDUSTRY were announced during 1970/71 although they did not become effective until July 1971. The Agricultural Physics Section located in the Pye Laboratory, Canberra, became the DIVISION OF ENVIRONMENTAL MECHANICS with Dr. J. R. Philip as its Chief. The Riverina Laboratory at Deniliquin, New South Wales, was transferred to the DIVISION OF LAND RESEARCH to form part of the Rangelands Research Unit. The Tobacco Research Institute at Mareeba, Queensland, was also transferred to the DIVISION OF LAND RESEARCH. A small group located in Hobart was transferred to the DIVISION OF HORTICULTURAL RESEARCH, and staff associated with the Baas Becking Geobiological Laboratory in Canberra were transferred to the DIVISION OF MINERALOGY.

Several other organizational changes were announced during 1970/71, although they did not become effective until the following financial year. They included:

CLOUD AND RAIN PHYSICS
The Cloud and Rain Physics Section attached to the DIVISION OF RADIOPHYSICS became the Cloud Physics Section of the DIVISION OF METEOROLOGICAL PHYSICS.

MINERAL PHYSICS
The Mineral Physics Section of the DIVISION OF MINERAL CHEMISTRY became an independent Section within the MINERALS RESEARCH LABORATORIES with Dr. K. G. McCracken as its Officer-in-Charge.

WOODLAND ECOLOGY
The Woodland Ecology Section of the DIVISION OF TROPICAL PASTURES became the Woodland Ecology Unit attached to the DIVISION OF LAND RESEARCH. Dr. R. M. Moore was appointed leader of the Unit.

Executive Officer

Dr. J. A. Allen was appointed to the newly created position of Executive Officer in May 1971. Dr. Allen was formerly Professor of Chemistry and Deputy Vice-Chancellor of the University of Newcastle. As Executive Officer, he is responsible for Head Office activities associated with planning—both long-term and short-term; for examining, on a continuing basis, CSIRO's technical advisory and innovative activities; and for coordinating Head Office activities.

Scientific liaison

Mr. E. E. Adderley was appointed to the newly created position of Counsellor (Scientific) in Tokyo in January 1971. He will be responsible for the provision of scientific advice to the Australian Ambassador in Japan and for reporting to Australia on aspects of Japanese research and development of interest to CSIRO and Commonwealth Government Departments. He will also be available to assist Australian scientists visiting Japan and to facilitate requests for information and equipment. Mr. Adderley was formerly a member of the DIVISION OF RADIOPHYSICS, where he was responsible for the design and analysis of cloud-seeding experiments.

Research

In a report of this size it is not possible to give a full account of all CSIRO's current investigations. More comprehensive information on the work of the Organization can be obtained from the separate annual reports of the individual Divisions.

The aim of this chapter is to report on one or two items of interest from each Division so as to show something of the wide range of CSIRO's research activities and their relevance to Australia's primary and secondary industries. In selecting the items, an attempt has been made to choose those which are of general interest and which lend themselves to description in terms that can be understood by the lay reader. This condition inevitably introduces a bias, as a good deal of fundamental work in the basic sciences is excluded. Often the scientific or potential industrial significance of such research can be appreciated only by specialists in the same field. For convenience of presentation, Divisions have been grouped under various headings such as 'Livestock', 'Food Processing', and 'Chemistry and Mineralogy'. This arrangement is quite arbitrary and is not meant to imply a rigid compartmentalization of research interests.

Brief descriptions of each Division in terms of staff, location of laboratories, and fields of research have been included so that the items reported in this chapter can be seen within the broader context of the Organization's overall research programme. Because of the restructuring of a number of Divisions during the year, the inclusion of figures on research expenditure in the explanatory tables might have proved misleading in some cases. These figures have therefore been deleted from the tables; however, detailed information on research expenditure is given in the financial section of this report.

The agricultural environment

Division of Soils

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

Staff: Research scientists 70, other professional staff 27, supporting staff 102

Fields of research:

Soil fertility—physical, chemical, and biological properties of soils in relation to plant growth
Soil water—landscape hydrology, water resources, salinity, water use by plants
Soil mineralogy and geochemistry—mineral forms of nutrient elements, changes in weathering, clay minerals
Surface chemistry—studies of nutrient and toxic elements, factors affecting availability, design of fertilizers
Clay soils—nature of water movement in clays, electrolyte and cation effects, structure and physical stability
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, on water loss, and on plant growth
Formation, distribution, and classification of soils—micromorphology, landscape relationships, transport of sediment

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.

Staff: Research scientists 42, other professional staff 35, supporting staff 138

Fields of research:

Land resources surveys in Australia and Papua–New Guinea
Principles and methodology of land classification
Dynamics of landscape
Hydrology in relation to catchment characteristics
Regional crop and pasture investigations at Kimberley Research Station, Coastal Plains Research Station, and Katherine Research Station
Crop–environment and root–nutrient relations
Biological systems analysis
Plant taxonomy
Structure and function of the climate/land/plant/animal ecosystem in arid Australia

Division of Meteorological Physics

Location: Aspendale, Melbourne
Staff: Research scientists 20, other professional staff 13, supporting staff 49

Fields of research:
Weather—the physical processes controlling it, both near the surface and at high levels
Exchange of heat, water vapour, and momentum between the atmosphere and the Earth's surface
Radiation—solar, atmospheric, and terrestrial
Agricultural meteorology—the interaction of plant and environment
Maintenance and development of standards in radiation and anemometry; calibration of radiometers and anemometers

The Division of Meteorological Physics also has a group of officers located at the COMMONWEALTH METEOROLOGICAL RESEARCH CENTRE. The Centre is financed and managed jointly by the Division and the Commonwealth Bureau of Meteorology. Research and administrative staff are appointed by CSIRO and other professional, technical, and ancillary staff by the Bureau.

Location: Melbourne
Staff: Research scientists 10, other professional staff 1, supporting staff 3 (14 other professional staff and a further 8 supporting staff are provided by the Bureau of Meteorology)

Field of research:
Derivation of numerical models for study of atmospheric behaviour, with emphasis on the general circulation, directed towards improved climatic understanding and weather prediction.

Monitoring the behaviour of cattle

The arid rangelands that cover nearly three-quarters of Australia and support some four million beef cattle may be regarded as a four-part system comprising climate, soils, plants, and animals. The most easily managed component of the system is the animal and for this reason basic knowledge of cattle ecology is essential to the development of guidelines for the conservation and management of our rangelands.

Cattlemen in central Australia are familiar with the way in which cattle graze selectively in order to obtain the forage that they prefer, and know that the location of watering-points plays a key role in influencing the animal's grazing activities. Temperature too has an important influence and, as grazing patterns change, body condition and reproduction are inevitably affected.

On Hamilton Downs station near Alice Springs, the Rangelands Research Unit of the DIVISION OF LAND RESEARCH is undertaking a systematic study of the factors determining the activity of cattle. Work is centred on Kunoth Well 'paddock', an area of 60 square miles

(155 square kilometres) typical of two of the most important rangeland types in the region.

Observers have kept regular 24-hour watches to find the watering habits of cattle, and to see how they are affected by changes of rainfall, temperature, and wind, and the location and quality of forage. Aerial surveys of cattle distribution have provided additional information. These visual observations will be supplemented by a system of radio telemetry; a contract has been let to a Sydney electronics firm to provide the basic equipment. Small transmitters attached to individual cows will feed information to a central station so that research workers can monitor each animal's location, body temperature, and respiration, and tell whether it is grazing, ruminating, resting, or walking. In this way they will be able to study how the animal reacts to climatic changes and to varying food supplies. The system will monitor a number of animals over a distance of 5–10 miles (8–16 kilometres).

Higher yields from cotton hybrids

Although hybrid vigour has been successfully used to obtain higher yields in crops such as maize, the possibility of exploiting hybrid vigour in cotton has tantalized plant breeders for many years. Unlike maize, which has separate male and female flowers, cotton has bisexual flowers. Until recently, the only way to effect cross fertilization in cotton, whether by hand or insects, was by first emasculating the flowers. Such a technique is quite impracticable where large numbers of hybrids have to be produced, but the problem has now been overcome by the development in the United States of male-sterile strains.

So far, experiments carried out in the United States with cotton hybrids have given disappointing results. While the hybrids performed much better than existing commercial varieties under low-yield conditions, the increase in yield obtained under high-yield conditions was relatively small. Since cotton yields in Australia are among the world's highest, it looked at first as though there was little to be gained by growing hybrid cotton locally. However, after examining the American results more closely, the DIVISION OF LAND RESEARCH found that although a wide range of cotton varieties had been used, the potential of African varieties had been neglected.

These varieties had already given satisfactory yields in field trials at the Kimberley Research Station in the Ord valley of Western Australia. In subsequent trials at the station, the Division found that hybrids between African and commercial American varieties outyielded the current high-yielding and widely grown commercial variety Stoneville 7A by up to 22%. In absolute terms this was an increase of 400 pounds of lint an acre (450 kilogrammes a hectare), which at world prices was worth an extra $120.

The Division is now investigating these hybrids further and is working on the development of systems of hybrid seed production for farmers.

Wheat husks hold record of water losses

Since the amount of water available to a wheat crop has a marked effect on its growth, a knowledge of how much water a crop has transpired is important if fertilizer responses of crops at different sites are to be compared. Until recently, field measurement of the amount of water transpired by a wheat crop has proved difficult. However, the DIVISION OF SOILS has now developed a simple and reliable method of estimating transpiration by determining the silicon content in the husks from wheat ears collected at harvest.

It has been known for some years that under controlled conditions in a glasshouse, the silicon content of a wheat plant could be related to the amount of water transpired. In order to see whether a similar correlation could be established for wheat crops in the field the Division analysed the silicon content of wheat husks taken from heads of wheat collected from a number of field trials in New South Wales, South Australia, and Western Australia. Estimates of the water transpired had been made for each of these sites from a study of soil moisture changes, incoming rainfall, and moisture losses other than those by transpiration through the growing plant. From these results the Division was able to derive a simple equation for the correlation between water transpired and percentage silicon. Further wheat samples were then taken from 60 sites in the four southern wheat-growing States where it was possible to make some estimate of transpiration from rainfall statistics. The equation obtained by relating these results to percentage silicon was similar to the equation derived earlier. The relationship therefore appears to hold over a wide range of soils and localities and the application of this technique is now being investigated by the South Australian Department of Agriculture in soil fertility trials.

Modelling crop environments

Plants grow in a climate very different from that defined by standard meteorological measurements. Moreover, two leaves on a single plant can be subject to greater extremes of environment than exist between the seasons. Since the leaves contribute more or less individually to the growth of the plant, in a manner dependent on their local environment, it is a basic problem in agricultural meteorology to relate the climate above a crop to that within the leaf canopy of the crop.

The DIVISION OF METEOROLOGICAL PHYSICS has developed a comprehensive mathematical model relating plant growth and plant environment to the climate above a crop. The model is in the form of a computer program which develops according to the meteorological information fed to it on conditions above the crop canopy. Starting from certain initial conditions of leaf and root density, soil water content, and various characteristics of plant physiology, the model predicts the environment appropriate to each new 'leaf' as it grows and so predicts the photosynthesis of each leaf. At the same time it places new leaves in the correct position on the maturing plant. It is this continuous interplay of self-generating information on microclimate within the crop with plant growth which distinguishes the model from others that use empirical relationships to determine the in-crop variables and which makes it possible to carry out theoretical experiments relating plant growth to changes in the general climate above a crop.

To check and improve the model, the Division, in cooperation with the Victorian Department of Agriculture, has initiated a field experiment at the Department's Rutherglen Research Station in northern Victoria. Measurements will be made of carbon dioxide content, temperature, water vapour pressure, and wind speed above and within the canopy of a real crop. These values will then be compared with the corresponding values predicted by the model. A selected area of some 20 acres has been planted to winter wheat and the experiment is expected to run for three years.

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.
Staff: Research scientists 115, other professional staff 68, supporting staff 318

Fields of research:
Research in the plant sciences and related fields of study on problems fundamental to biological production in Australia
- Crops and pastures—genetic resources, breeding, and selection, with associated basic genetic studies; establishment and management in biological systems
- Nutrition of plants—nutritional requirements, soil fertility, fertilizers, physiology of nutrient uptake, nitrogen fixation
- Plant–environment interactions—ecology and management of plant communities; 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
- Plant taxonomy
- Geobiology—biological and chemical processes associated with the formation of mineral deposits
- Plant chemotherapy—design and synthesis of molecules of potential biological activity

Division of Horticultural Research

Location: Glen Osmond, Adelaide, with a branch laboratory and field station at Merbein, Vic.
Staff: Research scientists 19, other professional staff 3, supporting staff 46

Fields of research:
Grape vines
- Genetic improvement—plant introduction, hybridization, selection
- Virus disease—assessment of importance, methods of control
- Crop management and production—mechanical harvesting, training and trellising, forecasting yields of wine grapes, control of fruit ripening, drying and processing of grapes

Fruit trees
- Production studies on citrus and apples—spacing and shape of trees, salinity effects

Plant parasitic nematodes
- Methods of control; interactions between host, parasite, and environment; physiology of locomotion, infection, and reproduction

Plant physiology and biochemistry
- Photosynthesis, sugar accumulation, flowering, and fruit set

Division of Irrigation Research

Location: Griffith, N.S.W.
Staff: Research scientists 14, other professional staff 9, supporting staff 50

Fields of research:
Water utilization by irrigated plants: soil–plant–water–atmosphere interactions
Agronomy of irrigated crops—citrus, cotton, vines
Plant physiology, biochemistry of photosynthesis
Dependence of photosynthesis and crop yield on light and soil moisture conditions
Climatology, hydrology of irrigated basins
Pollution—effects of residual herbicides
Environmental measurements—data capture, interfacing, and feedback from E.D.P. equipment
Irrigation channel networks—optimized design and system operation

Division of Tropical Pastures

Location: St. Lucia, Brisbane, with laboratories at Townsville and Lawes, Qld., and field stations at Beerwah, Mundubbera, Samford, and Townsville, Qld.
Staff: Research scientists 43, other professional staff 16, supporting staff 165

Fields of research:
Development of better pastures for tropical and subtropical eastern Australia
- Provision of new pasture species through plant introduction and breeding
- Pasture agronomy—selection of legumes and grasses, pasture establishment, management, utilization, and productivity
- Pasture ecology and physiology
- Nutrition and biochemistry of pasture plants—soil fertility, fertilizers, legume bacteriology
- Pasture species in animal nutrition
- Ecology and control of re-growth of woody species
- Numerical taxonomy

Destructive root rot fungus

The fungus *Phytophthora cinnamomi*, first identified attacking cinnamon plants in Sumatra in 1922, damages a wide range of agricultural, horticultural, and forest crops throughout the world. Originally, interest in the fungus arose through its attacks on crops such as pineapples, avocados, and peaches, and on flowering plants such as rhododendrons.

In 1965, the fungus was found to be associated with the 'die-back' of jarrah forests in Western Australia, a problem that first reached disturbing proportions in 1948. Now, the organism is believed to be responsible for a serious disease affecting eucalypt forests in east Gippsland and southern New South Wales. It has also damaged eucalypts in certain areas of Tasmania and pine nurseries in Queensland. Recently, it was shown to occur in native forests over the entire eastern seaboard, but not always associated with a significant disease problem. So far, more than 500 native species are known to be infected.

Although considerable work has been done on the fungus overseas, little is known about it in Australia. However, the problem is now being investigated by research groups from the Commonwealth Forestry and Timber Bureau, State Forestry Departments, the Australian National University, and the DIVISION OF PLANT INDUSTRY.

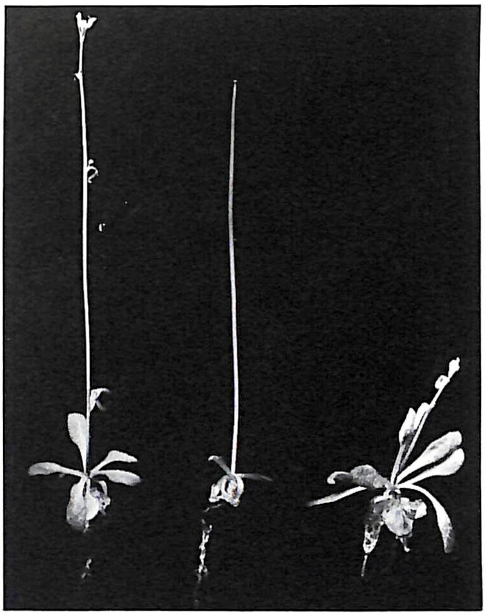
Working in close cooperation with the Forestry Department at the Australian National University, the Division has identified distinct biotypes or groups of the fungus—all belonging to the one species, but having distinctive properties and occurring in different regions. The Division is also developing chemical techniques that can be used to distinguish the organism from related species of similar appearance. This work should aid investigations into the ecology of the fungus, an important step, since the problem appears to be essentially an ecological one.

It is thought that the organism exists in the soil in undisturbed forests as a weak parasite living in balance with its hosts. Disturbances such as road-making and the construction of fire-breaks may well lead to environmental changes that favour pathogenic behaviour and enable the disease to develop along the disturbed zones. Such behaviour has been observed in Western Australia.

At present, no single factor can be implicated. The spread of the disease is probably due to the interaction of a number of factors such as increased soil temperature, changed microflora, decreased microbial competition, and mechanical spread of the infection. Much more work will be needed before suitable control measures are found.

Screening chemicals for their effects on plants

Many chemicals can affect the growth of crops by interfering with various physiological processes such as seed germination, cell division, flowering, and fruit set. The DIVISION OF PLANT INDUSTRY has developed a simple technique, using the small plant *Arabidopsis thaliana*, for screening new chemical compounds so that those that have an effect on plants can be detected. It is a comparatively simple matter to grow *Arabidopsis* under closely controlled conditions in nutrient agar in a test-tube. The plant flowers within 21 days of germination. The effect of different chemicals incorporated into the agar on the growth of the plant can be observed and, where appropriate, compared with responses induced by known plant hormones.



One group of chemicals being tested by the DIVISION OF PLANT INDUSTRY causes stem shortening and modifications to the flowering head, leaves, and roots of the plant. The *Arabidopsis* plant on the left was untreated; the two plants on the right were grown in the presence of one of these chemicals.

Better pastures for the Atherton Tableland

The dairy pastures of the Atherton Tableland have shown a steady decline in productivity since their establishment between 30 and 60 years ago on land that previously carried tropical rain forest. In the absence of maintenance or renovation, the original pastures of paspalum and kikuyu have deteriorated to carpet grass with the low carrying capacity of 1 beast to 4 acres (1·6 hectares). This reduction in carrying capacity appeared to be due largely to a decline in soil fertility, and in 1967 the DIVISION OF TROPICAL PASTURES began an investigation into the nutritional requirements of pastures in the area.

Pot trials suggested deficiencies of phosphorus, molybdenum, potassium, and sulphur, and in February 1969 field trials were set up to check this diagnosis and to determine responses of pasture plants to these nutrients over a 4-year period. The trials included both grass–legume and nitrogen-fertilized grass pastures.

Results so far indicate that grass–legume pastures need at least 40 pounds of phosphorus an acre (45 kilogrammes a hectare) for satisfactory establishment, that is, about 4 cwt of superphosphate an acre (500 kg a hectare). In the years immediately following establishment, it appears that 30–40 pounds of phosphorus an acre (34–45 kg a hectare) are required on soils derived from basalt and acid volcanic rocks, while other soil types may require rather less.

Tinaroo glycine and green-leaf desmodium are the two most widely used legumes on the Tableland, and of the two, Tinaroo glycine has proved the more sensitive to molybdenum deficiency. An initial dose of 1·4 ounces an acre (100 grammes a hectare) of molybdenum has proved necessary and a further addition of 1·4 ounces an acre appears necessary after another 3 years.

In areas of severe potassium deficiency annual applications of at least 60 pounds an acre (67 kg a hectare) of this element have had to be applied to maintain a high legume content with a vigorous companion grass.

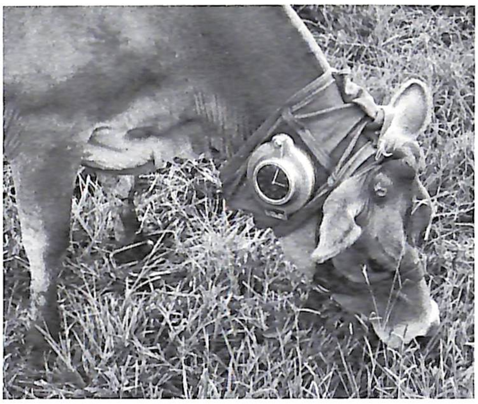
On nitrogen-fertilized pastures of pangola grass and kikuyu the Division has obtained low to medium responses to phosphorus and medium to large responses to potassium.

The programme will continue until June 1973, by which time the Division expects to have enough evidence to state the fertilizer applications needed in the area.

Improving cereal proteins

Of the twenty or so amino acids from which all proteins are made, eight are essential in our diet as they cannot be produced in the body. Much of the world's population derives the bulk of its protein from either rice, wheat, or maize, all of which are deficient in some of the essential amino acids, particularly lysine. Plant geneticists have already had some success in breeding varieties of maize with a higher lysine content and are now giving increasing attention to the possibility of raising the lysine content of wheat and other food grains.

The DIVISION OF PLANT INDUSTRY is approaching this problem by investigating lysine metabolism in bacteria, which for this particular purpose are easier to study than plants. The production of lysine and its incorporation in proteins follows much the same biochemical pathways in both plants and bacteria. Plants and bacteria synthesize their proteins from amino acid reserves, each of which is kept at a constant level by various control mechanisms. The chief of these is a feedback inhibition whereby the presence of a particular level of an amino acid blocks the further production of that acid. In bacteria, mutant strains can be selected that lack sensitivity to feedback inhibition for certain amino acids. In these strains, amino acid synthesis is not switched off at the normal level and over-production of the amino acid occurs. The Division has been examining the growth of bacteria in the presence of various lysine analogues—substances with a chemical structure closely resembling that of lysine. One analogue was found which permits the selection of mutant bacteria that produce higher than normal levels of lysine or intermediates in the lysine biosynthesis pathways. These mutants are providing information on the control systems that operate during the synthesis of lysine. By learning more about the biochemical mechanisms involved, the Division hopes to be able to develop techniques for selecting mutant strains of cereals that will produce greater amounts of lysine.



Vibra-recorders like the one strapped to the neck of this Jersey cow were originally developed in Germany for logging operating times of trucks and buses. At its research station at Samford near Brisbane the DIVISION OF TROPICAL PASTURES is, for the first time, using them to obtain a continuous record of the actual time spent by cattle in grazing. This information, together with measurements of food intake and milk output, is being used by the Division to evaluate different tropical pasture species.

Forecasting the grape crop

Many important decisions within the grape-growing industry depend on an accurate early-summer forecast of the crop expected at harvest time. Wineries, for example, must make some realistic estimate of yield in order to plan their vintages. As a result of a recently completed investigation carried out over a six-year period by the DIVISION OF HORTICULTURAL RESEARCH with the assistance of the DIVISION OF MATHEMATICAL STATISTICS it should now be possible to forecast crop yields more accurately using a series of simple measurements.

During the investigation, field observations were made in non-irrigated and part-irrigated vineyards in South Australia and in irrigated vineyards in the Murray Valley and Murrumbidgee irrigation areas. The grape varieties studied were Shiraz, Grenache, Doradillo, and Semillon. The best yield predictions were obtained by taking a random sample of vines in winter and counting the number of fruit-bearing units (spurs on spur-pruned varieties, nodes on cane-pruned varieties) on each vine. Then in spring a random sample of fruit-bearing units was taken and a count made of the number of berries on each. These two counts provide an estimate of the number of berries per vine. Later in the season when the berries are half grown the final berry size can be estimated and a prediction of yield made.

The system could provide the basis for objective forecasts of yield for particular wine-grape-growing areas. This would involve combining yield estimates with accurate information on the areas planted to vines, whether irrigated or not, and the age of the vines.

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.

Staff: Research scientists 33, other professional staff 30, supporting staff 131

Fields of research:
Basic studies—molecular biology and genetics, genetics and physiology of morphogenesis, statistics
Genetics in relation to 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 Maribyrnong and Werribee, Vic., Badgery's Creek, N.S.W., and Jimboomba, Qld.

Staff: Research scientists 42, other professional staff 29, supporting staff 192

Fields of research:
Infectious diseases of livestock—contagious bovine pleuropneumonia, bovine tuberculosis, infertility of cattle and sheep, foot diseases of sheep, virus diseases
Cattle tick and tick fever
Worm parasites of sheep and cattle, host–parasite relationships
Animal viruses—basic studies and transmission by insects
Immunology
Livestock diseases caused by plant poisons

Division of Animal Physiology

Location: Prospect, N.S.W., with the Pastoral Research Laboratory at Armidale, N.S.W., the Beef Cattle Research Unit at Brisbane and Townsville, Qld., and the Bloat Research Unit at Melbourne, Vic.

Staff: Research scientists 48, other professional staff 45, supporting staff 192

Fields of research:
Physiological basis of productive functions in ruminants
Reproduction—spermatogenesis, ovarian function, ovum transport, pregnancy, foetal physiology, parturition, neonatal physiology, embryonic mortality, neonatal mortality, synchronization of oestrus, reproductive behaviour

Body growth—hormonal control, intermediary metabolism
Wool growth—keratin synthesis, follicle development, crimp formation, hormonal control, innervation, and vascularization of skin
Endocrinology—isolation of pituitary hormones, measurement of blood hormone levels, mechanism of hormone action, steroid metabolism
Differences in production between individuals

Animal production from temperate and tropical pastures
Ecology of grazed ecosystems, soil–plant–animal interactions and nutrient cycles; intake and energy expenditure of grazing sheep, dietary selection; stocking rates, behaviour of grazing animals, forage conservation

Nutrition and animal production—sheep and cattle
Nutrition in relation to body growth, wool growth, and reproduction; appetite and food intake; digestion and absorption; rumen microbiology; metabolism of carbohydrates, proteins, and lipids; feed requirements, efficiency of feed utilization, nutritional value of feeds, protection of proteins and amino acids, modification of milk and body fats

Influence of environment on physiology of sheep and cattle
Regional and seasonal effects on wool growth and reproduction; effect of heat on testicular function and foetal development; effects of heat and cold on the cardiovascular, respiratory, and metabolic functions of lambs and adult sheep; physiology of sheep in semi-arid environments

Metabolic disorders of ruminants
Metabolic failure in stressed animals; digestive disorders; urinary calculi; pasture oestrogens

Physiology of Australian marsupials

Division of Nutritional Biochemistry

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

Staff: Research scientists 19, other professional staff 10, supporting staff 69

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

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

Cattle in the tropics

Breeds of cattle of British origin do not grow as well in the tropics as they do in temperate climates. Furthermore, they do not grow as well in the tropics as breeds of Indian origin. Those individuals belonging to the British breeds which grow better than their fellows resemble individuals belonging to the Indian breeds in that they tend to have coats made up of short thick hairs instead of long thin ones; they tend to have a larger thymus and larger lymph nodes; and they are less affected by worms and ticks. It has been found that coat type is associated with growth rate not only because coat type affects body temperature which in turn affects growth rate, but also and largely because some inner function of the animal affects both coat type and growth rate.

In order to throw some light on this inner function, the DIVISION OF ANIMAL GENETICS has been experimenting with both mice and cattle. The submaxillary salivary gland of the mouse contains a number of substances each of which has a profound effect on the growth of some organ or tissue. Some of these growth factors have been isolated and purified. One of them, the thymotrophic factor, when injected into mice causes the thymus to atrophy and the lymph organs to develop abnormally. The thymus and the lymph organs are part of the system responsible for mounting the animal's defence against infectious diseases and parasites. Other growth factors when injected into mice stop growth in liver, kidney, skin, and coat. Injection of whole extract of the gland and removal of the gland from young mice both cause general retardation of growth and gross abnormalities in many organs as well as atrophy of the skin and abnormal coat growth.

The parotid gland, which is one of the salivary glands of cattle, has been shown to contain some of the substances which can be extracted from mouse submaxillary glands and which affect growth. Removal of the parotid gland from cattle causes atrophy of the skin, the growth of a woolly coat, and atrophy of the lymph organs and thymus.

Cattle of European origin, when reared in a tropical climate, show many of the symptoms that result from interference with the salivary glands of mice and cattle. They grow a woolly coat, they grow slowly, their lymphoid tissues and thymus are wasted, and they are inefficient at repelling attack by parasites such as ticks and worms. It appears that failure of these cattle in the tropics is in part associated with interference by the environment with the normal metabolism of the growth factors associated with the parotid gland in cattle and the submaxillary gland in mice.

Preventing bloat in cattle

Bloat can be a serious problem among cattle grazing lush pastures. It occurs when gas released by microbial fermentation in the rumen becomes trapped in a persistent protein foam. Bloated animals suffer severe discomfort and may die, while production from those that recover may be reduced. Furthermore, many farmers are discouraged from making optimum use of their properties because of the risk of bloat.

The most widely used anti-bloat agents after the mineral oils are a group of chemicals known as pluronics, which are effective detergents. To prevent bloat in dairy cows they are administered in drinking water or in concentrates, or by twice-daily drenching at milking. But these methods are not usually practicable for beef cattle, which are raised under less intensive conditions and are not handled regularly.

The DIVISION OF ANIMAL PHYSIOLOGY has tackled the problem by inventing a capsule capable of continuously releasing into the rumen a quantity of pluronic sufficient to prevent bloat. In this way more efficient use is made of the pluronic than by twice-daily drenching, and a single treatment can be effective for many weeks. Normally, objects of moderate density administered orally to cattle are regurgitated within a few hours or days. A package dense enough to avoid this difficulty for 100 days and containing a reasonable payload of pluronic would weigh about 6½ pounds (3 kilogrammes) and be unacceptably heavy.

A solution to the problem was provided by the concept of a capsule that changes its shape when it enters the rumen. The capsule designed by the Division is about the size of a banana, and consists of a plastic cylinder formed of two half-cylinders hinged together along one side. Each half-cylinder contains the pluronic in an ethyl cellulose jelly. The closed cylindrical capsule is inserted into the oesophagus through a flexible plastic tube fitted with a plunger. It is swallowed in the closed position but when it enters the rumen it springs open due to the elasticity of the hinges, presenting a new shape that is too wide to be regurgitated. The pluronic is released slowly from the capsule over a period of weeks and some time later, after the contents have been exhausted, the hinges corrode, allowing the two halves to be regurgitated separately.

Early models of the capsule prevented bloat for up to three weeks, but new designs are being developed to extend this period. Longer periods of effectiveness should make the cost per day competitive with twice-daily drenching and the Division is now looking for new and more effective chemicals. Before a new device like the capsule can be marketed, it is necessary to make sure that neither the capsules nor the pluronics have any deleterious effects on health or production. Investigations carried out so far indicate that there is not likely to be any difficulty.

Apart from its use in controlling bloat, the technique of a sustained release capsule raises other intriguing possibilities. It could be used, for example, to dispense chemicals to kill stomach worms or to release magnesium into the rumen of cattle to prevent grass tetany. These and other possibilities are now being studied by the Division.

Rams that won't mate

Sexual inhibition has been observed occasionally in young rams in various parts of the world, but has not usually been regarded as a problem in Australia. However, recent research by the DIVISION OF ANIMAL PHYSIOLOGY has shown that in some strains of Merinos a significant proportion of young rams are sexually inhibited during their first mating season.

To investigate the problem, a simple test of libido was made on 75 eighteen-months-old rams from four studs. On three occasions each ram was placed in a pen for 20 minutes with five ewes in oestrus, and the number of mounts and services recorded. Twenty-three per cent did not mount at all, and another 4% mounted but did not serve. Even more striking was the observation that 44% of the rams from one of the four studs were inhibited. Similar results were obtained in another experiment, in which each ram was joined individually with 40 ewes for 2 days.

Finally, pairs of rams were run in flocks of ewes for 5 weeks to simulate normal flock mating conditions. Twenty-five per cent of the inhibited rams remained inactive for the whole 5 weeks, while the remainder took from 2 to 34 days before they began to mate. Only 57% of the ewes joined with pairs of inhibited rams lambed, compared with 85% of those joined with mixed pairs and 94% with pairs of active rams. Clearly, the performance of the inactive rams was inferior to that of the others. It is too early to say what degree of inhibition persists as the rams age, but it does seem that some of them are still somewhat inhibited during their second mating season.

A possible explanation for the inhibition is suggested by reports that some males in a number of domestic species are inhibited. In most domestic species the sexes are segregated before puberty, and it may be that rams treated in this way miss an important conditioning to ewes. This suggestion is now being tested by the Division and, if it proves correct, could lead to a recommendation to run some ewes with young rams after they are weaned. These ewes would be sterilized by tying the Fallopian tubes, but would show normal cyclic oestrus. The Division is also investigating whether the inhibition might be due, in part at least, to a genetic factor.

anthelmintic every 2 to 3 weeks to control worms, one was dipped at similar intervals to control ticks, and one was left untreated.

The resistance of an animal to ticks can be measured by counting the number of female ticks that reach maturity on it. Both the Brahman and the Africander crossbreds carried far fewer mature female ticks than the Shorthorn–Hereford crosses and treatment for ticks did not improve their growth markedly. By comparison, dipping improved the weight gain of the Shorthorn–Hereford crosses by 46%.

Drenching for worms was of little benefit to the Brahman crossbreds, but it increased the weight gain of the Africander crossbreds by 22% and of the Shorthorn–Hereford crosses by 30%. Nevertheless, the Brahman crossbreds had just as many worms, to judge by egg counts, as the Shorthorn–Hereford crosses.

The experiment also showed that while the tolerance of cattle to worms and ticks was influenced by nutrition, breed differences were much more important and their effect persisted even under extreme nutritional conditions.

Resistance to ticks and worms

At its National Cattle Breeding Station, 'Belmont', near Rockhampton, Queensland, the DIVISION OF ANIMAL GENETICS has been investigating the nature and heritability of resistance to ticks and resistance to worm parasites in British breeds of cattle and their crosses with breeds of Indian origin. Three lines of cattle were used in the investigation—Shorthorn × Hereford, Brahman half-breds, and Africander half-breds. Each line was divided into three groups. One group was drenched with an

Sheep, cattle, and disease

In Australia, where sheep and cattle are seldom run together, little attention has been given until recently to the possible interactions that can arise with disease agents that infect both sheep and cattle. One such interaction occurs with *Fusiformis nodosus*, the organism responsible for foot-rot in sheep. The DIVISION OF ANIMAL HEALTH, in collaboration with the Western Australian Department of Agriculture, has shown that *Fusiformis* can be transmitted from cattle to sheep under field conditions. This finding emphasizes the need to take cattle into account in sheep foot-rot eradication campaigns when sheep and cattle are run together.

Several other disease agents that infect both sheep and cattle are also being studied by the Division. One of them, the virus responsible for bovine malignant catarrhal (BMC) fever, is a cause of heavy mortality among cattle in Africa. The wildebeest or gnu, one of the large antelopes, is a carrier of this virus. If domestic cattle graze over pastures where wildebeest have been calving, many of them contract the disease and die. A disease similar to BMC has been recognized for some years in Australia. Recent work by the Division has shown that the infective agent of this BMC-like disease is carried by sheep. While there are no symptoms of infection in sheep, the agent is readily transmitted to cattle in contact with them. An attempt is being made to isolate the agent of BMC in Australia in order to learn more about it, and to find possible ways of reducing or preventing cattle losses from this disease.

Investigations of losses of lambs about lambing time, carried out by the Division in collaboration with the Victorian Department of Agriculture over the past three years, have revealed that some lambs that are born weak and therefore likely to die within a few hours of birth are infected with micro-organisms. One of these infecting agents has been identified as the virus responsible for bovine mucosal disease (MD). The Division has shown that MD virus can pass from infected cattle to sheep held in contact with them and that pregnant ewes can be infected with MD virus without showing any immediate signs of infection. However, the virus may invade the foetus, causing either abortion or the birth of a virus-infected lamb. The significance of these findings is being assessed in further experiments.

The bacterium *Vibrio fetus* is widespread in cattle herds throughout Australia and is one of the main causes of poor breeding performance. A similar organism, *Vibrio fetus* var. *intestinalis* is often carried in the faeces of cattle but appears to be quite harmless to cattle under Australian conditions. The Division has shown that inoculation of pregnant ewes with some types of *Vibrio fetus* var. *intestinalis* from cattle can result in still births and lesions in the lambs. Only certain strains of the organism cause these effects in sheep, and the Division is trying to discover whether infection can pass naturally from cattle to sheep and how infection of sheep by this organism can be controlled.

Killing internal parasites

Sheep and cattle are subject to parasitism by a number of helminths (worms) including flukes, nematodes, and tapeworms. Since these parasites live in an environment in which there is little or no oxygen, a number of the biochemical reactions they employ for obtaining energy from their food are different from the reactions employed by the oxygen-breathing animals in which they live. An important step in the breakdown of carbohydrates by helminths is the reduction of fumarate to succinate. This reaction is catalysed in helminths by an enzyme, fumarate reductase, which is not produced by sheep or cattle.

A study of the biochemistry of helminth parasites by the DIVISION OF ANIMAL HEALTH has shown that two widely used broad-spectrum anthelmintics, thiabendazole and tetramisole, completely inhibit the action of fumarate reductase. It seems likely that this is the reason for their effectiveness against a wide range of parasites as well as for their low toxicity to livestock. Chemically the two compounds do not resemble each other closely and they probably react with fumarate reductase in different ways. Thiabendazole, for example, produced only partial inhibition in a strain of *Haemonchus contortus* (barber's-pole worm) resistant to this anthelmintic whereas the same strain of *Haemonchus* was fully susceptible to tetramisole.

These findings suggest that the fumarate reductase reaction may be a particularly vulnerable part of the parasite's biochemistry. If so, it should be possible to formulate new anthelmintics that inhibit this reaction. Inhibition of fumarate reduction could also provide a quick and convenient test for the initial screening of new chemicals for anthelmintic activity. Only minute quantities of the chemical would be needed for the test. Two new anthelmintics developed by a drug company were tested by the Division and were found to be highly effective at inhibiting fumarate reduction. Ten other compounds structurally similar to known anthelmintics were also tested by the Division. They showed only weak inhibiting activity and were consequently found to be valueless as anthelmintics.

Pneumonia in sheep

Chronic pneumonia afflicts large numbers of farm animals in all parts of the world. In Victoria a chronic pneumonia in sheep has been gradually defined over several years by the DIVISION OF ANIMAL HEALTH. This pneumonia does not produce obvious signs in its early stage and causes no rise in temperature. Its apparently mild nature in the early stages may be followed by obvious pneumonia several months later.

Two years ago, two graziers in southern Queensland complained of widespread and serious unthriftiness and intolerance to exercise in their lambs because of pneumonia. A joint investigation by the Division and the Queensland Department of Primary Industries revealed a pneumonia somewhat similar to that previously defined in Victoria. Distressed breathing and other signs of pneumonia were produced experimentally by injecting ground-up lung tissue from sick sheep from the Queensland flocks into the trachea of baby lambs.

In a later experiment, mycoplasmas (a form of bacteria without rigid cell walls) isolated from lung material obtained in the original outbreaks were found to produce a similar disease. Mycoplasmas occur in the various types of sheep pneumonia described in other parts of the world, but have previously been regarded as secondary infections.

The diseases investigated in Queensland and Victoria are apparently the same, but neither the clinical nor the pathological pattern of the infection quite fits any of the known types of sheep pneumonia. Because of this it has not yet been possible to predict whether the disease will spread in Australia or subside into insignificance.

Insects, fish, and wildlife

Division of Entomology

Location: Canberra, with laboratories in Brisbane, Perth, and Sydney, and field stations at Rockhampton and Amberley, Qld., at Armidale, Trangie, and Wilton, N.S.W., and at Hobart, and biological control units at Ascot, England, Montpellier, France, and Pretoria, South Africa
Staff: Research scientists 66, other professional staff 38, supporting staff 152

Fields of research:
Genetics, physiology, biochemistry, behaviour, and pathology of insects as a basis for new methods of control
Ecology and control of insect pests—cattle tick, locusts and grasshoppers, pasture insects, forest insects, orchard insects, bush flies, sheep blowflies, termites, insect pests of stored products
Integrated control, pest management, theory of population dynamics
Insecticides—insect resistance, toxicology
Insect transmission of plant viruses and mycoplasmas
Insect tissue culture as a tool for studying cell metabolism and virus infection
Biological control of insect pests and weeds
Establishment of dung beetles to speed cycling of dung and control fly breeding
Taxonomy and maintenance of National Insect Collection

Division of Fisheries and Oceanography

Location: Cronulla, Sydney, with laboratories in Brisbane and Perth, and field stations at Karumba and Weipa, Qld., and Sams Creek, W.A.
Staff: Research scientists 26, other professional staff 27, supporting staff 76

Fields of research:
Biological and population studies of prawns, tuna, western rock lobster, southern rock lobster, Australian salmon, and abalone
Primary productivity of marine environments
Structure and circulation of ocean waters; numerical modelling; theory of ocean circulation; tides and mean sea level
Distribution and abundance of zooplankton
Oceanography in relation to fisheries
Thermodynamics of sea water

Marine Biochemistry Unit

Location: Cronulla, Sydney
Staff: Research scientists 2, other professional staff 2

Field of research:
Biochemistry of phytoplankton

Division of Wildlife Research

Location: Canberra, with laboratories at Helena Valley, W.A., and Darwin, and staff located at Alice Springs, N.T., and Mareeba, Qld.
Staff: Research scientists 23, other professional staff 13, supporting staff 88

Fields of research:
Biology of animals of economic importance—rabbits, kangaroos, dingoes, galahs, cormorants, 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

Controlling wood wasps with eelworms

The sirex wood wasp, a potentially serious pest of radiata pine, was first discovered in an Australian pine plantation nearly 20 years ago after accidental introduction from overseas. The wasp is now found throughout much of Victoria and Tasmania and is steadily spreading towards the pine plantations of Mt. Gambier in South Australia. Female sirex drill into the living pine trees before injecting their eggs along with toxic mucus and a symbiotic fungus. The mucus and fungus kill susceptible trees, and sirex larvae feed on the fungus as it spreads throughout the tree.

In 1962 the DIVISION OF ENTOMOLOGY commenced an intensive programme of investigations into the sirex problem, including a world-wide search for biological control agents. Among the agents investigated have been a number of nematodes (eelworms) which sterilize the female insect and which often achieve very high levels of parasitism.

The Division has discovered seven new species of the nematode *Deladenus*, which parasitizes 11 species of sirex and closely related insects from many European countries, North Africa, Pakistan, Japan, North America, and New Zealand. The Division has found that these nematodes have an extraordinary type of life history which consists essentially of two completely different breeding cycles: one which is parasitic within the sirex and one which lives free on the symbiotic fungus of sirex. Either cycle can continue without the intervention of the other, and the female nematodes of the two cycles are so different from each other that they would previously have been classified into different families.

Mass rearing of the free-living cycle is relatively simple, single cultures yielding up to 20 million nematodes. This ease of rearing greatly facilitates biological control programmes. It enables an armoury of different species and strains from world-wide sources to be kept in culture indefinitely.

Liberation of four strains of one nematode species in sirex-infested areas of Victoria and Tasmania has commenced with the distribution of more than 1000 logs containing sirex which had been inoculated with nematodes using a technique that yields over 90% parasitism. Results from the first year of field trials since liberation have been encouraging.

The six nematode species not yet released are being evaluated for their effectiveness against sirex. Since these species utilize a different symbiotic fungus from that found in Australia, selective breeding is being carried out to produce strains capable of feeding on the locally occurring fungus.

Fighting potato moths with viruses

The potato tuber moth is a major pest of potato and tobacco, and growers need to spray their crops with insecticides several times each season to protect them from attack. In recent years, strains of potato tuber moth resistant to the more commonly used insecticides have appeared in several countries including Australia. However, the isolation of a granulosis virus from the potato moth by the DIVISION OF ENTOMOLOGY in 1964 has led to the development of a promising new method of control which does not use insecticides.

Preliminary studies by the Division showed that a single application of the virus to potato plants resulted in a high rate of infection of insects feeding on the foliage for the rest of the season. The Division then produced a substantial quantity of the virus in its laboratories at Canberra. This was used in a large-scale field test on potato crops which was conducted in the Manjimup and Pemberton districts of Western Australia in collaboration with the State Department of Agriculture.

Potato crops at five different sites were given a single treatment with a concentrated suspension of virus applied through conventional spray equipment. Damage to tubers resulting from potato moth attack ranged from nil to 0·8% with an average of 0·3% in the virus-treated crops. By comparison, tuber damage in nearby crops treated with conventional insecticides ranged from nil to 21% with an average of 5%. Some of these crops had received from 5 to 12 applications of insecticide. The single application of virus resulted in almost total kill of potato moth larvae for periods of up to 10 weeks, suggesting that, unlike some insect viruses, it is not rapidly inactivated under field conditions by the ultraviolet radiation of sunlight.

Diseased insects were recovered not only from the five treated sites, but from 20 nearby farms as well. A local bird, the common silvereye, which eats potato moth larvae avidly, was found to help the dispersal of the virus which it passes in its droppings.

Emus on the move

In Western Australia emus periodically migrate from the arid interior towards the wheat belt, causing damage to wheat crops. Since 1964 the DIVISION OF WILDLIFE RESEARCH has been studying emu populations and their movements around Sandstone and Wiluna, and at Mileura station near Meekatharra.

During a large-scale southward winter migration of emus in 1969 the Division banded more than 150 emus in the Sandstone–Wiluna–Mileura region. Banded birds were later recovered some 300 to 350 miles (480 to 560 kilometres) to the south-west at Perenjori and Ajana. Nine months after banding, birds believed to have taken part in this movement were recovered near Carnarvon after a total journey of about 700 miles (1120 kilometres). There were, however, individual banded birds which remained in the same locality on Mileura station for some time and a more intensive study has begun in part of this area using marked birds.

Whether emus migrate in winter appears to depend on the quantity of green herbs and grasses available then and during the previous autumn, but the Division has not yet discovered why. Aerial survey counts made periodically over the whole of Mileura station have provided a good picture of how the birds use the different types of country on the station. Usually they live near rivers, creeks, and watercourses, and feed away from them only when heavy rains ensure that green food is available over a considerable area.

Scanning electron micrograph of a potato tuber moth. Magnification 100.

Ripping rabbit warrens

Observations by the DIVISION OF WILDLIFE RESEARCH over a number of years have shown that in the arid zone of Australia rabbit populations retreat during droughts to small pockets of distribution in stony warrens or warrens strategically situated close to seasonal 'swamps'. The Division is investigating the possibility that rabbits might be controlled effectively if attacks were concentrated on these refuge areas.

In a cooperative research project at Byrnedale station near Broken Hill over the past 5 years, the station owner, Mr. R. Caskey, has systematically ripped warrens on 22,500 acres (9000 hectares) of stony country. By 1970 only 5 of the 621 warrens ripped had been re-opened and the number of active burrow entrances per 1000 acres (405 hectares) had fallen from 40 to 1. On 57,500 acres (23,000 hectares) of similar land which had been left untouched, there were 857 active warrens present at the start of the study. During the ensuing drought this number fell to 350, but by 1970, under better climatic conditions, it had risen to 588. Over the same period the number of active burrow entrances per 1000 acres rose from 33 to 72.

Food for fish

In the water, as on land, all life ultimately depends upon photosynthesis. The most important photosynthetic organisms in the sea are the phytoplankton—minute unattached floating plants which occur in incalculably vast numbers in the surface layers where sunlight can penetrate. The phytoplankton are grazed by minute animals (zooplankton) which are in turn eaten by carnivorous zooplankton. These various forms of plankton are a source of food for other marine organisms.

The planktonic animal *Thalia democratica* is extremely common in Australian waters where it feeds on both phytoplankton and small zooplankton. It is about 1 centimetre long and can form dense swarms up to 50 miles (80 kilometres) across with densities of many hundreds of individuals per cubic metre. Because of its high water content and lack of known predators, *Thalia* has previously been regarded as relatively unimportant as a source of food for other marine organisms. The DIVISION OF FISHERIES AND OCEANOGRAPHY has now found that *Thalia* is eaten by a wide variety of planktonic animals, particularly crustacea, and that it is one of the most important animal species in the marine food chain in the tropical and temperate waters of Australia because of its high rate of population increase and the very high population densities it attains.

Studies by the Division have shown that the generation time of *Thalia* varies from several days to several weeks depending on food levels. Each individual produces from 60 to 150 young which have a high survival rate in the absence of predation. The intrinsic rate

The small animal in the internal cavity of this specimen of *Thalia democratica* is a crustacean predator which eats its prey from within.

of population increase is therefore very high. This rate of increase has not been estimated for other planktonic animals but the value for *Thalia* is greater than rates estimated for land animals including insects.

The individual growth rate, as measured by the rate at which carbon is incorporated into the body of the animal, is greater than the rate measured for other planktonic animals and is almost as high as that of the phytoplankton on which it feeds. Because of this it is able to exploit the rapid appearance of phytoplankton blooms. It seems probable that this high rate of grazing actually increases the amount of organic matter fixed by the phytoplankton and transferred to the animal plankton during the relatively short periods favourable for high production.

This information adds to our understanding of how primary plant production in the sea is transferred to animal populations, including fish. It also has a vital bearing on estimates of the total productivity of Australia's coastal waters.

The East Australian Current

The East Australian Current is a major component of the oceanic circulation off the east coast of Australia. It has an overall southward flow down the coast with a major eastward movement commencing in the vicinity of Sydney. Changes in the flow of the Current during the year bring about changes in the physical and chemical characteristics of the waters off the coast. These changes have a significant bearing on the weather on the mainland and are important for our deep-sea fisheries, particularly our tuna fisheries. For some years the DIVISION OF FISHERIES AND OCEANOGRAPHY has been gathering information from different parts of the Coral and Tasman Seas on such things as the movement, salinity, and temperature of the water at different depths. By piecing together this information as it accumulates, the Division is gradually building up a three-dimensional picture of the Current and how it changes throughout the year.

Twenty vessels of Australia's merchant shipping fleet are cooperating with the Division in a survey of the salinities and temperatures of the surface waters of the Coral and Tasman Seas. These ships have been fitted with an engine-room thermograph, which gives a continuous record of the temperature of engine cooling water at the intake located some 12 to 15 feet below water level. Samples of sea water are taken periodically and sent to the Division's laboratory at Cronulla where their salinity is determined. Currents can then be calculated from the temperature and salinity observations.

For many years an annual cycle of high salinities in winter and low salinities in summer has been known to exist along the Queensland and New South Wales coasts. Information collected for the Division by the merchant ships between 1966 and 1970 has revealed a separate two-yearly cycle of salinities, which, superimposed on the annual cycle, gives accentuated troughs of low salinity within the East Australian Current every second year.

The source of this low-salinity water appears to be an area north-east of the New Hebrides, from where it can be traced through the Coral and Tasman Seas. It follows two major paths of spread, one almost directly west into the central Coral Sea and the other roughly south-west into the northern Tasman Sea. The water that spreads into the central Coral Sea is transported southward by the East Australian Current and arrives in the northern Tasman Sea just two years after the water from the same source arrived by the more direct route.

Textiles and leather

Division of Protein Chemistry

Location: Parkville, Melbourne
Staff: Research scientists 40, other professional staff 26, 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
Mechanism and improvement of wool setting
Whitening and prevention of yellowing
New dyes and mothproofing agents for wool
Structure and synthesis of polymers for wool
Flammability of fabrics
Leather manufacture and hide proteins
Enzymes and muscle proteins

Division of Textile Industry

Location: Geelong, Vic.
Staff: Research scientists 22, other professional staff 23, supporting staff 159

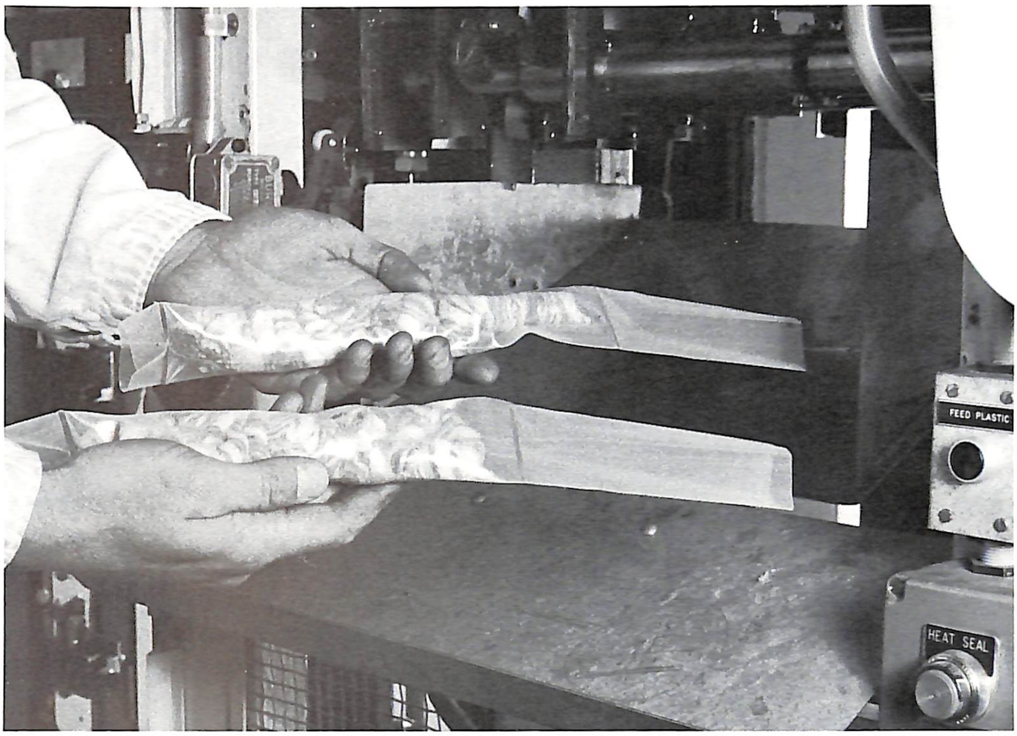
Fields of research:
Scouring and related processes
Prevention and treatment of vegetable fault in wool
Spinning and other mechanical processes
Dyeing and whitening of wool
Shrinkproofing and other treatments
Setting and prevention of wrinkling
Fleece properties and processing performance of different types of wool
New uses for wool
Cotton processing

Division of Textile Physics

Location: Ryde, Sydney
Staff: Research scientists 19, other professional staff 24, supporting staff 89

Fields of research:
Wool testing methods and equipment
Implications of new wool testing methods for manufacturing
Properties of fabrics, felting, shrinkproofing, setting, wrinkling
Wool structure and physical properties
Wool sampling
Wool drying and dyeing

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



These two samples of wool, each weighing about 50 grammes, were taken from a bale of wool by an automatic coring machine developed by the DIVISION OF TEXTILE PHYSICS. The machine automatically packs and seals the samples in polythene tubes.

Australian Objective Measurement Project

At present about three million bales of wool are opened each year on brokers' show floors for the benefit of buyers. If sale by sample could be made acceptable, wool handling costs would be considerably reduced. For the first time the selling process could be separated from the physical handling of bales. The bulk of the wool could be assembled at convenient holding locations and, after sale, be directed by the most economical transport means to shipping points, with resultant savings in time, space, and labour.

Testing equipment and techniques developed by the DIVISION OF TEXTILE PHYSICS are playing an important part in a two-year programme of industrial trials aimed ultimately at assessing the feasibility of selling wool on the basis of test results and samples.

The trials, named the Australian Objective Measurement Project, are a collaborative undertaking involving the wool industry, the Australian Wool Board, the School of Wool and Pastoral Sciences at the University of New South Wales, the Bureau of Agricultural Economics, the New South Wales Department of Technical Education, and CSIRO. An officer from the DIVISION OF TEXTILE PHYSICS has been appointed Project Manager.

The trials will be conducted on three aspects of wool selling: pre-sale sampling, pre-sale testing, and sale by sample. The investigation into pre-sale sampling is based on the application of the Division's automatic coring machines which can extract and package samples from bales at a rate of 120 bales an hour. The reliability with which these machines can provide samples from a wide and representative range of wools from all States is being examined. Machines are being run in stores under industrial conditions so that the costs and logistics of the operations can be studied, along with the problems of sample identification, storage, and retrieval.

Once the validity of pre-sale sampling has been established, there could be a considerable increase in the number of pre-sale tests required and this would necessitate studies of large-scale testing techniques. Both conventional and newly developed test methods are being examined for costs, capacity, and precision in tests of yield, vegetable matter, and fineness. Research in the Division is leading to machines that enable the yield (or actual wool content) of the raw wool and its fineness to be measured in a test-line type operation.

The third and most important aspect of the project concerns selling by sample instead of by showing bales. The trials of sale by sample envisage that information on yield, vegetable matter, and fineness of auction lots will accompany a display sample drawn from the bales in the lot. Ways are being sought of extracting display samples that are sufficiently representative of the wool in the lot for a buyer to be able to evaluate all the characteristics he sees in a conventional showing of bales.

Washable permanent-press wool slacks

Men's wool slacks that can be machine-washed and either dripped dry or tumbled dry without shrinkage or loss of shape went on sale in Australia for the first time in February 1971. The slacks were treated by a process invented by the DIVISION OF TEXTILE INDUSTRY and developed in collaboration with the Australian Wool Board.

Over the years several different procedures for producing permanent-press effects in all-wool garments have been devised by the Division. Of these, a method involving the treatment of finished garments with a polymer followed by hanging in steam was selected as the one most suitable for rapid industrial development because it required the least specialized equipment and the fewest additional operations on the garment. After examining a number of polymers the Division selected two, Synthappret LKF and Braxan LFA, which met the necessary criteria for the process and could be cured rapidly by steaming.

In the new technique, slacks are sent to the processing plant ready to wear except for the permanent-press treatment. Batches of garments are loaded into a modified dry-cleaning machine where the polymer is applied using a non-aqueous solvent such as perchlorethylene. The solvent is then evaporated and the slacks are removed from the dry-cleaning machine and steam-pressed for a few seconds to remove any wrinkles and sharpen the creases. They are then placed on hangers specially designed so that the slacks hang without wrinkles or distortion of the creases. A number of garments are hung on a trolley which is rolled into the steam oven where the slacks are steamed for two hours. After cooling they are ready for folding and boxing in the usual manner. Properties of wool such as strength and abrasion resistance are unchanged by the permanent-press treatment.

At the moment the process is limited by production capacity to slacks, but successful experimental treatments have been carried out on shirts, blouses, skirts, tunics, and other wool clothing.

Selectively dyeing wool

By altering the chemical reactivity of wool fibres it is possible to control the rate at which cloth made from the wool will take up coloured dyes. At the DIVISION OF PROTEIN CHEMISTRY work has already been carried out on dye-assist, or rapid-dyeing, wools. A new process to produce dye-resist, or slow-dyeing, wools is now being investigated.

The Division has found that the side chains of amino-acid residues of the proteins of wool can be modified by treatment with sulphuric acid under controlled conditions in such a way that the wool becomes dye-resist.

Multiple colour tones can now be obtained by piece-dyeing in a single bath using a fabric woven from a pattern of modified and untreated yarns. Similar contrast effects could also be used in the manufacture of tufted wool carpets.

In terms of wool marketing, changes in fashion can be met at a later stage in fabric production; the amount of stock carried by the mill would be less and an important element of flexibility would be added. For example, instead of the wool being dyed and woven into a pattern of coloured checks, the fabric can be woven from an undyed mixture of treated and untreated yarns and dyed at a much later stage using whatever colours are then in popular demand.

Complex salt for tanning hides

The leather industry has traditionally used chromium salts or, more recently, zirconium salts for tanning hides. However, these tanning liquors are not always consistent in their action on hides and, particularly in the case of zirconium salts, require closely controlled high-acidity conditions for effective use.

In a search for a more suitable tanning liquor, the DIVISION OF PROTEIN CHEMISTRY has experimented with a wide range of mixed chromium and zirconium salts. The Division has found not only that these mixtures are effective but also that a well-defined compound with tanning activity can be isolated from the solutions.

The Division has now isolated and characterized the compound, a new type of basic zirconium–chromium sulphate complex which has been provisionally named Zircryst. Tests carried out on the new compound indicate that it will act as a satisfactory tanning agent without the disadvantages of conventional salts.

In contrast to zirconium sulphate, Zircryst can be used over a wide range of acidity and is less inclined to form insoluble products in the tanning liquor. Most important, it remains in the tanning solution as a single molecular species, providing reproducibility of results and a more stable solution.

Several methods of preparation have been developed and the compound is now being evaluated on a pilot scale. The exact structure of the new complex is being determined in conjunction with the DIVISION OF MINERAL CHEMISTRY.

Food processing

Division of Food Research

Location: Food Research Laboratory, North Ryde, Sydney, with the Meat Research Laboratory at Cannon Hill, Brisbane, and the Dairy Research Laboratory at Highett, Melbourne
Staff: Research scientists 75, other professional staff 69, supporting staff 177

Fields of research:
Nature and control of changes in foodstuffs caused by time, temperature, and microorganisms
- Chemistry and biochemistry of foods and food flavours
- Physiology of fruits, vegetables, and meat animals
- Physiology and ecology of food-spoilage and food-poisoning microorganisms
- Microbiology and enzymology of cheese-making
- Heat and mass transfer in the storage and transport of foods
- Technology, processing, and packaging of canned, frozen, and dried foods; mechanization of cheese manufacture
- Formulation of new foods and utilization of by-products

Wheat Research Unit

Location: North Ryde, Sydney
Staff: Research scientists 4, other professional staff 3, supporting staff 3

Fields of research:
Biochemical aspects of wheat and flour quality
Biochemistry of wheat proteins, wheat carbohydrates, and wheat lipids
Morphology of the wheat kernel

Dust from wheat

Dust is a serious nuisance whenever wheat is handled in large quantities. It might be expected that much of this dust would be small particles of dirt and other inorganic material picked up during growth and harvesting. But studies by the WHEAT RESEARCH UNIT have shown that most of the dust particles are derived from the grain itself. They consist mainly of broken pieces of bristle from the brush and fragments of the outer layers of the pericarp and seed coat surrounding the kernel.

The pericarp is a fibrous layer formed from the ovary wall. As the grain ripens the cells of the ovary wall dry out and collapse, forming ridges where the cell walls remain. This structure renders the grain susceptible to surface abrasion and impact damage during handling and this is probably the reason for the large amounts of dust that arise when wheat is moved in bulk.

Different varieties of wheat differ in the surface pattern of their outer pericarp and in the length and profusion of the bristles comprising the brush on the end of the grain. The brush could probably be reduced or eliminated by selective breeding but better handling methods will be needed to reduce abrasion and impact damage to the pericarp.

Bell–Siro Cheesemaker 2 Mk II at the factory of the Camperdown–Glenormiston Dairying Company Limited.

Machine-made cheese

The factory of the Camperdown–Glenormiston Dairying Company Limited at Camperdown, Victoria, became the first factory in the world to take full advantage of the Bell–Siro system of automated Cheddar cheese manufacture when its Bell–Siro Cheesemaker 2 Mk II (see picture above) commenced successful operation in November 1970. The Bell–Siro system is the result of fifteen years of research and development by the Dairy Research Laboratory of the DIVISION OF FOOD RESEARCH in collaboration with the food machinery manufacturing firm of Bell Bryant Pty Ltd.

The manufacture of Cheddar cheese can be divided into four phases. In the first, milk is converted into a mixture of curds and whey, the curds are 'cooked', and the free whey is drawn off. This stage has been automated to a large extent. In the second or 'cheddaring' phase, the curds are fused into large slabs with a fibrous texture. This operation is carried out in the Cheesemaker 2 machine. Phase three is carried out in Cheesemaker 3 where the slabs are milled into finger-sized pieces, salt is added, and the salted curd is placed in large drums or in stainless steel hoops holding about 40 pounds (18 kilogrammes) of cheese. In the fourth phase the curd is compressed in the hoops and, later, packaged. The Division is currently working on the mechanization of this stage.

The first commercial model of the

Bell–Siro Cheesemaker 2 appeared in 1967. The Mark II model installed at Camperdown incorporates a number of radical changes in design in the interests of mechanical simplicity, increased throughput, lower cost, and greater flexibility in the types of cheese made. Curd treatment is continuous and the machine can be used to produce Cheddar, Cheshire, Cheedam, Colby, stirred-curd, and Romano cheese varieties. It has a throughput of 6000 pounds (2700 kilogrammes) of cheese an hour.

Cold tolerance in plants and animals

Many plants and animals suffer injury and even death when exposed to low temperatures, yet other plants and animals can tolerate them without distress. Cabbages and broad beans flourish in temperatures far below those which kill melons and tomatoes. Reptiles, amphibia, and fish survive temperatures lethal to many warm-blooded animals. Some warm-blooded animals can hibernate, others cannot. A joint investigation by the DIVISION OF FOOD RESEARCH and the University of California over the last two years has provided a clue to the mechanism that enables some organisms to resist cold stress. The investigation has been concerned with the changes in the activity of respiratory enzymes associated with the membranes of mitochondria.

Mitochondria are minute particles found in most plant and animal cells. Enzymes present in the membranes of the mitochondria break down carbohydrates into carbon dioxide and water and in doing so release considerable amounts of chemical energy. This energy is repackaged in molecules of adenosine triphosphate (ATP) and stored there until required for the various energy-consuming processes within the cell. The mitochondria can be regarded as powerhouses producing energy from fuel, and the ATP molecules as charged batteries that store energy.

Research at the University of California some years ago showed that the mitochondrial membranes of chill-sensitive plant tissues contained more saturated and less unsaturated fatty acids than those of chill-resistant tissues. Moreover, the mitochondrial membranes of chill-sensitive tissues were less flexible at low temperatures. Experiments with artificial mixtures of saturated and unsaturated fatty acids similar to those found in the membranes showed that the temperature at which these mixtures solidified could be lowered considerably by slightly increasing the proportion of unsaturated fatty acids. These findings suggested that the fatty acids of the mitochondrial membrane might undergo an abrupt phase change from semi-fluid to semi-solid at the critical temperature below which cold injury occurred.

This hypothesis has now been investigated jointly by the University and the DIVISION OF FOOD RESEARCH. Mitochondria were isolated from several chill-resistant and chill-sensitive crop plants and examined at a range of temperatures from 32°F to 104°F (0°C to 40°C). The fatty acids of the chill-resistant plants showed no change, but when the chill-sensitive plants reached 50°F (10°C) a dramatic phase change occurred in the fatty acids of the mitochondrial membranes. As the phase change occurred mitochondrial respiration was suppressed, throwing the whole metabolism of the cell out of balance and reducing the energy available to the cell. This is thought to lead to a build-up of injurious by-products in the cell, causing tissue damage, the extent of which depends on the duration and severity of the cold stress. This phase change was found to take place at precisely the temperature at which the changes in the activity of the oxidative enzymes occurred.

Somewhat similar results were obtained with animal mitochondria. The mitochondria of cold-blooded animals such as fish and reptiles remained semi-fluid, even down to 32°F (0°C). Warm-blooded mammals, however, registered a temperature-triggered phase change between 72°F (22°C) and 75°F (24°C) similar to that which occurred in chill-sensitive plants at 50°F (10°C). The mitochondria of those warm-blooded mammals which have the capacity to hibernate were found, during hibernation, to assume the characteristics of those found in cold-blooded animals.

Apart from its considerable scientific interest, the work could have important implications for agriculture and medicine. If chemical or genetic means could be found of manipulating the fatty acid content of mitochondrial membranes, it might be possible, for example, to extend the geographic range of many important food crops, to store fruit and vegetables for longer periods at much lower temperatures, and to extend considerably the storage time of vital human organs in transplant 'banks'.

Flame-sterilizing canned foods

Sterilizing canned foods by direct heating in a gas flame has many advantages over the conventional practice of heating in high-pressure steam. Flame sterilization is a continuous process, giving high throughputs in equipment of compact design. It is rapid, resulting in improved quality in the processed foods, and it is economical both in use of fuel and in heat recovery. The recent discoveries of natural gas in Australia provide an additional reason for interest in this process.

A flame-sterilizing unit of greatly improved efficiency has been designed and built in the DIVISION OF FOOD RESEARCH. The project was inspired by a French method of flame sterilization which utilizes a slow continuous rolling motion of the cans over a 'lazy' gas flame. The desired sterilization temperature of 265°F (129°C) is reached in about 2 minutes and the rate of heating is about 0·6 degF (0·33 degC) a second.

In the pilot-scale flame sterilizer built by the Division, the cans are revolved one and a half revolutions in one direction, then one and a half revolutions in the reverse direction at about 60 cycles a minute. The reversing can rotation sets up turbulent agitation within the can and permits the use of a strong gas flame to give rapid heating without burning either the can contents or the lithographed label. In this way rates of heating as high as 4 degF (2·2 degC) a second have been achieved.

The CSIRO process is already being used commercially in Australia for flame-sterilizing milk drinks and its application to other dairy products and vegetables is now being investigated.

Engineering and construction

Division of Applied Geomechanics

Location: Syndal, Melbourne, with a laboratory in Adelaide and a field station at Cobar, N.S.W.

Staff: Research scientists 14, other professional staff 15, supporting staff 39

Fields of research:

Geomechanics and geotechnology
  Stress-deformation studies; rock stress; soil and rock fabric; fracture mechanics; physico-chemical factors in soil and rock stability; creep; statistical mechanics; development of design procedures

Regional geotechnical studies
  Studies for urban planning and for engineering evaluation in developing areas

Integrated geomechanics projects
  Building foundations; retaining structures; stabilized pavements; stability of high-rise stopes

Division of Mechanical Engineering

Location: Highett, Melbourne

Staff: Research scientists 17, other professional staff 22, supporting staff 48

Fields of research:

Air conditioning and refrigeration—comfort cooling, criteria for thermal comfort, development of equipment
Utilization of solar energy—water heaters, air heaters, distillation
Industrial aerodynamics—diffusers, fan design, acoustics, model studies
Grain storage—cooling and other methods of insect control, drying
Agricultural machinery

Division of Building Research

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

Staff: Research scientists 20, other professional staff 35, supporting staff 94

Fields of research:

Building materials—cement and concrete, ceramic products, gypsum products, paint, plastics, bituminous products
Structures
Architectural acoustics
Thermal aspects of buildings
Tropical building
Operations research
Systems research

Division of Forest Products*

Location: South Melbourne

Staff: Research scientists 40, other professional staff 43, supporting staff 148

Fields of research:
Fundamental properties of wood and its constituents
Sawn wood, harvesting and conversion of logs to wood products, sorting, seasoning, grading
Timber for building and structural purposes, timber lamination
Panel products, plywood, particle board, reconstituted wood
Behaviour of wood in service, control of deterioration, biological degradation agents
Paper and fibreboard—manufacture and properties, pulping of wood and pulp preparation, blending of pulps, wood chips, recovery processes and effluent
Optimum use of wood resources

* On May 24, 1971 that part of the Division of Forest Products concerned with wood as a structural material was integrated with the Division of Building Research.
The remaining part of the Division of Forest Products, which was concerned with research for the pulp and paper industries, was integrated with the Division of Applied Chemistry.

Fire-resistant plaster ceilings

Gypsum, the basis of fibrous plaster, does not burn. When heated it decomposes, inhibiting the spread of fire by absorbing heat and by emitting nearly 21% of its weight as water vapour. However, ordinary cast gypsum is ineffective as a barrier to the spread of fire in buildings because it tends to disintegrate when heated.

The factors leading to the physical deterioration of building elements of cast gypsum in fires have been studied by the DIVISION OF BUILDING RESEARCH. Adding materials such as vermiculite and perlite greatly improved the cohesion of heated gypsum but tended to reduce its resistance to the penetration of heat. Glass fibre, however, was found to promote the cohesion of cast gypsum without impairing its insulating properties. Resistance to the penetration of heat of cast gypsum when in the form of actual building elements such as plaster sheeting was found to depend almost completely on thickness. Such characteristics as density seemed to have little influence.

With the assistance of the Fibrous Plaster Federation of Australia and New Zealand, the Division has developed a commercially feasible fibrous plaster sheeting resistant to fire. A ceiling/roof system made from this material and incorporating specially designed fire-resistant joints obtained a fire resistance rating of one hour from the Commonwealth Experimental Building Station at Ryde, N.S.W.

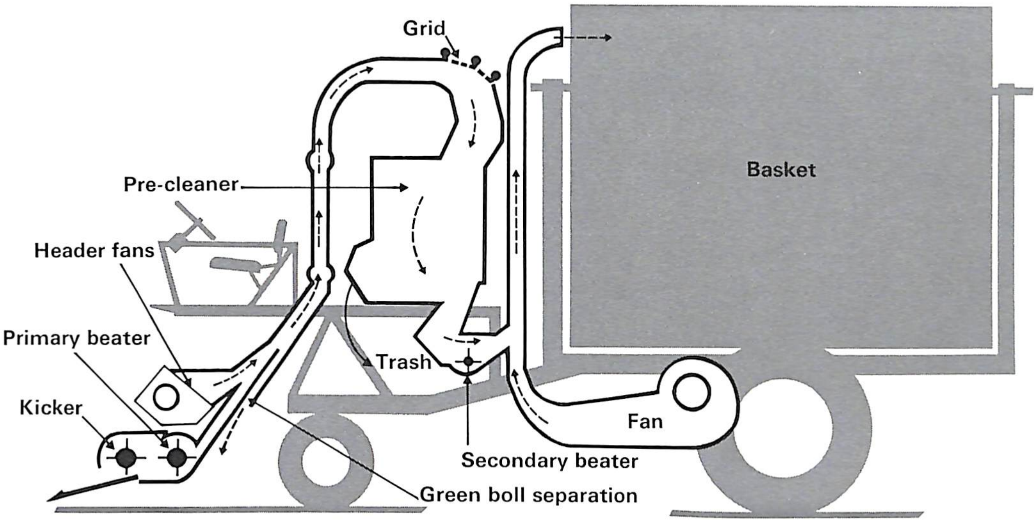
Harvesting narrow-row cotton

Cotton is conventionally grown in rows 40 inches (102 centimetres) apart and harvested with spindle pickers. These are expensive, complicated machines with a relatively low work capacity (about 350 acres or 140 hectares a season) and high maintenance costs. Stripper harvesters, which use brushes or rolls to remove complete bolls, have higher work capacities than spindle pickers, but they pick up too much trash and embed it in the lint, making it difficult to produce clean lint in the ginning process.

There are some advantages to be gained by sowing cotton in rows only 7 inches (18 centimetres) apart, but harvesting cotton grown in this way calls for the use of a special type of harvester. Equipment to meet this need is available on the market but improved harvesters would encourage wider use of the narrow-row system.

A self-propelled stripper harvester suitable for use with narrow-row cotton has been designed and constructed by the DIVISION OF MECHANICAL ENGINEERING and is now undergoing final stages of development.

The machine is powered by an 86-horse-power diesel engine with hydrostatic transmission so that the main driving power is by means of hydrostatic motors in each of the main driving wheels, giving steplessly variable speeds forwards and backwards. The picking head is 12½ feet (3·8 metres) wide with 96 steel fingers which strip off all the bolls, whether open or immature. A rotating kicker removes the bolls from the fingers and passes them back to a higher-speed shaft with rubber paddles extending over the full width of the machine. The paddles throw the bolls up a tapering duct which has grids at the top, and much of the fine trash and dust is blown through the grids by the air flow produced by fans located on the stripping header. The duct also has an opening which is so arranged that the heavier green bolls fall through it while the lighter mature



bolls and trash are blown over it. The remaining seed cotton and trash are fed into a pre-cleaner where most of the remaining trash is removed. The seed cotton finally passes to a secondary beater and is then conveyed to a vertical duct where it is blown into a basket at the rear of the harvester. This basket has a capacity of 1100 cubic feet (31 cubic metres), enough to hold 3500 pounds (1590 kilogrammes) of seed cotton.

In trials conducted in the Namoi area of New South Wales in 1971 the machine achieved a harvest rate of 20 acres (8 hectares) in a 6-hour day, compared with 6 acres (2·4 hectares) a day achieved by a conventional spindle picker. It is clear that more care must be taken in the establishment, cultivation, and preparation of the crop if good results are to be achieved. Nevertheless, the new narrow-row machine offers the possibility of faster harvesting and lower costs.

Predicting earth behaviour

In the design of building foundations, dams, and pavements it is important to be able to predict what effect the loads involved will have on the rocks and earth mass below the ground surface. The civil engineer wants to know the amount of deformation of the subsurface and the whereabouts and nature of zones that are stressed to such a degree that failure may occur. The DIVISION OF APPLIED GEOMECHANICS has developed analytical methods to allow theoretical computations of these aspects of design to be applied to practical situations.

The theoretical model on which predictions are based consists of a series of horizontal linearly elastic layers, simulating layers of deposited earth or rock. While not a strictly accurate model of actual soil and rock masses, the model has been found to provide valuable predictions of earth behaviour, particularly in the design of pavements which recover almost completely from deformation.

In one practical application, the programs are used to predict the way foundation loads of a building are distributed within the underlying soil layers. By coupling this information with test data on the stress-deformation properties of the soils, it is possible to predict the total settlement of the foundation and the rate at which it will occur.

In pavement design, the loading, geometry, and material properties are used as input data and the computer programs are used to predict the stresses, strains, and displacements developed in critical zones. The life of the pavement can then be predicted using laboratory and field experimental data to relate the magnitude of these effects to the fatigue life of the various pavement materials.

The Division is making the results available to engineers in two forms. The effects of the variables can be outlined in a graphical form or any particular practical problem with its particular set of variables can be solved by the use of one of a series of specially prepared computer programs. These programs, which have already been used for several construction projects, enable engineers to obtain from the Division the solutions to a wide range of load-deformation problems.

Wood chips from Papua–New Guinea

The behaviour of wood chips during pulping and the quality of the pulp produced depend on a number of factors. The duration and temperature of the treatment, the nature and concentration of the chemicals used, and the wood species and chip size all affect the final product. In addition, the response of the pulp to bleaching and beating treatment influences the efficiency of the manufacturing process and the properties of the paper.

The pulping characteristics of Australian hardwoods, both individually and mixed, have been studied for many years by the Paper Science Section of the DIVISION OF FOREST PRODUCTS (now the Paper Science Section of the DIVISION OF APPLIED CHEMISTRY). The information obtained by the Section has provided a valuable technical background to the recent negotiations between Australian and Japanese interests which led to the establishment of a viable hardwood chip export industry in New South Wales and Tasmania.

At the request of the Department of External Territories, the Section is now studying the pulping behaviour of mixed tropical hardwoods from the rain forests of Papua–New Guinea which cover about four-fifths of the total land area. The situation in Papua–New Guinea is complicated by the fact that the mixtures contain over 150 hardwood species, many of which have not previously been considered from an industrial viewpoint. Trees from one area, however, have already been shown to be suitable for the preparation of pulp for wrapping paper and cardboard.

In another region, near Vanimo, some 20 miles from the West Irian border, plans are being made to establish a wood chip industry in which an initial investment of $64 million is expected. The Paper Science Section is now engaged in investigating the pulping properties of the mixed hardwoods from this area, where over 600,000 acres of forest are involved. The suitability of the woods for pulping and subsequent utilization in writing and printing papers is being considered.

Chips from a representative sample of 2000 trees are being used to study the behaviour of chip mixtures. The effect of individual species of hardwood on the pulping characteristics of the mixture is being ascertained. Where one species is identified as being responsible for an inferior product or for making the process uneconomic, the Section will investigate the relative merits of adapting the process or separating the logs at an earlier stage.

The study is important in terms of the economic benefits that can be derived by the Territory from a successful wood chip industry. The value of wood chips for pulping depends on freight costs, pulp yield, pulp quality, and processing costs, each of which depends in turn on a number of technical factors. If successful wood chip industries can be established in the Territory, the total export value of chips could be of the order of tens of millions of dollars a year.

Design techniques for indoor environments

Architects and engineers have traditionally used handbook techniques to estimate air-conditioning requirements for a wide range of buildings. However, computer programs developed by the DIVISIONS OF BUILDING RESEARCH and of MECHANICAL ENGINEERING have now made it possible to predict the air-conditioning requirements of buildings more realistically using three different mathematical models, each having its own particular merits.

The computing technique developed by the DIVISION OF MECHANICAL ENGINEERING enables both buildings and their air-conditioning systems to be analysed. The user may not only predict the maximum plant size required but also examine the influence of differing plant installations on the air conditions within a building, and assess the effects of many more variables much more rapidly than he could have previously. He may also take advantage of the thermal characteristics of a building by allowing a small daily swing of indoor dry-bulb temperature during occupancy. This technique allows significant reductions to be made in the capacity of the installed plant. Air-conditioning systems account for some 20% of the $160 million current capital investment in office building construction in Australia. In this context, the new technique can make a direct contribution to the industry by estimating required capacity and by predicting energy requirements and running costs. Good correlations have been obtained in practice between measured and predicted office temperatures. The program has been used on many projects, including two large Melbourne office buildings, a South Australian school, Queensland homes, a warehouse in Victoria, and a supermarket in New South Wales. Collaboration between the Division and practising engineers is growing as the technique becomes more widely accepted and the benefits realized.

Many properties of a building affect indoor temperatures. These include building orientation and shape, insulation and thermal inertia of the various building elements, the size and nature of the windows, shading by screens, and the reflectivity of the various outdoor building surfaces. Because of the complex relationships between these many variables, it is not easy to predict the effects of changes in them on temperatures in the building. The DIVISION OF BUILDING RESEARCH has developed a computer program which combines a harmonic analysis method of calculating indoor temperatures and air-conditioning loads with a method for determining the optimum values for the different variables concerned. The optimum values obtained depend on the criterion selected. This can be either the reduction of thermal discomfort within an enclosure to a minimum, or the attainment of minimum peak cooling or heating load with respect to a specified constant or variable indoor air temperature. The optimization procedure can be repeated for different climates and different types of construction, using upper and lower constraints on any variables if so desired, and will give optimum values for 14 variables at the one time.

The optimization program has been applied to the thermal design of panelized construction for residential housing in Melbourne, Sydney, Kambalda (Western Australia), and Kieta (Bougainville). It has shown that the most suitable density for wall materials should be 10 lb/ft^3 (160 kg/m^3), that concrete floors should be provided for unconditioned buildings, and that the roof should be adequately insulated (an overall thermal transmittance of 0·1 Btu/(hr ft^2 degF) or 0·6 W/(m^{2}K)).

Extension to the consideration of minimum cost of building, especially in the case of multi-storey office buildings, has also been achieved, using a present worth–cost model which considers building envelope costs, air-conditioning plant costs, and air-conditioning running costs.

Chemistry and mineralogy

Division of Chemical Engineering

Location: Clayton, Melbourne
Staff: Research scientists 22, other professional staff 22, supporting staff 50

Division of Mineral Chemistry

Location: Garden City, Port Melbourne, with a laboratory in Sydney
Staff: Research scientists 45, other professional staff 52, supporting staff 134

Division of Mineralogy

Location: Floreat Park, Perth, with laboratories in Canberra, Melbourne, and Sydney
Staff: Research scientists 29, other professional staff 19, supporting staff 43

The Divisions of Chemical Engineering, Mineral Chemistry, and Mineralogy comprise the MINERALS RESEARCH LABORATORIES. Because of the integrated nature of the research programmes of these Divisions, fields of research have been shown below for the MINERALS RESEARCH LABORATORIES as a whole rather than for individual Divisions.

Fields of research:

Mineral exploration
- Methods of exploration—geochemical and geophysical techniques; borehole logging
- Nature, disposition, and mode of origin of nickel sulphide ores, copper–lead–zinc stratiform ores, and ores of tin and other metals associated with granites and porphyries
- Processes leading to the accumulation of hydrocarbon deposits; nature and effects of carbonaceous matter associated with ores

Mineral processing and utilization
- Mineral sulphides—behaviour during mining and processing
- Mineral beneficiation—grinding; gravity, electrostatic, and electromagnetic separation processes; flotation
- Process metallurgy—pyrometallurgy, hydrometallurgy, electrometallurgy
- Fluidization
- Chemistry and processing of mineral sands and iron ores
- Fossil fuels—chemical and petrological properties of Australian coals; utilization of Australian coals; production of electrode carbon from natural gas
- Air pollution—removal of harmful materials from gases, particularly those originating from the combustion of fossil fuels and the processing of minerals

Support studies
- Composition and origin of solutions responsible for transport of metal species during ore deposition
- Sulphide mineralogy
- Occurrence and properties of clays, talcs, silicas, limestones, and similar categories of rock and non-metallic mineral materials
- Rock physics

Structure of solids
Interactions at the water–solid interface
Halide metallurgy
Reaction mechanisms and kinetics
Thermodynamics
Process evaluation, development, and control
Fundamentals and applications of unit operations in chemical engineering

Division of Applied Chemistry

Location: Fishermens Bend, Port Melbourne, with a microanalytical laboratory at the University of Melbourne

Staff: Research scientists 34, other professional staff 32, supporting staff 74

Fields of research:
Chemistry of natural products—alkaloids, terpenes, and hormones
Synthetic organic chemistry and organometallic chemistry
Chemical thermodynamics, reaction mechanisms, and catalysis
Bush fires
Polymer chemistry
Water purification
Surface chemistry
Nucleation and crystallization
Microanalytical laboratory

Division of Chemical Physics

Location: Clayton, Melbourne

Staff: Research scientists 34, other professional staff 15, supporting staff 52

Fields of research:
Atomic absorption and resonance spectroscopy
Molecular spectroscopy
Optical diffraction gratings
Mass spectroscopy
Magnetic resonance spectroscopy
X-ray structure analysis
Electron diffraction
Electron microscopy
Solid state investigations
Low-temperature studies
Theoretical chemistry
Development of scientific instruments and techniques

Studying bush fires

Although bush fires have long been part of the Australian scene, little is known about the smoke they produce. However, if the practice of controlled burning—now a routine operation for reducing the fire hazard in some Australian forests—is to be used on an increasing scale, it will be desirable to know how bush-fire smoke affects air quality. To find this out, the DIVISION OF APPLIED CHEMISTRY, with the assistance of the DIVISION OF METEOROLOGICAL PHYSICS, undertook a series of investigations in December 1970 in collaboration with the Western Australian Forests Department.

An aircraft was used to collect smoke samples, which were analysed for total particulate matter, tar, soot, and inorganic ash, and for gaseous products such as carbon dioxide, carbon monoxide, ammonia, sulphur dioxide, oxides of nitrogen, ozone, and olefins. Studies were also made of particle sizes and of the diffusion properties of the smoke columns as they were blown downwind.

Although smoke reduces visibility through the atmosphere, the results of the study suggest that bush-fire smoke is not involved to any serious extent in the production of photochemical smog, a dense, severely irritant atmosphere produced by the reaction between nitrogen oxides and hydrocarbons under the influence of sunlight. Moreover, undesirable compounds such as sulphur dioxide and ozone were found to be present in only minute quantities.

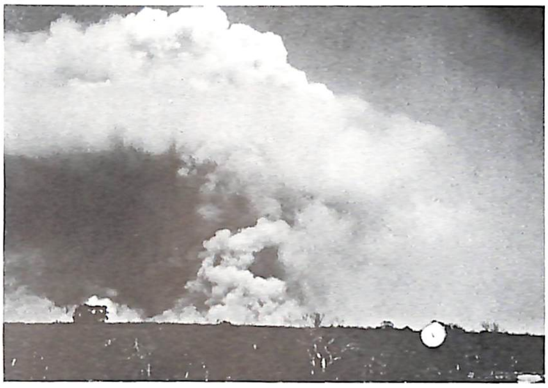
In another investigation, the two Divisions collaborated to study the meteorological processes accompanying the development of major wild fires. Three large fires were lit by the Western Australian Forests Department to provide a series of intense simulated wild fires. Measurements were made from a number of observation points nearby and from an aircraft which flew through the smoke columns produced. Each fire covered an area of about 7500 acres (3035 hectares) and maximum burning rates were of the order of 30,000 tons (30,480 metric tons) of fuel an hour. In the hottest fire the convection column rose to more than 14,000 feet (4·26 kilometres).

Time-lapse pictures obtained in these experiments showed some remarkable effects. Strong flow of air into the smoke columns from all directions was evident and, above the condensation level, convection took on new impetus owing to the release of latent heat. In the hottest fire the total heat evolved by condensation of moisture in the smoke plume was estimated to be only slightly less than that produced from the burning fuel on the ground.

Electrode carbon from natural gas

In collaboration with the Broken Hill Proprietary Company Limited the DIVISION OF MINERAL CHEMISTRY is developing a novel continuous process to make carbon of electrode-grade quality from natural gas and other petroleum hydrocarbons. Electro-metallurgical industries in Australia currently use nearly 100,000 tons of petroleum coke a year to fabricate carbon electrodes, used mainly for the smelting of aluminium. Petroleum coke has to be imported from the United States and future supplies are uncertain because of changes in oil-refinery practice. The Division has therefore been investigating the possibility of producing electrode carbon from Australian natural gas in order to safeguard our supplies and to promote the expansion of Australia's electro-metallurgical industries.

Earlier bench-scale experiments in the Division have shown that pyrolytic carbon may be produced by cracking



This sequence of photographs of a simulated wild fire in Western Australia was taken from a distance of about 10 miles (16 kilometres) by the DIVISION OF APPLIED CHEMISTRY. The pictures show the development of the smoke cloud followed by the formation of condensation clouds above the fire area. In the bottom picture the distinct mushroom shape of the smoke column can be clearly seen below the condensation clouds.

natural gas and other hydrocarbons at temperatures of about 1100°C. A hard, dense form of carbon is produced which appears to be a satisfactory alternative to petroleum coke for the manufacture of electrodes. Present work is aimed at producing large samples of pyrolytic carbon, so that its suitability as electrode carbon can be tested, and at providing the data needed for a design and feasibility study of a commercial manufacturing process.

A major step in the development of the process has been the design, construction, and operation of a technical-scale cracking reactor. The reactor is of a moving-bed type where carbon particles heated to about 1100°C move slowly downwards as a mass against an upward-flowing stream of hydrocarbon gas. The gas is cracked into its elements, hydrogen and carbon. The hydrogen passes out at the top of the reactor and is collected for future use while the carbon is deposited as a thin, hard layer on the surface of the particles. The particles flow from the bottom outlet of the reactor to be picked up by a stream of hot combustion gas, generated by a gas burner. The particles are reheated and transported to the top of the reactor, where they re-enter the cracking cycle. Once they have grown to about ⅛ inch (3·2 mm) in diameter the grains are removed from the cracking cycle. Natural attrition within the reactor ensures that there is always an ample supply of smaller particles to grow by deposition of the carbon from the cracking reaction.

The solid product, which is virtually pure carbon, appears as hard rounded grains with a silvery-grey lustre. The gaseous product contains 80% or more of potentially useful hydrogen.

The reactor is capable of producing 1·5 pounds (0·68 kilogramme) an hour of pyrolytic carbon and 38 cubic feet (2·1 cubic metres) of hydrogen from about 100 cubic feet (5·7 cubic metres) an hour of natural gas (methane) or 30 cubic feet (1·7 cubic metres) an hour of propane. The test rig is simple in construction and is fitted with automatic controls; it has run continuously for several days with little attention.

Making carbon tetrachloride

Experiments being conducted by the DIVISION OF CHEMICAL ENGINEERING could lead to a commercial process for producing carbon tetrachloride by the chlorination of wood or coal char. The new process was suggested by analogy with the reaction between carbon and hydrogen to form methane which was studied by the Division some years ago. The Division has shown that carbon and chlorine will react directly with each other if the temperature and pressure are high enough. It has also shown that, provided excess chlorine is present, carbon tetrachloride is the only compound produced in significant quantity.

In the proposed process, chlorine reacts with wood or coal char in a fluidized bed. Carbon tetrachloride product is separated from unreacted chlorine by fractionation in two columns. The chlorine is recycled to the reactor, part of the recycle stream being treated continuously to prevent the accumulation of unwanted components.

Most carbon tetrachloride is made by chlorinating hydrocarbons and this produces large quantities of hydrogen chloride as a by-product as well as various chlorocarbons other than carbon tetrachloride. Since these by-products are generally unwanted and since forecast chlorine production in Australia is expected to be greater than requirements, the Division believes that the new process could prove competitive with conventional methods of production.

Borehole logging

Much of the money spent on mineral exploration in Australia is spent on drilling. There are two main methods, rotary and percussion. Rotary drilling or hard rock coring allows the operator to withdraw cores from the hole so that he can inspect and analyse rock samples from any given depth. Percussion drilling costs only about one-fifth as much as rotary drilling and is five times as fast, but it provides much less information on the geological formations and rock types encountered. If ways could be found to overcome this disadvantage, percussion drilling could be used far more widely and mineral exploration costs would be lowered considerably.

For the last few years the DIVISION OF MINERAL CHEMISTRY, in conjunction with Conzinc Riotinto of Australia Limited, has been working on an instrument which, when lowered down a borehole, will identify various metallic and non-metallic elements in the surrounding rocks. The instrument, known as a borehole logger, contains a radioactive source that bombards the walls of the hole with neutrons. Most elements respond by emitting gamma rays that are characteristic of the element concerned. The gamma rays are detected by the instrument and their pulse signals transmitted to a pulse-height analyser coupled to a small computer. Detailed information can be obtained from any selected region intersected by the borehole, such as a sulphide-bearing ore seam.

A scanning procedure has been devised which enables the position and extent of a mineralized zone to be detected. Signals from the detector are processed by the computer connected to the pulse-height analyser as the logging instrument moves up the hole at a speed of about 4 feet a minute. Results are then printed out and compared with depth and other information needed to convert the figures to data on what elements are present at what depth and in what amount. All the electronic instrumentation, together with a logging winch, slip-ring assembly, and depth-measuring gear, is housed in a mobile field laboratory.

In field trials carried out by the Division on the nickel sulphide (pentlandite) occurrences at Widgiemooltha, Western Australia, and the iron ore (haematite–magnetite) occurrences at Nowa Nowa, Victoria, promising correlations have been obtained between detector signals and the position of the ore body and the abundance of the element concerned. Both nickel and iron were monitored in nickel ores, enabling nickel/iron ratios in the ore body to be calculated automatically.

Hydrogen, oxygen, sodium, magnesium, aluminium, silicon, sulphur, chlorine, chromium, iron, nickel, copper, lead, and the naturally radioactive elements potassium, thorium, and uranium have already been detected in boreholes about 300 feet (90 metres) deep with varying degrees of sensitivity. In addition, the scattering of gamma rays from a radioactive cobalt source has been used to describe rock type and to locate mineralized zones in the field. The density of the formation and its effective atomic number are determined simultaneously and provide a rough but useful guide to ore grade. Metal-rich formations are readily distinguished from the host rock by their high density and high atomic numbers.

Physics

Division of Radiophysics

Location: Epping, Sydney, with the Australian National Radio Astronomy Observatory at Parkes, N.S.W., and a radio observatory at the CSIRO Solar Observatory, Culgoora, N.S.W.
Staff: Research scientists 39, other professional staff 30, supporting staff 168

Fields of research:
Solar radio astronomy
Cosmic radio astronomy
Experimental cloud seeding
Cloud and rain physics

Division of Tribophysics

Location: Parkville, Melbourne, with a laboratory at Fishermens Bend, Port Melbourne
Staff: Research scientists 28, other professional staff 16, supporting staff 41

Fields of research:
Chemistry, physics, and technology of metals, alloys, ceramics, and refractories
Surface and interfacial phenomena
Adsorption and catalysis

Physical Metallurgy Section

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

Fields of research:
Grain boundaries in metals
Changes in metals during deformation
Field ion microscopy
Metallurgical analysis

Division of Applied Physics

Location: Chippendale, Sydney
Staff: Research scientists 37, other professional staff 49, supporting staff 126

Fields of research:
Standards of electrical quantities, length, mass, time interval, and quantities derived from them
Magnetic and dielectric properties of materials
Vibration
Applied mechanics

Division of Physics

Location: Chippendale, Sydney, with an optical observatory at the CSIRO Solar Observatory, Culgoora, N.S.W.

Staff: Research scientists 22, other professional staff 28, supporting staff 62

Fields of research:
Maintenance and development of standards of temperature, humidity, viscosity, light, and radiation, and associated research
Solid state physics
Fluid physics
Solar physics

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

Measuring the oxygen content of molten copper

Zirconia is a ceramic material used in high-duty furnace refractories and in engineering components that are required to perform for long periods at high temperatures under severe conditions of corrosion and abrasion. To minimize the effects of a change of crystal structure which begins at around 1000°C and involves a 7–9% volume change, zirconia is normally alloyed with certain metal oxides such as lime, magnesia, or yttria. In this stabilized form, zirconia alloys have the interesting property of being able to conduct electricity at high temperatures by transporting oxygen ions through an otherwise impermeable crystal lattice. This property has led the DIVISION OF TRIBOPHYSICS and a number of other laboratories throughout the world to investigate the possibility of using probes made from stabilized zirconia to measure the concentration of oxygen in molten metals—an important factor in many metallurgical processes.

In the probes developed by the Division, problems of mechanical and thermal shock have been overcome and the cost of the equipment kept low by fusion-welding a small pellet of stabilized zirconia into a cheap robust tube of aluminous porcelain, mullite, or alumina. When opposite faces of the pellet are exposed to different oxygen pressures or concentrations, oxygen ions migrate through the lattice from high to low pressure or concentration. If provision is made for an electrical connection to each face of the pellet, the device will function as a concentration cell. Variations in the amount of oxygen in a melt can be measured by the electrical output from such a cell, the internal face being exposed to a standard reference oxygen concentration.

Probes developed by the Division have been used by Copper Refineries Pty. Ltd. of Townsville, Queensland, to obtain continuous measurements of the oxygen content of molten copper during the casting of electrolytic anodes and high-purity wire bars intended for fabrication into high-conductivity copper wire. The oxygen content of this latter product is important because of its detrimental effect on electrical conductivity. In addition, the interrelated effects of dissolved oxygen and hydrogen influence the 'set' or solidification behaviour of copper castings, which, if incorrectly set, must be recycled through the melting and casting process.

Since October 1970, the refinery has been able to monitor the change in oxygen content over the duration of the casting process, a period of about 6 hours a day. A probe that will last for five or six casts is now in the final stages of assessment.

Better radio telescopes

Radio telescopes like the 210-foot (64-metre) instrument operated at Parkes, New South Wales, by the DIVISION OF RADIOPHYSICS focus the energy collected by a large parabolic reflector onto a small receiving aerial or 'feed'. The same feed can also be used to radiate energy, as in telescopes used for satellite communications, and the overall efficiency of the telescope is identical in each case. This efficiency rarely exceeds 50% for prime-focus telescopes and the loss must be compensated by using a substantially bigger and more costly reflector for a given application.

One major component of loss occurs in transferring energy from reflector to feed. The Division has undertaken a theoretical analysis of the electromagnetic fields focused on the feed and has shown that they represent a set of waves of an unusual kind. Only about 65% of the energy of these waves can be absorbed by normal feeds. A new type of wave-guide feed with corrugated walls has been devised which can, in principle, absorb over 90% of the focused energy. A related property of the feed is that its response to radio 'noise' interference emitted thermally by the ground can, theoretically, be made very small, further improving telescope performance. An even bigger improvement is possible for spherical reflectors because the feed can also be designed to overcome losses due to spherical aberration.

The new feed provides response patterns with inherent axial symmetry and uniform polarization in all directions, properties which have long been sought for certain applications. Attenuation in the corrugated waveguide is significantly lower than in smooth waveguides and its use has been suggested for reducing the transmission loss between satellite-communication telescopes and their terminal equipment. Several types of the new feed have been made for the Parkes telescope and one was used to enhance reception of signals during the first Apollo moon landing. Research to develop the full potential of the feeds is continuing.

The second main component of loss in radio telescopes is caused by departures of the reflector from the proper shape. This sets a lower limit to the operating wavelength. To study these errors on the Parkes telescope, the DIVISION OF RADIOPHYSICS has collaborated with the DIVISION OF APPLIED PHYSICS in the development of an automatic survey camera which has been permanently installed at the centre of the reflector. In one night, this instrument can measure the surface errors at some 700 points, for several elevation angles, with an average uncertainty of 1 millimetre. Auxiliary optical and levelling facilities enable the internal alignment of the instrument to be checked and its axis to be related to certain axes that influence the directional pointing accuracy of the telescope. Versions of the CSIRO instrument have since been installed in two large radio telescopes in Canada and Germany.

Extensive measurements at Parkes with this camera have shown that a substantial part of the losses due to deflections of the basic reflector structure can be recovered by re-focusing the feed laterally and axially and by correcting the pointing direction, as the telescope tilts. The residual loss is then small compared with that due to the manufacturing errors of the panels forming the 64-metre-diameter reflecting surface. These easily comply with the original 1955 specification requiring operation only to 21-centimetre wavelength and in practice operation down to 6 centimetres has been possible. However, the DIVISION OF RADIOPHYSICS has now designed panels with a much higher surface accuracy and installed these out to a diameter of 32 metres. Extension to a diameter of 46 metres will be undertaken if wind-loading measurements now in progress are favourable. Radio measurements have confirmed that the performance improvement predicted by the camera measurements for the present stage has been fully achieved and the shortest operating wavelength has been reduced to less than 3 centimetres. This is particularly opportune because of the present trend to shorter wavelengths in radio astronomy and the appearance of large second-generation telescopes in other countries.

Temperature scales near absolute zero

Over the last four years the DIVISION OF PHYSICS of the National Standards Laboratory has taken part in a unique international experiment to compare the world's principal scales of temperature in the range from 1 to 30 K above absolute zero, that is, from about −272°C to −243°C. Some national laboratories, including the National Standards Laboratory, have established low-temperature scales in this range based on the changes with temperature in the pressure of a constant volume of helium gas. Other laboratories have based their scales on changes in the magnetic susceptibility of a paramagnetic salt and still others on the velocity of sound in helium gas. These changes in a particular physical property are measured in a primary thermometer, which is a large and elaborate piece of equipment, and are then related to the absolute temperature by known physical laws. Unless scales established independently around the world can be interrelated to millidegree accuracy, physical measurements made with them will disagree.

The Australian, Russian, and United States gas-based scales and the Dutch and United States magnetically based scales have been intercompared by exchanging a batch of germanium resistance thermometers and calibrating them in each of the laboratories concerned. These secondary thermometers consist of small (5 mm) chips of germanium doped with selected impurities. The electrical resistance of these chips varies rapidly in a stable and reproducible manner with temperature. They are robust and enough of them survived the shocks of handling and transport around the world to retain their original calibrations to better than 1 mK (0·001°C) so that the comparison could be made.

The Division has collated and analysed the results of the intercomparison and has found that these independent scales differ by as much as 30 mK. Most of this variation has been traced to systematic experimental factors associated with the different methods used to establish the scales. If world-wide agreement can be reached on common measurement procedures, the ultimate scales will probably agree to within 2–3 mK. This will facilitate the establishment of a new international scale between 4·2 K and about 20 K, a region which at present has no single agreed scale.

Monitoring voltage standards

At the National Standards Laboratory, Sydney, the standard volt is maintained by a bank of Weston cadmium cells held in a closely controlled environment. The Australian standard is compared regularly with the national standards of nine other countries by the International Bureau of Weights and Measures.

The DIVISION OF APPLIED PHYSICS, which is responsible for maintaining the Australian standard, has been using a technique based on the Josephson effect to monitor it with an accuracy of one part in ten million. The Josephson effect is observed in a number of structures in which a weak electrical link is produced between two superconducting metals maintained at a low temperature. It is characterized by two phenomena. One of these, the d.c. Josephson effect, is observed as the flow of current through such a junction with zero potential difference. The other is the a.c. Josephson effect in which a potential, established across a junction, results in the generation of an alternating current, the frequency of which is directly proportional to the applied potential difference. Since frequency can be measured with great precision, this relation provides the basis for a standard of potential difference which can be shown experimentally to be independent of gross variation of junction materials, geometry, and environment.

The output of the cells used to maintain the national standard of potential difference is several hundred times the maximum obtainable from a Josephson junction. In comparing the two potential differences, therefore, the Division has had to make d.c. measurements of extreme precision. Measurements over a period of about a year have shown excellent reproducibility and have made it possible to detect a slight but acceptable drift of the standard. Comparison with the results of overseas research using different Josephson junctions and different techniques of measurement has shown close agreement in the values obtained for the constant relating voltage to frequency.

The vibration interferometer

An instrument known as a vibration interferometer has been developed by the DIVISION OF APPLIED PHYSICS of the National Standards Laboratory for the absolute calibration of reference accelerometers. These in turn are used for the transfer calibration of working accelerometers in a number of industries including those concerned with the manufacture of aircraft and guided weapons. The sensitivity of these reference accelerometers must be accurately established against the basic standards of length and time. Before the development of the interferometer, reference accelerometers had to be sent overseas for absolute calibration. The first calibration of an accelerometer of this kind in Australia was undertaken in 1971 for the Government Aircraft Factories at Fishermens Bend, Victoria.

The interferometer in its present form can provide sinusoidal vibrations with an acceleration up to $2g$ in the frequency range from 200 to 1000 hertz. Frequency is measured in terms of the National Standards Laboratory frequency standard. Vibration amplitudes from $1 \cdot 4 \times 10^{-7}$ to 70×10^{-7} metre peak displacement are measured directly by interferometry in terms of the wavelength of mercury light. The resolution is about 1×10^{-9} metre.

Arrangements are now being made for a laboratory intercomparison of standard accelerometers with the United States National Bureau of Standards.

Statistics and computation

Division of Computing Research

Location: Canberra, with subsidiary installations at Adelaide, Brisbane, Melbourne, Perth, Sydney, and Griffith, N.S.W.

Staff: Research scientists 10, other professional staff 31, supporting staff 62

Fields of research:
Improvement of operating systems
Development of classification methods
Pattern recognition
Simulation techniques
Design of engineering structures
Speech recognition
Data base management
Computer languages

Division of Mathematical Statistics

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

Staff: Research scientists 23, other professional staff 30, supporting staff 34

Fields of research:
Computing with particular reference to statistics
Analysis of climatological data
General distribution theory
Experimental design
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.

Staff

Senior Appointments

Dr. J. A. Allen, Executive Officer, HEAD OFFICE

Mr. A. J. Gaskin, Chief, DIVISION OF MINERALOGY

Dr. D. F. A. Koch, Chief, DIVISION OF MINERAL CHEMISTRY

Dr. R. W. R. Muncey, Chief, DIVISION OF BUILDING RESEARCH

Mr. I. E. Newnham, Director, MINERALS RESEARCH LABORATORIES

Mr. M. V. Tracey, Chief, DIVISION OF FOOD RESEARCH

Dr. J. P. Wild, Chief, DIVISION OF RADIOPHYSICS

The following appointments were announced during the year although they do not take effect until the financial year 1971/72:

Dr. B. S. Harrap, Officer-in-Charge, Dairy Research Laboratory, DIVISION OF FOOD RESEARCH

Dr. K. G. McCracken, Officer-in-Charge, MINERAL PHYSICS SECTION

Dr. J. R. Philip, Chief, DIVISION OF ENVIRONMENTAL MECHANICS

Deaths

Dr. P. M. Abel, ANIMAL GENETICS

Dr. J. E. Falk, PLANT INDUSTRY

Mr. J. W. Gottstein, FOREST PRODUCTS

Mr. J. P. Hamilton, MECHANICAL ENGINEERING

Mr. D. L. McIntosh, WILDLIFE RESEARCH

Retirements

Dr. E. G. Bowen, RADIOPHYSICS
Dr. R. Carrick, WILDLIFE RESEARCH
Dr. P. Elek, ANIMAL HEALTH
Mr. W. R. Ferguson, HEAD OFFICE
Mr. F. J. Gay, ENTOMOLOGY
Mr. C. A. Gladman, APPLIED PHYSICS
Dr. C. G. Greenham, PLANT INDUSTRY
Mr. W. B. Hitchcock, WILDLIFE RESEARCH
Dr. A. Howard, FOOD RESEARCH
Mr. A. A. Johnson, FOOD RESEARCH
Mr. T. Kaar, FISHERIES AND OCEANOGRAPHY
Dr. G. Kaess, FOOD RESEARCH
Mr. R. S. T. Kingston, FOREST PRODUCTS
Mr. I. Langlands, BUILDING RESEARCH
Mr. G. Loftus Hills, DAIRY RESEARCH
Mr. L. L. McCready, APPLIED PHYSICS
Mrs. J. F. Melvin, FOREST PRODUCTS
Mr. W. H. Taylor, BUILDING RESEARCH
Mr. R. F. Turnbull, FOREST PRODUCTS

Professorships

The following officers resigned during the year to accept appointment to university chairs:

Dr. J. C. Boray, ANIMAL HEALTH; Associate Professor, Parasitology Institute, University of Zurich, Switzerland

Dr. T. G. Chapman, LAND RESEARCH; Professor of Engineering, Royal Military College, Duntroon

Mr. J. W. Holmes, SOILS; Professor of Earth Sciences, Flinders University

Dr. J. R. McWilliam, PLANT INDUSTRY; Professor of Agronomy, University of New England

Dr. H. R. Wallace, HORTICULTURAL RESEARCH; Professor of Plant Pathology, Waite Agricultural Research Institute

Honours and awards

Dr. J. A. Allen, HEAD OFFICE; Emeritus Professor, University of Newcastle

Mr. E. E. Bond, WHEAT RESEARCH UNIT; Member of the Order of the British Empire; Farrer Medal

Mr. C. S. Christian, MEMBER OF EXECUTIVE; Companion of the Order of St. Michael and St. George

Mr. J. R. Egerton, ANIMAL HEALTH; David Syme Research Prize (shared)

Dr. L. T. Evans, PLANT INDUSTRY; Fellow of the Australian Academy of Science

Mr. J. L. Farrant, CHEMICAL PHYSICS; Member of Executive Committee, International Federation of Societies for Electron Microscopy

Miss F. E. Franz (retired), HEAD OFFICE; Imperial Service Medal

Dr. E. L. French, ANIMAL HEALTH; Honorary Associate, Department of Microbiology, Monash University

Mr. L. B. Graham, REGIONAL ADMINISTRATIVE OFFICE, MELBOURNE; British Empire Medal

Dr. H. McL. Gordon, ANIMAL HEALTH; Golden Fleece Award, Californian Woolgrowers' Association

Dr. S. D. Hamann, APPLIED CHEMISTRY; H. G. Smith Medal, Royal Australian Chemical Institute

Mr. W. H. Hartley (retired), HEAD OFFICE; Officer of the Order of the British Empire

Dr. A. K. Head, TRIBOPHYSICS; Fellow of the Australian Academy of Science

Mr. W. A. Holt (retired), REGIONAL ADMINISTRATIVE OFFICE, SYDNEY; Imperial Service Medal

Dr. I. G. Jarrett, NUTRITIONAL BIOCHEMISTRY; President, Endocrine Society of Australia

Mr. J. F. Kefford, FOOD RESEARCH; President, Australian Institute of Food Science and Technology; Member, Executive Committee, International Union of Food Science and Technology

Mr. W. B. Kennedy, BUILDING RESEARCH; President, Operational Research Society of Victoria

Dr. R. H. Laby, ANIMAL PHYSIOLOGY; Member of the Order of the British Empire

Mr. G. Lorenz, APPLIED PHYSICS; Engineering Citation, Society of Manufacturing Engineers

Dr. K. G. McCracken, MINERAL CHEMISTRY; Doctor of Science, University of Adelaide

Mr. R. N. Morse, MECHANICAL ENGINEERING; President, International Solar Energy Society

Dr. M. F. R. Mulcahy, MINERAL CHEMISTRY; Doctor of Science, University of Oxford

Dr. E. W. Radoslovich, SOILS; Member, Standing Committee of Senate, University of Adelaide

Dr. A. L. G. Rees, CHEMICAL PHYSICS; Member of Executive Committee of International Council of Scientfic Unions; Leighton Memorial Medal, Royal Australian Chemical Institute; Einstein Memorial Lecturer, Australian Institute of Physics

Dr. T. W. Scott, ANIMAL PHYSIOLOGY; Bond Gold Medal, American Oil Chemists' Society

Dr. O. B. Slee, RADIOPHYSICS; Doctor of Science, University of New South Wales

Mr. P. A. Taylor, MECHANICAL ENGINEERING; President, Agricultural Engineering Society (Australia)

Mr. M. V. Tracey, FOOD RESEARCH; President, Australian Biochemical Society

Dr. A. J. Wapshere, ENTOMOLOGY; Mercer Award, Ecological Society of America

Professor H. C. Webster, HEAD OFFICE; Fellow, Australian Institute of Physics

Dr. D. E. Weiss, APPLIED CHEMISTRY; Fellow of the Australian Academy of Science; Archibald D. Olle Prize, New South Wales Branch of Royal Australian Chemical Institute

Sir Frederick White, Chairman of Executive (retired); Doctor of Science (Honorary), University of Papua and New Guinea; Fellow, Australian Institute of Physics

Dr. G. Winter, MINERAL CHEMISTRY; Doctor of Science, University of Melbourne

Advisory Council

Executive

J. R. Price, D.Phil., D.Sc., F.A.A. (*Chairman*)
V. D. Burgmann, B.Sc., B.E.
C. S. Christian, C.M.G., B.Agr.Sc., M.S.
M. F. C. Day, B.Sc., Ph.D., F.A.A.
L. Lewis, B.Met.E.
E. P. S. Roberts, C.M.G.
Sir Henry Somerset, C.B.E., M.Sc.
K. L. Sutherland, Ph.D., D.Sc., F.A.A.
Professor E. J. Underwood, C.B.E., Ph.D., D.Rur.Sc., D.Sc.(Agric.), F.A.A., F.R.S.

Chairmen of State Committees

NEW SOUTH WALES—K. L. Sutherland, Ph.D., D.Sc., F.A.A.
QUEENSLAND—Professor F. N. Lahey, D.Sc.
SOUTH AUSTRALIA—A. M. Simpson, C.M.G., B.Sc.
TASMANIA—V. G. Burley, C.B.E., B.E.
VICTORIA—H. P. Weber, C.B.E., M.Sc.
WESTERN AUSTRALIA—L. C. Brodie-Hall, A.W.A.S.M.

Co-opted Members

Professor G. M. Badger, Ph.D., D.Sc., F.A.A.
A. P. Beatty
K. F. Beazley, M.A., M.H.R.
Professor D. C. Blood, M.V.Sc
C. W. Bridges-Maxwell, M.H.R.
J. Darling
Professor F. J. Fenner, M.B.E., M.D., F.A.A., F.R.S.
M. W. Howell, B.E., F.S.A.S.M.
C. R. Kelly, M.H.R.
J. Melville, C.M.G., M.Sc., Ph.D.
Professor R. N. Robertson, C.M.G., Ph.D., D.Sc., F.A.A., F.R.S.
Professor J. M. Swan, Ph.D., D.Sc.
Professor H. R. Vallentine, B.E., M.S.
W. J. Vines
R. G. Ward, M.A., Ph.D.
R. M. Watts, B.V.Sc.
Professor B. R. Williams, M.A.
D. R. Zeidler, C.B.E., M.Sc.

State Committees

New South Wales State Committee

K. L. Sutherland, Ph.D., D.Sc., F.A.A. (*Chairman*)
J. B. Massy-Greene, M.A.
D. F. McMichael, B.Sc., M.A., D.Phil.
Professor B. R. Williams, M.A.
A. J. Higgs, B.Sc. (*Secretary*)

Queensland State Committee

Professor F. N. Lahey, D.Sc. (*Chairman*)
K. J. C. Back, M.Sc., Ph.D.
A. P. Beatty
C. B. P. Bell, C.B.E.
K. E. Gibson, B.Sc.
B. H. Gunn, B.Com., A.A.U.Q., A.A.S.A.
R. E. Harrison, B.Agr.Sc.
J. M. Harvey, D.Sc.
E. B. de N. Joyce, O.B.E.
I. W. Morley, I.S.O., B.M.E., B.Met.E.
Sir Ellis Murphy, M.B., Ch.M., F.R.C.P., F.R.A.C.P.
L. V. Price, O.B.E.
R. M. Reynolds
E. P. S. Roberts, C.M.G.
W. J. D. Shaw, O.B.E.
Professor M. Shaw, M.Eng., M.Mech.E.
Professor R. L. Specht, M.Sc., Ph.D.
Professor J. F. A. Sprent, Ph.D., D.Sc., F.R.C.V.S., F.A.A.
E. F. Henzell, B.Agr.Sc., Ph.D. (*Secretary*)

South Australian State Committee

A. M. Simpson, C.M.G., B.Sc. (*Chairman*)
A. J. Allen, A.R.M.T.C., F.R.A.C.I.
D. H. Brown, M.Sc.
A. D. Chenery
Professor A. M. Clark, M.Sc., Ph.D.
W. W. Forrest, B.Sc., Ph.D.
B. J. Hailstone, M.I.T.A.
R. G. M. Harvey, B.Sc.Agr.
J. E. Harris, B.E.
D. R. Hawkes
M. R. Irving, B.V.Sc.
J. F. Jenkinson, A.A.S.A., A.C.I.S.
Brigadier J. G. McKinna, C.B.E., D.S.O., M.V.O., C.St.J., E.D.
J. Melville, C.M.G., M.Sc., Ph.D.
L. W. Parkin, M.Sc., A.S.T.C.
Emeritus Professor J. A. Prescott, C.B.E., D.Sc., D.Ag.Sc., F.A.A., F.R.S.
H. C. Schmidt
E. W. Schroder, B.E., A.A.S.A.
H. Wilckens
D. W. Dewey (*Secretary*)

Tasmanian State Committee

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K. A. Brodribb
W. Bryden, C.B.E., B.A., M.Sc., Ph.D., F.R.S.
E. J. Cameron, C.B.E., M.A.
A. H. Crane, B.Sc., M.For.
R. J. Downey
T. A. Frankcomb, O.B.E.
G. Hall, C.B.E., B.Sc.
R. W. Henry, B.Sc.
Professor W. D. Jackson, B.Sc., Ph.D.
A. W. Knight, C.M.G., B.Sc., B.Com., M.E.
A. R. Mead, Dip.Comm.
P. R. Stone
J. G. Symons, B.E., F.S.A.S.M.
H. R. Twilley
D. D. von Bibra, O.B.E.
Professor G. C. Wade, M.Agr.Sc., D.Sc.
D. Martin, D.Sc. (*Secretary*)

Victorian State Committee

H. P. Weber, C.B.E., M.Sc. (*Chairman*)
A. D. Butcher, M.Sc.
Professor J. M. Swan, Ph.D., D.Sc.
R. G. Ward, M.A., Ph.D.
D. S. Wishart, B.V.Sc.
D. R. Zeidler, C.B.E., M.Sc.
R. N. Sanders, B.V.Sc., M.R.C.V.S. (*Secretary*)

Western Australian State Committee

L. C. Brodie-Hall, A.W.A.S.M. (*Chairman*)
C. C. Adams
A. McA. Batty, B.Sc., Dip.Chem.Eng.(Lond.)
Professor N. S. Bayliss, C.B.E., B.A., Ph.D., D.Sc., F.A.A.
R. F. Blanks, M.Sc., Ph.D.
C. R. Bunning, C.B.E., B.C.E.
G. H. Cooper
D. M. Cullity, B.Sc.
R. R. H. Doran, F.I.E.Aust.
K. W. Edwards, O.B.E., A.A.S.A.
Air Chief Marshal Sir Basil Embry (R.A.F. retired), G.C.B., K.B.E., D.S.O. (4 bars), D.F.C., A.F.C.
Professor B. J. Grieve, M.Sc., Ph.D., D.I.C.
N. G. Humphries, C.B.E., A.A.S.A.
Professor P. R. Jefferies, M.Sc., Ph.D.
J. N. Langford
P. B. Lefroy
G. N. Lewis, Dip.Agr.
T. J. Lewis
Professor R. J. Moir, B.Sc.(Agric.)
J. P. Norton, O.B.E.
E. P. O'Callaghan
Professor R. T. Prider, B.Sc., Ph.D.
Professor J. P. Quirk, B.Sc.Agr., Ph.D., D.Sc.
W. D. L. Ride, M.A., D.Phil.
L. W. Samuel, B.Sc., Ph.D.
J. H. Shepherd, B.Sc., B.Agr.Sc., Dip.For.
Professor W. R. Stern, M.Sc.Agr., Ph.D.
Professor E. J. Underwood, C.B.E., Ph.D., D.Rur.Sc., D.Sc.(Agric.), F.A.A., F.R.S.
W. R. Wallace, Dip.For.
Professor H. H. Waring, D.Sc., F.A.A.
R. Woodall, M.Sc.
J. P. Brophy (*Secretary*)

Staff

The following is a list of professional and senior administrative staff of the Organization as at June 30, 1971.

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

Executive
CHAIRMAN
J. R. Price, D.Phil., D.Sc., F.A.A.
MEMBERS OF THE EXECUTIVE
V. D. Burgmann, B.Sc., B.E.
C. S. Christian, C.M.G., B.Agr.Sc., M.S.
M. F. C. Day, B.Sc., Ph.D., F.A.A.
L. Lewis, B.Met.E.
E. P. S. Roberts, C.M.G. (part-time)
Sir Henry Somerset, C.B.E., M.Sc. (part-time)
K. L. Sutherland, Ph.D., D.Sc., F.A.A. (part-time)
Professor E. J. Underwood, C.B.E., Ph.D., D.Rur.Sc., D.Sc.(Agric.), F.A.A., F.R.S. (part-time)

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

Secretariat

Administrative Branch

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

ASSISTANT SECRETARY (WORKS AND BUILDINGS)
B. Beresford Smith, B.Sc., B.E.

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

ASSISTANT SECRETARY (STAFF)
J. Coombe

M. J. Beech
P. J. R. Chivers, B.Sc.
P. J. Crawford, B.Sc., Ph.D.
H. C. Crozier, B.A., Dip.Ed.
A. J. Culnane
E. C. French
N. H. Grafen
J. W. Hallam, A.M.T.C.
I. L. Harvey, B.Sc., B.A.
J. F. Mitchell
R. W. Murnain, B.Sc.
L. C. R. Thompson, B.Sc.
J. R. Warwick, B.A.
I. D. Whiting, B.A.
D. V. Young, B.A.

CHIEF LIBRARIAN
Miss B. C. L. Doubleday, M.A., F.L.A.A.

P. Aukland, B.A.
Miss J. A. Conochie, B.Sc., F.L.A.A.
A. Dalby, M.A., B.Sc.(Econ.)
P. H. Dawe, B.A., A.L.A.A.
Miss M. J. Dunstone, B.Sc., Dip.Ed.
Miss M. J. Elliott, A.L.A.A.
W. F. Evans, B.Sc.
J. H. Gilmore, B.Sc.
G. Hitoun, B.A.
G. L. Jackson, B.Sc., Ph.D.
Miss L. C. Lawrence (*at Canberra*)
G. Losonci (*at Sydney*)
Miss M. E. McMullen, B.A., A.L.A.A.
M. Prazak (*at Brisbane*)
J. Rhemrev (*at Sydney*)
Miss J. Sharpe, B.Sc.
J. D. Shortridge, B.A. (*at Adelaide*)
Miss M. M. Sly, B.Sc., B.L.S.
Miss F. B. South, B.A., A.L.A.A.

FINANCE MANAGER
R. W. Viney, M.B.E., F.A.S.A., A.C.I.S.

J. W. Barrie
I. C. Bogg, B.Ec.
D. J. Bryant, A.A.S.A.
P. J. Byrne
I. F. Carrucan, A.A.S.A.
M. F. Combe
H. Kwong
F. G. Martich
R. L. McVilly, F.A.S.A., A.C.I.S.
E. Osfield
J. B. Sleigh

ASSISTANT SECRETARY (COMMUNICATION SERVICES)
G. R. Williams, B.Ec.

H. P. Black
P. Bruce, A.R.P.S.
S. T. Evans, B.Sc.
C. D. Kimpton, B.Agr.Sc.
D. J. Sandry, B.Sc., A.S.T.C.

ADMINISTRATIVE SERVICES
G. D. McLennan, B.Com.

J. Graham
E. S. Johnson
P. S. Knuckey
F. S. Lowson, A.C.W.A.
P. V. Mogg
J. M. Short, A.A.S.A., A.C.I.S.

LIAISON OVERSEAS
London
CHIEF SCIENTIFIC LIAISON OFFICER
E. G. Hallsworth, Ph.D., D.Sc.
LIAISON OFFICERS
R. D. Croll, B.Agr.Sc.
D. B. Thomas, B.A.
Tokyo
COUNSELLOR (SCIENTIFIC)
E. E. Adderley, B.Sc.
Washington
COUNSELLOR (SCIENTIFIC)
Professor H. C. Webster, C.M.G., Ph.D., D.Sc.
SCIENTIFIC ATTACHE
C. Garrow, B.Com., D.P.A., M.Agr.Sc., A.A.S.A.

Agricultural and Biological Sciences Branch

SECRETARY (AGRICULTURAL AND BIOLOGICAL SCIENCES)
A. F. Gurnett-Smith, B.Agr.Sc.

ASSISTANT SECRETARIES
K. L. Avent, B.Agr.Sc.
P. F. Butler, M.Ag.Sc.
B. F. McKeon, B.Agr.Sc.
J. F. Burdett, M.Ag.Sc.
A. W. Charles, B.Sc.Agr., M.Sc.
A. C. Doery, B.Agr.Sc.
M. R. E. Durand, M.B.E., B.Vet.Med., M.R.C.V.S.
N. B. Lee, M.A.
R. W. R. Miller, B.A., Dip.Agr.Sc.
P. S. Muecke, B.Sc., Ph.D.
G. T. Sibley, B.Agr.Sc.
D. V. Walters, M.Agr.Sc. (*seconded to Queensland Department of Primary Industries*)
H. R. Webb, B.Agr.Sc., B.Com.

SECRETARY TO COMMONWEALTH AND STATES VETERINARY COMMITTEE
J. H. Whittem, B.V.Sc.

SECRETARY, WOOL RESEARCH PROGRAMME REVIEW COMMITTEE
D. B. Williams, B.Sc.Agr., B.Com., Ph.D.

Industrial and Physical Sciences Branch

SECRETARY (INDUSTRIAL AND PHYSICAL SCIENCES)
J. P. Shelton, M.Sc., A.B.S.M.

ASSISTANT SECRETARIES

J. B. Allen, B.Sc., Ph.D.
P. A. Grant, F.R.M.I.T., F.I.P.A.
S. Lattimore, B.Sc., A.R.C.S., F.Inst.P.
R. L. Aujard, B.Sc.
D. Burgess, B.Sc.
A. D. Duncan, M.Sc.
T. J. Healy, B.Sc.
S. Y. Ip, B.Ec.
R. S. McCredie, B.Sc., Ph.D.

CONSULTANT TO THE EXECUTIVE (FUEL TECHNOLOGY)
H. R. Brown, B.Sc.(Eng.) (*at Sydney*)

Regional Administrative Offices

Regional Administrative Office, Brisbane
Hibernian Building, 246 Queen Street, Brisbane, Qld.
REGIONAL ADMINISTRATIVE OFFICER (ACTING)
K. J. Turner, B.Com.
PERSONNEL OFFICER
M. H. Lamont

Regional Administrative Office, Canberra
Limestone Avenue, Campbell, A.C.T.
REGIONAL ADMINISTRATIVE OFFICER
K. J. Prowse
ACCOUNTANT
V. J. Taylor, B.Com., A.A.S.A.
PERSONNEL OFFICER
P. A. O'Brien

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

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

Animal Research Laboratories

ANIMAL RESEARCH COMMITTEE
I. W. McDonald, B.V.Sc., B.Sc., Ph.D. (*Chairman*)
A. T. Dick, O.B.E., D.Sc., F.A.A.
A. E. Pierce, Ph.D., D.Sc., F.R.C.V.S., D.V.S.M.
J. M. Rendel, B.Sc., Ph.D., F.A.A.
D. F. Stewart, D.V.Sc., Dip.Bact.

Division of Animal Genetics

Headquarters: Delhi Road, North Ryde, N.S.W.
CHIEF
J. M. Rendel, B.Sc., Ph.D., F.A.A.
RESEARCH ASSISTANT TO CHIEF
A. Packham, B.V.Sc., A.A.S.A.
ADMINISTRATIVE OFFICER
R. W. Harriss, B.Ec.
LIBRARIAN
Miss E. Ahearn, A.L.A.A.
CHIEF RESEARCH SCIENTIST
S. N. Fazekas de St. Groth, M.D., Ch.B., Sc.M., F.A.A.
SENIOR PRINCIPAL RES. SCIENTISTS
G. W. Grigg, M.Sc., Ph.D.
H. J. Hoffman, M.Sc., Ph.D.
Miss J. Koch, M.D.
M. A. Naughton, B.Sc., Ph.D.
Miss H. Newton Turner, B.Arch., D.Sc.
A. Sibatani, D.Sc., D.Med.Sc.
PRINCIPAL RESEARCH SCIENTISTS
A. A. Dunlop, M.Agr.Sc., Ph.D.
B. D. H. Latter, B.Sc.Agr., Ph.D.
Miss M. E. McClain, B.A., Ph.D.
T. Nay
A. H. Reisner, A.B., Ph.D.
D. M. Robertson, B.Sc., Ph.D.
B. L. Sheldon, B.Sc.Agr., Ph.D.
W. R. Sobey, B.Sc., Ph.D.
SENIOR RESEARCH SCIENTISTS
F. E. Binet, M.D.
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D. A. Saunders, B.Sc.

At Alice Springs Research Station, Alice Springs, N.T.
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L. K. Corbett, B.Sc.

At Tobacco Research Institute, Mareeba, Qld.
EXPERIMENTAL OFFICER
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At Darwin Laboratories, McMillan Road, Darwin, N.T.
PRINCIPAL RESEARCH SCIENTIST
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B. C. Abbey

Wool Research Laboratories

WOOL RESEARCH LABORATORIES COMMITTEE
F. G. Lennox, D.Sc.(*Chairman*)
J. G. Downes, B.Sc.
M. Lipson, B.Sc., Ph.D.

Division of Protein Chemistry

Headquarters: 343 Royal Parade, Parkville, Vic.

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Division of Textile Industry

Headquarters: Princes Highway, Belmont, Geelong, Vic.

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J. D. Leeder, M.Sc.
V. A. Williams, B.Sc., Ph.D. *(seconded to Research Laboratory of Pacific Mills, U.S.A.)*

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Division of Textile Physics

Headquarters: 338 Blaxland Road, Ryde, N.S.W.

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K. D. Sinclair, A.S.T.C.

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J. P. Connell, B.Sc.
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R. A. Foulds, B.Sc., M.Phil.
V. Gardavsky, Dipl.Ing.
B. N. Hoschke, B.Sc., Ph.D.
P. Kelly, B.Sc., Dip.Ed.
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T. W. Mitchell, A.S.T.C.
A. McD. Richardson, B.E.E.
R. A. Rottenbury, B.Sc.
J. E. Sisson, B.A.
L. J. Smith, A.S.T.C.
A. E. Stearn, B.Sc.
G. L. Stott, B.A., A.S.T.C.

Unattached Officers

G. B. Gresford, B.Sc., A.R.M.T.C. *(seconded to United Nations as Director for Science and Technology, Department of Economic and Social Affairs)*
F. G. Nicholls, M.Sc. *(seconded to the International Union for Conservation of Nature and Natural Resources, Switzerland)*

PRINCIPAL RESEARCH SCIENTIST
Miss S. H. Allen, B.Sc. *(seconded to the Institute of Medical and Veterinary Science, Frome Road, Adelaide, S.A.)*

Finance

As indicated earlier in this report, a number of CSIRO Divisions have been restructured during the year. However, for accounting purposes it has been necessary to record income and expenditure for the whole of the financial year under the original headings shown in the 1970/71 estimates. In other words, income and expenditure are shown as they would have been if none of the organizational changes had occurred. These changes will become effective, for accounting purposes, as from July 1, 1971.

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, including major items of equipment** ($)	**Total** ($)
Treasury appropriation, including revenue	44,061,386	1,535,725	1,619,276	47,216,387
Wool Research Trust Fund	7,388,031	—	1,342,069	8,730,100
Meat Research Trust Account	1,256,121	—	100,720	1,356,841
Wheat Research Trust Account	211,705	—	11,000	222,705
Dairy Produce Research Trust Account	313,372	—	—	313,372
Tobacco Industry Trust Account	222,848	—	9,166	232,014
Other contributors	1,951,548	—	187,523	2,139,071
Total	55,405,011	1,535,725	3,269,754	60,210,490

Annual Expenditure

The following summary gives details of expenditure by CSIRO Divisions and Sections on other than capital items from July 1, 1970 to June 30, 1971.

DIVISION OR SECTION	Treasury Funds ($)	Contributory Funds ($)	Total ($)
Head Office			
The main items of expenditure under this heading are salaries and travelling expenses of the administrative staff at Head Office and the Regional Administrative Offices, salaries and expenses of officers at the Liaison Offices in London and Washington, and general office expenditure.	3,511,322	27,077	3,538,399
Research Programmes			
Animal Health and Reproduction			
Animal Genetics	1,146,331	515,720	1,662,051
Animal Health	1,772,334	549,645	2,321,979
Animal Physiology	392,385	1,841,551	2,233,936
Nutritional Biochemistry	504,146	244,719	748,865
Plant Industry	3,078,596	1,423,855	4,502,451
Entomology and Wildlife			
Entomology	2,127,334	575,103	2,702,437
Wildlife Research	702,161	323,851	1,026,012
Soils	1,864,099	153,336	2,017,435
Horticulture and Irrigation			
Horticultural Research	578,194	26,194	604,388
Irrigation Research	594,999	25,286	620,285
Tropical Pastures	1,639,497	325,129	1,964,626
Land Research			
Land Research	1,372,649	317,189	1,689,838
Rangelands Research	268,149	245	268,394
Processing of Agricultural Products			
Food Preservation	1,743,080	443,784	2,186,864
Dairy Research	435,921	207,726	643,647
Wheat Research	21,239	75,507	96,746
Textile Industry	94,956	1,287,455	1,382,411
Textile Physics	—	1,035,200	1,035,200
Information and Publications			
Central Library	324,590	—	324,590
Editorial and Publications Section	679,421	—	679,421
Film Unit	86,787	—	86,787

Chemical Research of Industrial Interest			
Administration of Chemical Research Laboratories	183,588	—	183,588
Chemical Engineering	846,882	26,960	873,842
Applied Chemistry	1,433,810	57,641	1,491,451
Chemical Physics	1,115,493	13,762	1,129,255
Protein Chemistry	98,924	1,103,220	1,202,144
Fisheries and Oceanography	1,241,093	83	1,241,176
Processing and Use of Mineral Products			
Mineral Chemistry	2,301,196	143,732	2,444,928
Applied Mineralogy	775,761	57,581	833,342
Physical Metallurgy	56,042	—	56,042
Baas Becking Geobiological Group	8,000	74,998	82,998
Physical Research of Industrial Interest			
Physics	1,073,690	10,748	1,084,438
Applied Physics	1,932,084	—	1,932,084
General Physical Research			
Radiophysics	2,186,365	4,979	2,191,344
Meteorological Physics	786,299	—	786,299
Upper Atmosphere	113,185	—	113,185
Radio Research Board	40,000	65,498	105,498
Commonwealth Meteorology Research Centre	91,847	—	91,847
General Industrial Research			
Building Research	1,070,479	62,195	1,132,674
Tribophysics	513,828	—	513,828
Applied Geomechanics	535,514	56,886	592,400
Mechanical Engineering	725,176	63,599	788,775
Processing of Forest Products			
Forest Products	1,681,098	146,875	1,827,973
Research Services			
Computing Research	601,628	—	601,628
Mathematical Statistics	665,923	658	666,581
Western Australian Laboratories	276,419	—	276,419
Extramural investigations	90,858	—	90,858
Australian Mineral Development Laboratories	59,992	—	59,992
Developmental projects	150,475	—	150,475
Miscellaneous Grants	467,547	55,638	523,185
Research Associations	329,859	—	329,859
Research studentships	348,974	—	348,974
Other grants and contributions	856,892	—	856,892
Total expenditure	45,597,111	11,343,625	56,940,736

Capital Expenditure under CSIRO Control

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

DIVISION OR SECTION	Treasury Funds ($)	Contributory Funds ($)	Total ($)
Head Office	12,692	—	12,692
Animal Health and Reproduction			
Animal Genetics	94,192	44,130	138,322
Animal Health	105,826	75,000	180,826
Animal Physiology	1,851	112,505	114,356
Nutritional Biochemistry	14,999	7,789	22,788
Plant Industry	122,131	524,723	646,854
Entomology and Wildlife			
Entomology	4,395	360	4,755
Wildlife Research	9,191	110,769	119,960
Soils	46,292	—	46,292
Horticulture and Irrigation			
Horticultural Research	34,472	—	34,472
Irrigation Research	25,038	—	25,038
Tropical Pastures	96,870	6,131	103,001
Land Research			
Land Research	14,828	—	14,828
Rangelands Research	2,000	—	2,000
Processing of Agricultural Products			
Food Preservation	104,889	310	105,199
Dairy Research	7,009	14,195	21,204
Wheat Research		10,500	10,500
Textile Industry	29,175	161,961	191,136
Textile Physics		127,871	127,871
Chemical Research of Industrial Interest			
Chemical Engineering	29,520	—	29,520
Applied Chemistry	16,640	—	16,640
Chemical Physics	112,365	—	112,365
Protein Chemistry	—	407,491	407,491
Fisheries and Oceanography	41,054	—	41,054
Processing and Use of Mineral Products			
Mineral Chemistry	58,816	40,965	99,781
Applied Mineralogy	—	5,000	5,000
Physical Research of Industrial Interest			
Physics	5,047	—	5,047
Applied Physics	77,267	—	77,267
General Physical Research			
Radiophysics	85,520	—	85,520
Meteorological Physics	10,479	—	10,479
General Industrial Research			
Building Research	12,929	—	12,929
Tribophysics	61,721	—	61,721
Mechanical Engineering	29,614	778	30,392
Processing of Forest Products			
Forest Products	32,959	—	32,959
Research Services			
Computing Research	288,668	—	288,668
Mathematical Statistics	14,160	—	14,160
Western Australian Laboratories	4,687	—	4,687
Miscellaneous	11,980	—	11,980
Total capital expenditure	1,619,276	1,650,478	3,269,754

Contributions

This table summarizes receipts and expenditure during 1970/71 of funds provided by contributors and recorded in a special account entitled 'Specific Research Account'. The largest amounts contributed for specific research projects are provided from joint Commonwealth–Industry Research Funds such as the Wool Research Trust Fund and the Meat Research Trust Account. However, sums which are quite substantial in total are contributed by industrial organizations and other bodies, including several United States Government agencies.

DIVISION OR SECTION	Receipts 1970/71 and balances brought forward ($)	Expenditure 1970/71 ($)
Animal Genetics		
Wool Research Trust Fund	386,009	398,870*
Meat Research Trust Account	101,660	103,248*
Other contributors	64,255	57,732
Animal Health		
Wool Research Trust Fund	305,403	311,164*
Meat Research Trust Account	286,060	283,248
Dairy Produce Research Trust Account	19,502	19,011
Other contributors	25,425	11,222
Animal Physiology		
Wool Research Trust Fund	1,761,704	1,825,430*
Meat Research Trust Account	89,256	77,409
Other contributors	63,641	51,217
Nutritional Biochemistry		
Wool Research Trust Fund	238,542	245,891*
Meat Research Trust Account	5,727	5,726
Other contributors	—	891*
Plant Industry		
Wool Research Trust Fund	1,540,505	1,544,751*
Wheat Research Trust Account	22,260	19,582
Dairy Produce Research Trust Account	20,924	19,955
Tobacco Industry Trust Account	243,802	232,014
Other contributors	179,628	132,276
Entomology		
Wool Research Trust Fund	73,174	53,799
Meat Research Trust Account	199,053	192,063
Wheat Research Trust Account	35,000	29,810
Other contributors	342,357	299,791
Wildlife Research		
Wool Research Trust Fund	223,554	227,589*
Meat Research Trust Account	112,803	105,203
Other contributors	106,127	101,828
Soils		
Wheat Research Trust Account	46,639	40,853
Other contributors	155,908	112,483
Horticultural Research		
Other contributors	36,311	26,194
Irrigation Research		
Other contributors	66,552	25,286
Tropical Pastures		
Meat Research Trust Account	167,155	168,512*
Dairy Produce Research Trust Account	78,853	77,467
Other contributors	154,526	85,281
Land Research		
Meat Research Trust Account	37,105	34,476
Other contributors	348,034	282,713
Rangelands Research		
Other contributors	608	245
Food Preservation		
Meat Research Trust Account	431,086	377,220

* Expenditure in excess of receipts will be recovered in 1971/72.

DIVISION OR SECTION	Receipts 1970/71 and balances brought forward ($)	Expenditure 1970/71 ($)
Wheat Research Trust Account	870	870
Other contributors	107,633	66,004
Dairy Research		
Dairy Produce Research Trust Account	213,488	196,939
Other contributors	26,127	24,982
Wheat Research Unit		
Wheat Research Trust Account	86,734	86,007
Textile Industry		
Wool Research Trust Fund	1,473,391	1,423,890
Other contributors	37,271	25,526
Textile Physics		
Wool Research Trust Fund	1,198,064	1,129,098
Other contributors	363,301	33,973
Film Unit		
Other contributors	302	—
Chemical Engineering		
Meat Research Trust Account	10,187	9,736
Other contributors	59,317	17,224
Applied Chemistry		
Wool Research Trust Fund	29,824	30,565*
Other contributors	75,619	27,076
Chemical Physics		
Other contributors	34,766	13,762
Protein Chemistry		
Wool Research Trust Fund	1,536,516	1,471,001
Other contributors	25,773	39,710*
Fisheries and Oceanography		
Other contributors	83	83
Mineral Chemistry		
Other contributors	334,857	184,697
Applied Mineralogy		
Other contributors	92,165	62,531
Baas Becking Geobiological Group		
Other contributors	98,292	74,998
Physics		
Other contributors	19,357	10,748
Applied Physics		
Other contributors	8,256	—
Radiophysics		
Other contributors	139,545	4,979
Radio Research Board		
Other contributors	79,341	65,498
Building Research		
Other contributors	152,225	62,195
Tribophysics		
Other contributors	4,521	—
Applied Geomechanics		
Other contributors	94,800	56,886
Mechanical Engineering		
Wheat Research Trust Account	48,076	45,583
Other contributors	69,375	18,794
Forest Products		
Other contributors	210,043	146,875
Mathematical Statistics		
Other contributors	2,830	658
Head Office—agricultural liaison		
Wool Research Trust Fund	50,600	27,077

* Expenditure in excess of receipts will be recovered in 1971/72.

DIVISION OR SECTION	**Receipts 1970/71 and balances brought forward** ($)	**Expenditure 1970/71** ($)
Miscellaneous		
Wool Research Trust Fund	40,975	40,975
Other contributors	300,041	14,663
	4,993,713	12,994,103
Cash advance received to meet expenditure in July 1971 against 1971/72 allocation for research financed from joint Commonwealth–Industry Research Funds:		
Wool Research Trust Fund	500,000	
Meat Research Trust Fund	137,737	
Wheat Research Trust Account	13,118	
Dairy Research Trust Account	25,901	
Tobacco Industry Trust Account	21,745	
Total contributions	15,692,214	12,994,103

General Revenue

During 1970/71, general revenue amounting to $1,140,713 was received by the Organization. Details of the receipts are as follows:

Sale of publications	47,095
Sale of equipment purchased in former years, and other receipts	107,486
Sale of produce, including livestock	108,828
Royalties from patents	187,332*
Testing fees	83,929
Computing charges to outside users	586,744
Miscellaneous receipts	19,299
Total	1,140,713

Of the above sum $1,014,111 was spent during 1970/71 and a further $42,000 was spent from the balance remaining in the Special Account as at 1/7/70. This expenditure was approved by the Minister for Education and Science and the Treasurer as part of the general estimates.

* A further $15,353 was received as royalties on CSIRO patents and was paid to the Commonwealth Department of Primary Industry for credit to the Wool Research Trust Fund. The patent royalties included $10,200 for the self-twist spinning machine.

AUDITOR-GENERAL'S OFFICE
CANBERRA, A.C.T.

16 August, 1971

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

Dear Sir,

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

In compliance with section 30(2.) of the Science and Industry Research Act 1949–1968, the Organization has submitted financial statements for the year ended 30 June 1971 for my report thereon. These comprise—

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

A copy of the statements, which are in the form approved by the Treasurer, is attached.

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

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

Yours faithfully,

(Sgd.) V.J.W. SKERMER

(V.J.W. SKERMER)

AUDITOR-GENERAL FOR THE COMMONWEALTH

Summary of Receipts and Payments

	Funds held July 1, 1970 ($)	Receipts ($)	Total funds available ($)	Payments ($)	Funds held June 30, 1971 ($)
Special Account					
Parliamentary Appropriation: Operational	—	44,541,000.00	44,541,000.00	44,541,000.00	—
	(—)*	(38,660,000.00)	(38,660,000.00)	(38,660,000.00)	(—)
Parliamentary Appropriation: Capital	26,893.25	1,596,000.00	1,622,893.25	1,619,275.99	3,617.26
	(21,442.34)	(1,665,000.00)	(1,686,442.34)	(1,659,549.09)	(26,893.25)
Revenue and Other Receipts	155,781.05	1,140,713.25	1,296,494.30	1,056,111.50	240,382.80
	(20,127.20)	(1,013,128.75)	(1,033,255.95)	(877,474.90)	(155,781.05)
Total: Special Account	182,674.30	47,277,713.25	47,460,387.55	47,216,387.49	244,000.06
	(41,569.54)	(41,338,128.75)	(41,379,698.29)	(41,197,023.99)	(182,674.30)
Specific Research Account	3,231,738.44	12,460,475.98	15,692,214.42	12,994,102.69	2,698,111.73†
	(2,239,504.10)	(11,560,336.95)	(13,799,841.05)	(10,568,102.61)	(3,231,738.44)
Other Trust Moneys‡	32,653.38	207,674.69	240,328.07	228,227.16	12,100.91
	(52,392.45)	(302,396.92)	(354,789.37)	(322,135.99)	(32,653.38)
Cafeteria Account§	9,565.96	99,303.05	108,869.01	97,986.06	10,882.95
	(13,863.06)	(110,658.13)	(124,521.19)	(114,955.23)	(9,565.96)
Total	**3,456,632.08**	**60,045,166.97**	**63,501,799.05**	**60,536,703.40**	**2,965,095.65**
	(2,347,329.15)	**(53,311,520.75)**	**(55,658,849.90)**	**(52,202,217.82)**	**(3,456,632.08)**

* Figures in brackets refer to 1969/70 Financial year.
† Includes investments totalling $732,950.00.
‡ Moneys held temporarily on behalf of other organizations and individuals.
§ Operating receipts and expenses of CSIRO cafeterias at Melbourne and Sydney.

J. R. Price (*Chairman*) R. W. Viney (*Finance manager*)

Consolidated Statement of Payments

1969/70 $		1970/71 $
	Head Office (including Regional Administrative Offices)	
2,135,687	Salaries and allowances	2,442,558
216,925	Travelling and subsistence	258,235
188,579	Postage, telegrams, and telephone	216,981
494,480	Incidental and other expenditure	620,625
3,035,671		3,538,399
	Research Programmes	
	Agricultural research	
6,078,829	Animal health and reproduction	6,966,831
4,024,542	Plant industry	4,502,451
3,196,700	Entomology and wildlife	3,728,449
1,799,303	Soils	2,017,435
1,031,763	Horticulture and irrigation	1,224,673
1,749,220	Tropical pastures	1,964,626
1,722,513	Land research	1,958,232
4,609,831	Processing of agricultural products	5,344,868
1,018,110	Information and publications	1,090,798
4,142,718	Chemical research of industrial interest	4,880,280
1,003,180	Fisheries and oceanography	1,241,176
2,949,338	Processing and use of mineral products	3,417,310
2,742,857	Physical research of industrial interest	3,016,522
2,853,985	General physical research	3,288,173
2,569,170	General industrial research	3,027,677
1,572,928	Processing of forest products	1,827,973
1,492,686	Research services	1,845,953
453,407	Miscellaneous	523,185
45,011,080		51,866,612
	Grants	
314,173	Research associations	329,859
359,803	Research studentships	348,974
771,495	Other grants and contributions	856,892
1,445,471		1,535,725
	Capital Works and Services	
1,005,963	Buildings, works, plant, and developmental expenditure	1,945,941
371,245	Scientific computing equipment	456,000
769,819	Other equipment	745,515
67,179	Development of Queensland cattle station	48,299
58,699	Development of Ginninderra field station	73,999
2,272,905		3,269,754
	Other Trust Moneys	
217,309	Remittance of revenue from investigations financed from Industry Trust Accounts	109,326
104,827	Other miscellaneous remittances	118,901
322,136		228,227
	Cafeteria Account	
114,955	Operating expenses of CSIRO cafeterias at Melbourne and Sydney	97,986
52,202,218	**Total Payments**	**60,536,703**

J. R. Price (*Chairman*)

R. W. Viney (*Finance manager*)

Statement of Payments—Special Account*

1969/70 $		1970/71 $
	Head Office (including Regional Administrative Offices)	
2,115,162	Salaries and allowances	2,428,461
215,697	Travelling and subsistence	257,599
188,579	Postage, telegrams, and telephone	216,981
486,242	Incidental and other expenditure	608,281
3,005,680		3,511,322
	Research Programmes	
	Agricultural research	
3,321,370	Animal health and reproduction	3,815,196
2,748,998	Plant industry	3,078,596
2,397,691	Entomology and wildlife	2,829,495
1,615,585	Soils	1,864,099
989,792	Horticulture and irrigation	1,173,193
1,425,832	Tropical pastures	1,639,497
1,448,266	Land research	1,640,798
1,952,159	Processing of agricultural products	2,295,196
1,015,229	Information and publications	1,090,798
3,122,622	Chemical research of industrial interest	3,678,697
993,381	Fisheries and oceanography	1,241,093
2,709,192	Processing and use of mineral products	3,140,999
2,697,654	Physical research of industrial interest	3,005,774
2,793,622	General physical research	3,217,696
2,457,126	General industrial research	2,844,997
1,464,083	Processing of forest products	1,681,098
1,492,686	Research services	1,845,295
441,036	Miscellaneous	467,547
35,086,324		40,550,064
	Grants	
314,173	Research associations	329,859
359,803	Research studentships	348,974
771,495	Other grants and contributions	856,892
1,445,471		1,535,725
	Capital Works and Services	
507,242	Buildings, works, plant, and developmental expenditure	417,986
371,245	Scientific computing equipment	456,000
655,184	Other equipment	622,992
67,179	Development of Queensland cattle station	48,299
58,699	Development of Ginninderra field station	73,999
1,659,549		1,619,276
41,197,024	**Total Payments**	**47,216,387**

* Special Account refers to moneys paid to CSIRO out of the Consolidated Revenue Fund of the Commonwealth and other related moneys specifically covered by Section 26C of the Science and Industry Research Act 1949–1968.

J. R. Price (*Chairman*) R. W. Viney (*Finance manager*)

Statement of Payments—Specific Research Account

1969/70 $		1970/71 $
	Head Office (including Regional Administrative Offices)	
20,525	Salaries and allowances	14,097
1,228	Travelling and subsistence	636
—	Postage, telegrams, and telephone	—
8,238	Incidental and other expenditure	12,344
29,991		27,077
	Research Programmes	
	Agricultural research	
2,757,459	Animal health and reproduction	3,151,635
1,275,544	Plant industry	1,423,855
799,009	Entomology and wildlife	898,954
183,718	Soils	153,336
41,971	Horticulture and irrigation	51,480
323,388	Tropical pastures	325,129
274,247	Land research	317,434
2,657,672	Processing of agricultural products	3,049,672
2,881	Information and publications	—
1,020,096	Chemical research of industrial interest	1,201,583
9,799	Fisheries and oceanography	83
240,146	Processing and use of mineral products	276,311
45,203	Physical research of industrial interest	10,748
60,363	General physical research	70,477
112,044	General industrial research	182,680
108,845	Processing of forest products	146,875
—	Research services	658
12,371	Miscellaneous	55,638
9,924,756		11,316,548
	Capital Works and Services	
498,721	Buildings, works, plant, and developmental expenditure	1,527,955
114,635	Other equipment	122,523
613,356		1,650,478
10,568,103	**Total Payments**	**12,994,103**

J. R. Price (*Chairman*)

R. W. Viney (*Finance manager*)

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