CSIRO 1969/70

Commonwealth Scientific and Industrial Research Organization, Australia

CSIRO Twenty-second Annual Report 1969/70

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This Report of the work of the Commonwealth Scientific and Industrial Research Organization for the year ending June 30, 1970, 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

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

CSIRO is governed by an Executive of five full-time members and four part-time members. The Executive is responsible to the Minister for Education and Science for the policy and work of the Organization.

For carrying out research, CSIRO is divided into a number of Divisions and Sections. Each Division is under the control of a Chief (in the case of a Section, an Officer-in-Charge), who is responsible to the Executive. Each Chief is responsible for the activities of his Division, within the limits of the funds allocated and the general policy decisions made by the Executive.

The Executive is assisted in the development, administration, and implementation of its policies by a Secretariat comprising an Administration Branch, an Agricultural and Biological Sciences Branch, and an Industrial and Physical Sciences Branch. Each Branch is under the control of a Secretary.

Contents

Cover

Fabricating a pressure-reducing orifice from stabilized zirconia in a vacuum hot press. See story on page 57.

CSIRO and the Apollo missions

At the request of the United States National Aeronautics and Space Administration (NASA), CSIRO made available its 210-foot diameter radio telescope at Parkes, New South Wales, for reception of signals from the Apollo 11 spacecraft, particularly during the most critical phases of the mission when the lunar module, Eagle, was on the surface of the Moon. This assistance was sought because reception of good-quality television signals from a quarter of a million miles away called for the most powerful radio telescope available.

At 12.46 p.m. (Sydney time) on Monday, July 21, 1969, Commander Neil Armstrong set foot on the Moon's surface. Six minutes later the Moon came into full radio view of the Parkes radio telescope and for the next 4 hours and 55 minutes the historic television pictures of Man's great venture on the Moon, which were watched by some 600 million viewers in 49 countries of the world, came through Parkes.

Nine months later the 210-foot radio telescope played an important part in the emergency arrangements to help the Apollo 13 astronauts return to earth following an explosion in the service section of their spacecraft. Shortly after the explosion CSIRO received an urgent request from NASA for support from Parkes. Within 4½ hours the radio telescope had been converted to receive voice communications and telemetry transmissions from Apollo 13. The spacecraft was transmitting at the lowest possible signal level and this was one of the main reasons for enlisting the aid of the Parkes antenna. These signals were only a thousandth of the strength of those normally received from astronauts on the Moon. (Photograph courtesy *The Australian Women's Weekly*.)

Dr. J. R. Price

Dr. J. R. Price, D.Phil., D.Sc., F.A.A., was appointed Chairman of CSIRO in May 1970 following the retirement of Sir Frederick White. Dr. Price has been a Member of the Executive since 1966.

He graduated B.Sc. with honours from the University of Adelaide in 1933 and M.Sc. from the same university in 1935. He was then awarded an overseas scholarship by the Royal Commissioners for the Exhibition of 1851 and left for Britain where he worked at the University of Oxford under Professor Sir Robert Robertson. After graduating D.Phil. he became Head of the Chemistry Section at the John Innes Horticultural Institution in 1937. When war broke out he transferred to the Ministry of Supply and worked on propellants and explosives.

In 1945 he returned to Australia and joined the CSIR Division of Industrial Chemistry. He was appointed Officer-in-Charge of the Organic Chemistry Section in 1960 and in 1961 the Section became a Division with Dr. Price as its Chief.

Dr. Price was awarded the degree of Doctor of Science by the University of Adelaide in 1954, the H. G. Smith Memorial Medal of the Royal Australian Chemical Institute in 1956, and the Institute's Leighton Memorial Medal in 1969. He was elected a Fellow of the Australian Academy of Science in 1959.

Dr. Price is a member of the Academy's Science and Industry Forum and has served on a number of Academy committees. As Chairman of the National Committee for Chemistry from 1966 to 1969 he was Chairman of the Organizing Committee for the XXIInd Congress of the International Union of Pure and Applied Chemistry and the XIIth International Conference on Coordination Chemistry, which were held in Sydney in 1969.

Dr. Price has also been active in the affairs of the Royal Australian Chemical Institute. He was President of the Victorian Branch in 1959 and Federal President from 1962 to 1964.

Sir Frederick White

Sir Frederick White, K.B.E., D.Sc., Ph.D., F.A.A., F.R.S., retired from CSIRO on May 25 after nearly eleven years as its Chairman.

Sir Frederick was educated at Victoria University College, Wellington, New Zealand. He graduated B.Sc. in 1927 and M.Sc. (with first-class honours) in 1928. In 1929 he won a postgraduate scholarship which took him to St. John's College at Cambridge. He worked in the Cavendish Laboratory under Lord Rutherford, and was awarded his doctorate in 1932.

From Cambridge, Sir Frederick went to Kings College, London, where he served as a lecturer in physics in Sir Edward Appleton's department. During this period he carried out research on various aspects of radio propagation, and published a text-book on electromagnetic waves.

In 1937 he was appointed Professor of Physics at Canterbury University College in New Zealand. In New Zealand he took a leading part in the establishment of the Research Laboratory of the British Empire Cancer Campaign Society.

In 1941 Sir Frederick was given leave by his University to assist CSIR in the organization of its Radiophysics Laboratory in Sydney, and in 1942 he was appointed Chief of the Division of Radiophysics. In 1945 he resigned his professorship and joined the Head Office staff of CSIR as Assistant Executive Officer. He was appointed a member of the Executive Committee of the Council in 1946.

When the Council was reconstituted as CSIRO in 1949 Sir Frederick was made a Member of the Executive and in 1957 he became Deputy Chairman. He was appointed Chairman of CSIRO in 1959 following the death of Sir Ian Clunies Ross.

Sir Frederick has been the recipient of many high honours. He was elected a Fellow of the Australian Academy of Science in 1960 and of the Royal Society in 1966. In 1962 he was created a Knight Commander of the Order of the British Empire. During 1970 he received the honorary degree of Doctor of Science from the Australian National University and Monash University and was elected to the newly created position of Chairman of ANZAAS.

Just before his retirement the Advisory Council paid the following tribute to Sir Frederick: 'This Advisory Council records its deep appreciation of the excellent work of the Chairman, Sir Frederick White, both as scientist and as an administrator. It recognizes and records with pride that by his ability and his outstanding personal qualities of courage, patience, and humility, he not only has gained an international reputation supported by high awards but has been responsible in no small measure for the steady development of CSIRO and the high regard in which CSIRO is held by the Government, by industry, and by the public in general. It now wishes him a long, happy, and fruitful retirement.'

Introduction

The late 1960s have witnessed a sharply mounting concern in public, political, and scientific circles throughout the world over the degradation and deterioration of the environment in which we live. In Britain a Standing Royal Commission on Environmental Pollution has been set up 'To advise on matters, both national and international, concerning the pollution of the environment; on the adequacy of research in this field; and on the future possibilities of danger to the environment'. In the United States, President Nixon has established an Environmental Quality Council. More recently he has offered his nation 'a $10,000 million nation-wide clean-waters programme', and has called on the United States motor industry to develop a virtually pollution-free car by 1975.

In Australia, Senate Select Committees have presented reports on air and water pollution while at the 41st Congress of the Australian and New Zealand Association for the Advancement of Science in Adelaide in August 1969 the Governor General, Sir Paul Hasluck, attacked the 'filthy mess' of modern environment. 'When civilized man looks out from the padded cell of urban life', he said, 'what a destruction of the human environment he would see if only his eyes had not become too narrowly focused on his house, motor car, golf course, his cocktail bar and his television set. If man looked out he would see a countryside despoiled, wild life being exterminated, vegetation withered, air and sea polluted, rivers made foul, green fields turned into rubbish dumps for old model cars and the night and day made hideous with a blasphemous blaze of uncontrolled noise'.

None of the problems mentioned by Sir Paul is new. For years individuals have warned of the possible disappearance of one or other species of plant and animal, the dangers of uncontrolled use of pesticides, the growing pollution of the oceans by oil slicks, or the pollution of the atmosphere by industry and the internal combustion engine. It is only recently, however, that these problems have ceased to be viewed as separate issues and have become recognized as aspects of the overall quality of man's environment. Moreover, many of the issues have come to be seen not merely as local problems affecting a particular city or region but as global problems in which everyone has a stake.

It is possible to trace the growing concern for environmental quality in the last few years and to identify events such as the publication of Rachel Carson's 'Silent Spring' and the Torrey Canyon disaster which have focused public attention on environmental issues and given impetus to public concern. Yet it is perhaps the seemingly unrelated event of the recent Apollo flights which has, more than any other event, caused Man to reflect on the deterioration of his environment. As the British astronomer Fred Hoyle has commented, '. . . suddenly everybody has become seriously concerned to protect the natural environment. It seems more than a coincidence that this awareness should have happened at exactly the moment man took his first step into space'.

When man saw the first pictures of the Earth as it appeared from the Moon, his world suddenly became smaller. He was made to recognize more clearly than he had ever done before that his planet was not unlimited—that the Earth's ecosystem was bounded rather than infinite. He was a traveller in space and the world his spaceship. The Apollo flights also brought into question the relevance of science in the world today. The very feat of landing an astronaut on the Moon served to show how much more remained to be achieved here on Earth where man was fouling his nest at an ever-increasing rate. In this mood it was understandable that many people should come to regard science and technology with suspicion if not outright hostility.

Unfortunately it is all too easy in the present climate of opinion to see only the problems that have sprung, however indirectly, from scientific and technological advances and to overlook the very considerable benefits that these advances have brought. Some critics would like to try to call a halt to the assault on the environment by abandoning science and technology. Yet such a move would be to abandon the weapons with which environmental deterioration must be fought. In their readiness to find a scapegoat for the environmental problems that plague us many people forget that scientists have been among the first to warn of the dangers of pollution and the need for conservation. Science has never been more relevant than it is today. If we are to develop techniques for predicting or recognizing early the objectionable consequences of technological innovations so as to minimize their effects, we shall need more science, not less.

It would be wrong, however, if we were to allow our concern for the environment to lessen our sense of perspective and blind us to all else. If we are to meet the growing cost that protection of the environment will impose upon us, we must not slacken the scientific effort that is necessary for the development and welfare of our primary and secondary industries. In recent years the Government has provided increasing support for a number of projects in CSIRO specifically concerned with conservation and pollution—projects aimed at matters such as water purification, the development of new insecticides of low mammalian toxicity, and biological control of insect pests. The Government has also provided additional support for a number of less specific but none the less relevant areas of investigation such as meteorological physics and the movement of underground waters. At the same time the Executive has been conscious of the need to maintain, and in some cases expand, its research in those areas which are of no immediate relevance to the protection of the environment but which none the less are essential or of potential significance to the economy. The Executive believes that in maintaining such a balance, CSIRO can best serve both the immediate and the long-term interests of the Australian community.

J. R. Price

Chairman

General Review

New Minister

Mr. Nigel Bowen succeeded Mr. Malcolm Fraser as Minister for Education and Science in November 1969, following the appointment of Mr. Fraser as Minister for Defence.

Finance

In 1969/70 CSIRO spent \$51·8 million, an increase of \$5·2 million over the previous year's expenditure. This amount included grants totalling \$1.45 million which were made for studentships and to outside bodies such as the Commonwealth Agricultural Bureaux and the Standards Association of Australia. It also included \$2·3 million which CSIRO spent on capital works and services under its control and on items of research equipment costing more than \$10,000 each. In addition, the Department of Works and the Department of the Interior spent \$3·3 million on buildings and other works for CSIRO and on the acquisition of land.

About four-fifths of CSIRO's income for 1969/70 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 set up by primary producer groups representing the wool, meat, wheat, dairying, and tobacco industries. These funds are derived from a levy on produce matched by a Government contribution.

Details of where CSIRO's funds came from and how they were spent during 1969/70 are given in Chapter 4 of this Report.

New research programmes

Much of the additional money provided by the Government and by industry committees for expenditure on research during 1969/70 was committed to existing research programmes and to inescapable increases such as higher salaries and running costs, and new equipment and facilities.

Of the money that remained, two new projects approved by Cabinet in 1968/69 accounted for \$260,800. The two projects were the establishment of the COMMONWEALTH METEOROLOGY RESEARCH CENTRE (\$62,200) and an investigation by the DIVISION OF FISHERIES AND OCEANOGRAPHY of the biology and ecology of prawns in northern Australian waters (\$198,600).

Additional support for four projects which were started in 1968/69 accounted for a further \$38,000. These projects were:

ANIMAL HEALTH
Establishment of a microbiology unit at the Long Pocket Laboratories, Indooroopilly, Brisbane, to investigate infectious diseases of livestock in northern Australia.
HORTICULTURAL RESEARCH
Mechanical harvesting of grapes for dried fruit and wine.
TROPICAL PASTURES
Nodulation in tropical legumes.
APPLIED CHEMISTRY
Development of new insecticides of low mammalian toxicity.

After providing for the above commitments the Executive was able to allocate a further $250,000 to commence or expand research in the following areas which it regards as either important or promising:

APPLIED GEOMECHANICS
Expansion of field studies in soil and rock mechanics. $51,900.
ANIMAL PHYSIOLOGY
Expansion of research on factors affecting the reproductive efficiency of beef cattle in northern Australia. $38,100.
WILDLIFE RESEARCH
Initiation of research on the biology and ecology of native fauna in northern Australia. $33,300.
PLANT INDUSTRY and SOILS
Initiation of a programme of research on factors limiting agricultural production in the high-rainfall areas of south-west Western Australia. $28,200.
DEVELOPMENT POOL
Increase in availability of funds and staff positions from a Development Pool to assist Divisions with the further development of promising industrial processes and inventions. $21,400.
MECHANICAL ENGINEERING
Development of stripper–harvester for harvesting broadcast cotton. $21,000.
ENTOMOLOGY
Establishment of experiments at National Cattle Breeding Station, 'Belmont', near Rockhampton, to study seasonal fluctuations in cattle tick numbers in central Queensland and the factors responsible. $19,600.
MINERAL CHEMISTRY
Expansion of research on chemistry of sulphide ores. $15,800.
SOILS
Development of methods for predicting the fertilizer requirements of pastures. This is an extension of the Division's work on predicting the fertilizer requirements of wheat crops. $14,200.
FOOD PRESERVATION
Initiation of psycho–physiological studies to complement current research on the flavour of foods. $6,500.

Changing research programmes

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

As a result of terminating various projects during 1969/70, CSIRO has been able to redeploy a number of staff among new or expanded investigations of other problems.

Among the more important projects completed were:

COMPUTING RESEARCH
A computer programme that enables meteorological data to be processed and presented as a map showing the predicted weather situation several hours later has been successfully developed. The resources involved have been transferred to investigations concerned with speech recognition problems relating to digital computers.
BUILDING RESEARCH
Research on network analysis, a technique used for the scheduling of large complex buildings, has been reduced following industry's widespread acceptance of the technique. The

officers concerned are now studying productivity of building operations and design costs.

SOILS

Projects in Tasmania on soil surveys and the mineral status of soils have been successfully concluded, and the staff are now beginning a new project on the soils used for growing apples.

APPLIED PHYSICS

Research on the hydrogen maser has enabled a frequency standard to be successfully established. Staff have been transferred from the hydrogen maser project to study improvements to the standard of electromotive force.

BUILDING RESEARCH

Work that has led to methods of improving the durability and the performance of bituminous roofing membranes has been terminated. The resources have been directed to studies of the durability of plastic building materials.

Buildings

The cost of laboratories has risen sharply during the year as a result of the general increases in building costs. It is partly for this reason that the main item on the year's building programme, an extension to the Townsville laboratory of the DIVISION OF TROPICAL PASTURES, has had to be deferred for further consideration. It is hoped, however, that work on this extension will be commenced during 1970/71.

The biggest project completed during the year was the $1·4 million laboratories at Clayton, Melbourne, for the DIVISION OF CHEMICAL ENGINEERING. This is the second Division of the Chemical Research Laboratories to move to Clayton from Fishermen's Bend.

Other major projects completed during the year include:

TROPICAL PASTURES—Extension to Cunningham Laboratory, St. Lucia, Brisbane. $303,000.

DAIRY RESEARCH—Extension to laboratory, Highett, Melbourne. This laboratory was financed jointly by the Commonwealth and the dairy manufacturing industry. $300,000.

TEXTILE INDUSTRY—Extension to wet-process building, Geelong, Victoria. This building was financed from the Wool Research Trust Account. $132,000.

ANIMAL HEALTH—Small-animals breeding building, Long Pocket Laboratories, Indooroopilly, Brisbane. $130,000.

Construction of the following buildings began during the year:

PROTEIN CHEMISTRY—Extension to laboratory at Parkville, Melbourne. This project is being financed from the Wool Research Trust Account. $380,000.

FOOD PRESERVATION—Extension to laboratory at North Ryde, Sydney, and provision of further cool-room accommodation. $302,000.

WILDLIFE RESEARCH—Additional laboratory at Canberra. $225,000.

METEOROLOGICAL PHYSICS—Replacement of laboratory at Aspendale, Melbourne. $165,000.

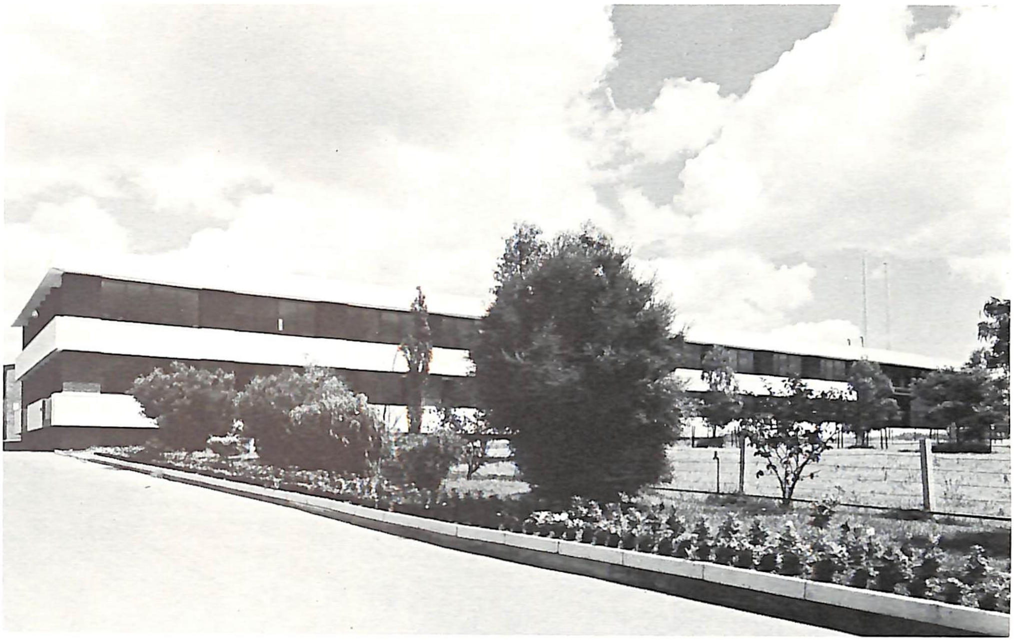
During the year contracts were let for the following projects:

WESTERN AUSTRALIAN LABORATORIES—Extension to the Laboratories at Floreat Park, Perth, to house the Western Australian group of the DIVISION OF APPLIED MINERALOGY. $500,000.

ANIMAL HEALTH—New building at Parkville, Melbourne, to provide office and laboratory accommodation and to house library. $470,000.

CANBERRA LABORATORIES LIBRARY—New library building at Black Mountain, Canberra, to serve Divisions located on the Black Mountain site. $440,000.

WILDLIFE RESEARCH—Laboratory at Darwin for studies of tropical wildlife. The building will cost $278,000, of which some $100,000 has been provided by the F. C. Pye Fund.



Extension to wet-process building, Division of Textile Industry, Geelong, Victoria.

The new laboratories for the Division of Chemical Engineering at Clayton, Melbourne.

Mineral physics

The Executive has decided to establish a mineral physics unit to supplement the already considerable programme of research now being undertaken in CSIRO on mineral chemistry and mineral processing.

Dr. K. G. McCracken, a former Professor of Physics at the University of Adelaide, has been appointed to lead the mineral physics research. Dr. McCracken will be located initially in the Division of Mineral Chemistry and, after examining current developments in the application of physics to the problems of the mineral industry, will advise the Executive on an appropriate programme of research for CSIRO in this field.

At the invitation of the Executive, Professor S. H. Ward, Professor of Geophysical Engineering at the University of California, visited a number of mining and exploration sites in Australia in June 1970 and prepared a report on the role CSIRO might play in conducting research on the development of geophysical methods suited to the Australian environment.

Ore Dressing Investigations

The Ore Dressing Investigations Section ceased operation as a separate unit in February 1970. Most of the former members of the Section have transferred to the Division of Chemical Engineering where they will work on various processes for separating ores. Two officers have transferred to the Division of Mineral Chemistry to work on the chemistry of sulphide ores.

Applied Geomechanics

The Division of Soil Mechanics has been redesignated the Division of Applied Geomechanics. The new name is considered more appropriate to the Division's interests which now embrace the physical properties of both soil and rock.

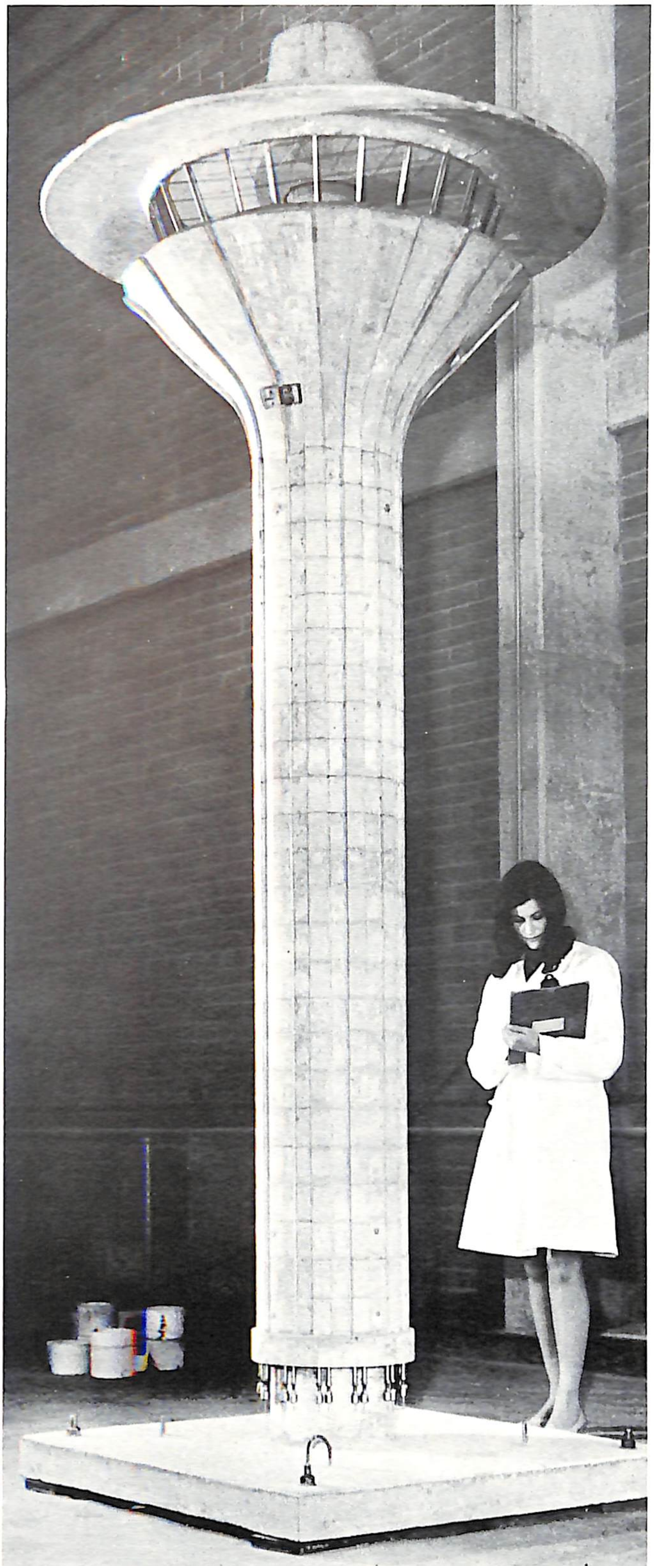
Grain storage

In January 1970, Federal Cabinet approved an agreement between CSIRO and the Australian Wheat Board to establish a laboratory for research on grain storage problems. The research will be financed by Treasury and the Australian Wheat Board. The need for increased research on grain storage has become urgent because of the high standards now demanded by importing countries with regard to levels of insect infestation and pesticide residues, the threat of the development of insect strains resistant to the chemicals currently used for grain protection, and the large increase in the amount of wheat at present in store and the expected future storage situation.

Under the agreement, the Board will meet the cost of construction of a Stored Grain Research Laboratory at Canberra, at an estimated cost of $280,000. The laboratory will be part of the Division of Entomology, and by 1975 will employ 10 research scientists and supporting staff. Estimated running costs are about $380,000 a year and will be shared equally between the Board and CSIRO.

The Laboratory's research programme will be concerned with improving the chemical methods of control currently in use and with investigating the nature and development of insect resistance to insecticides, non-chemical methods of control, and the biology and physiology of insect pests of stored grain.

A Stored Grains Research Liaison Committee will be appointed to advise the Executive on grain storage problems and on the research programme of the Laboratory. The Committee will include representatives of the Australian Wheat Board, State bulk-grain handling authorities, CSIRO, and the Commonwealth Department of Primary Industry.



Experimenting with scale models can be a useful and convenient method of finding out how a structure will behave under the different conditions it is likely to encounter during its life. This model, built to a scale of 1 in 10 in micro-concrete, was used by the DIVISION OF BUILDING RESEARCH to test the behaviour of a 120-feet-high shipping control tower during cyclonic gales. Wind tunnel tests were also carried out on a one-hundredth scale model built of plastic. The test results showed that a 150 m.p.h. gale would cause a deflection of only about one inch at the top of the tower—not enough to interfere with the satisfactory operation of equipment in the air-conditioned control room. The control tower has since been built at Port Hedland, Western Australia, by the State Public Works Department.

Research

In a report of this size it is not possible to give a full account of all of CSIRO's current research. This chapter includes only one or two items of interest from each Division. Anyone wanting more comprehensive information on the work of the Organization should consult the separate annual reports of the individual Divisions.

In selecting the items for this chapter, 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.

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

Division of Soils

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

Finance: $1,799,303 (Treasury $1,615,585, contributory $183,718)

Staff: Research scientists 72, other professional staff 25, supporting staff 100

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.

Finance: $1,722,513 (Treasury $1,448,266, contributory $274,247)

Staff: Research scientists 36, other professional staff 32, supporting staff 117

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
Finance: Treasury $648,976
Staff: Research scientists 19, other professional staff 14, supporting staff 47

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

Commonwealth Meteorology Research Centre

The Commonwealth Meteorology Research Centre is financed and managed jointly by the Division of Meteorological Physics 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
Finance: Treasury $62,197 (CSIRO contribution only)
Staff: Research scientists 10, supporting staff 3 (14 other professional staff and a further 5 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.

New Guinea's fertile plains

It has been widely assumed that chemical weathering is so severe in the humid tropics that the soil beneath tropical rain forests consists of a thick mantle of mature soil, from which most of the nutrients have been leached, overlying a layer of deeply and thoroughly weathered rock. It was thought that sediments derived from such areas would comprise quartz sand and silt, and clay rich in iron and aluminium oxides. Fresh gravel, stones, and rocks deposited by streams were thought to be derived by erosion of the stream bed.

Work carried out by the DIVISION OF

LAND RESEARCH during various land resource surveys in the humid tropics of New Guinea has shown that the situation, in that country at least, is quite different. In New Guinea the soils beneath the rain forests on the steep hill and mountain slopes are shallow and immature. Fresh cobbles and gravel deposited by streams are derived from hillside slumps and landslides rather than from the stream bed itself. Derived sediments deposited on fans and on alluvial and coastal plains are rich in fragments of decomposing rock and mineral grains.

An examination of sedimentary deposits from the Safia–Pongani area of north-east Papua revealed that the fine sand fractions contained only about 4% of quartz. About half of the remainder comprised rock fragments in various stages of weathering, while the other half comprised decomposing minerals. Sedimentary fractions coarser than fine sand consisted almost entirely of rock fragments except for a few samples where concretions of limestone or ironstone or both were common. Undecomposed mineral grains were most common in the fine sand and coarse silt, and clay minerals dominated the fine silt and clay fractions.

The sedimentary deposits were so young that the soils on them showed only slight leaching and weathering. These soils are rich in plant nutrients and on the well-drained non-stony portions of the plains have a high agricultural capability. New Guinea has significant areas of these soils in its coastal and alluvial plains which have not yet been developed for agriculture.

A land resources survey team from the DIVISION OF LAND RESEARCH crossing a swamp in New Guinea. The Division has now surveyed the natural resources of some 80,000 square miles of the Territory of Papua and New Guinea.

Termites in the soil

Termites are found in great numbers in many Australian soils. Since 1965 the DIVISION OF SOILS has been studying their role in soil formation and in the plant–soil nutrient cycle.

Of 12 common species investigated, 11 excavate subsoil and use it to build mounds and other above-ground structures. They select fine materials (clay and silt) in preference to coarse (sand), and their activities result in partial overturning of soil profiles. Measurements have shown that termite mounds may contain up to 25 tons of soil per acre (62,500 kilogrammes per hectare), representing a layer about ¼ inch (6 mm) thick over the entire surface. Mounds and other structures are eventually eroded away and the soil they contain is deposited on the ground surface. Some Australian termite mounds probably last for 50 to 100 years, though many are built and eroded away in shorter periods, of the order of 10 years.

Plants do not grow on termite mounds, so that the nutrients in the mounds are withheld from the plant–soil system. These nutrients may comprise a substantial proportion of the total nutrients in an area. In tropical savannah land near Darwin, where very large mounds of *Nasutitermes triodiae* are common, the Division has estimated that although the mounds contain 2% of the topsoil, they contain about 5% of its nitrogen and phosphorus, 9% of its available calcium, 22% of its available magnesium, and 13% of its available potassium.

Termites forage over a wide area from their mounds or nests, bringing back grass, wood, dung, and other organic material to feed the termite colony which, in large mounds, may consist of up to several million individuals. In an area of dry sclerophyll eucalypt forest which the Division has been studying near Adelaide there are at least nine species of termites. Six of them feed mainly on dead wood and three on grass or plant litter. One species, *Nasutitermes exitiosus*, eats about 17% of the total amount of dead wood that falls to the ground. This removal of organic matter, which would otherwise have decomposed where it fell and been returned to the soil, interferes with the cycling of plant nutrients from soil to plant and back again. After the termites have digested the organic matter the excreted material is incorporated in the termite mounds and it may be many years before it finds its way back into the soil.

Most soil animals feed on plant litter that is already partially decomposed by microbes or fungi, or feed on the microbes or fungi themselves. Some termites have similar food preferences, but many eat living or freshly fallen plant tissue. Estimates show that the weight of termites in forest and grassland is of the same order as the weight of grazing animals, so that in many of these areas termites can be regarded as competitors with livestock for food.

Soil microbes and plant growth

The interactions between plants, soil, and microorganisms living in the soil are complex and can have a profound effect on plant growth. Attempts to modify these interactions and stimulate plant growth by introducing beneficial microorganisms have proved difficult. Nevertheless, in field trials the DIVISION OF SOILS has obtained increases in yield of up to 20% with wheat and 13% with barley by inoculating the seed before sowing with selected strains of *Azotobacter* and other bacteria. Inoculation has also increased yields of maize, tomatoes, and subterranean clover in glasshouse trials.

In the wheat investigations the effect on yield varied according to seasonal conditions. Increases in yield were obtained in one year in three although in some years there were small decreases. The Division found that the bacteria develop on the roots of the wheat seedlings and produce various substances that stimulate plant growth. As a result flowering and grain formation may occur up to a week earlier. The bacteria may benefit the plant in other ways too. There is evidence to suggest that they may be antagonistic towards root-damaging fungi and that they increase the uptake by plant roots of phosphate and perhaps other mineral nutrients as well. In some soils the bacteria may also destroy naturally occurring compounds that are toxic to plants.

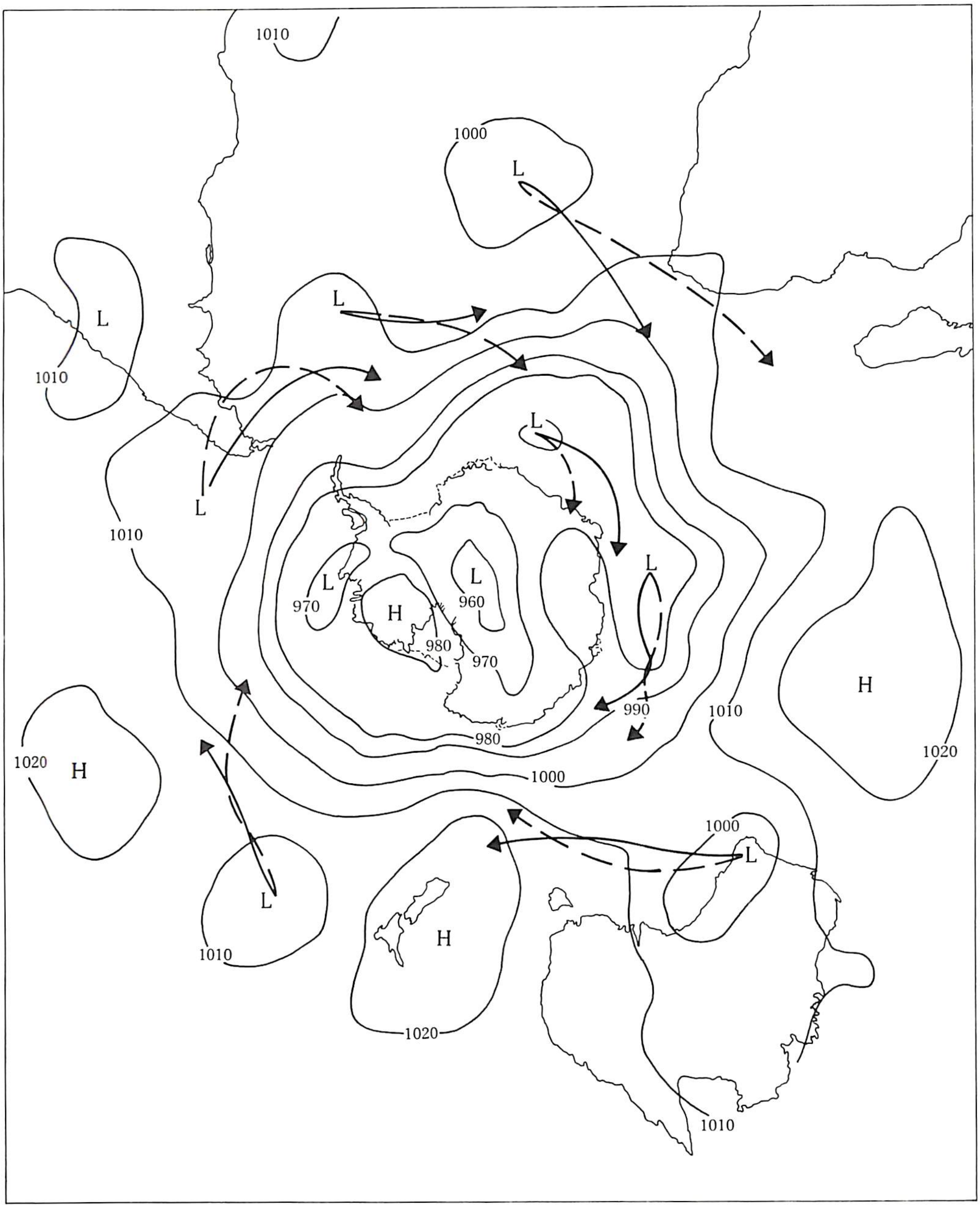
Not all soil microorganisms are beneficial. Some of them are able to depress yields. In glasshouse experiments with wheat grown on a range of soils sterilized by gamma-rays the Division has obtained increases in grain yields of up to 300%. It has also been able to increase the growth of pine seedlings in the field by 74% by fumigating the soil before sowing the seed. This effect is due partly to the destruction of harmful microbes in the soil and partly to the decomposition of dead microbes releasing nutrients that the plants can use. If no further steps are taken to maintain soil sterility a new microbial population will develop which is different in composition from the original population and is often beneficial rather than antagonistic to the growth of plants.

Soil sterilization is expensive and at present would be economic only for some glasshouse and horticultural crops. But if cheap chemical sterilants are developed in the future, the technique could prove worth while in forestry and agriculture.

Predicting weather by mathematical models

Present attempts to extend weather forecasting much beyond 24 hours encounter great difficulties and uncertainties. At the Commonwealth Meteorology Research Centre, managed jointly by the DIVISION OF METEOROLOGICAL PHYSICS and the Commonwealth Bureau of Meteorology, experiments are being made with sophisticated mathematical models which serve to analyse global weather processes on a computer and have a forecasting capability over the whole of the Southern Hemisphere. Basically, the models consist of a series of mathematical equations representing actual physical processes that take place in the atmosphere including, for example, radiation exchange, surface heating, and transfer of water vapour. These equations form the framework and into this is fed meteorological information such as pressure, temperature, wind speed, and upper air data for a large number of stations over the Southern Hemisphere. Initial forecasts from the model have shown good correlation with the weather situation over the whole hemisphere as far ahead as four days.

Experimental checks of performance of the models are being carried out in collaboration with the World Meteorological Centre. They represent one of the most complete computerized weather model integrations yet to be carried out in this hemisphere.



The first of a series of experimental 4-day forecasts for the Southern Hemisphere using a 'primitive equation' model prepared at the Commonwealth Meteorology Research Centre. Surface isobars on November 4, 1969, are shown together with the predicted (full lines) and observed (hatched lines) movement of the main low pressure centres over the following 4 days.

Division of Plant Industry

Location: Canberra, with laboratories in Brisbane, Deniliquin, N.S.W., Hobart, and Perth, and field stations and experimental farms at Canberra, Deniliquin, N.S.W., Baker's Hill, Kelmscott, and Pinjar, W.A., and the Tobacco Research Institute at Mareeba, Qld.
Finance: \$4,024,542 (Treasury \$2,748,998, contributory \$1,275,544)
Staff: Research scientists 115, other professional staff 67, supporting staff 317

Fields of research:
Research in the plant sciences and related fields of study on problems fundamental to agricultural production in Australia
- Pasture improvement and utilization—plant introduction, breeding, selection, establishment, evaluation, and management in grazing and ley systems
- Nutrition of plants—nutritional requirements, soil fertility, fertilizers, physiology of nutrient uptake, nitrogen fixation
- Plant–environment interactions—ecology and management of native vegetation; weed control; biophysics—interactions with physical environment, particularly energy and water
- Biochemical and physiological processes in plants
- Plant diseases—host–pathogen interactions
- Tobacco agronomy and breeding
- Plant taxonomy

Division of Horticultural Research

Location: Glen Osmond, Adelaide, with a branch laboratory and field station at Merbein, Vic.
Finance: \$503,555 (Treasury \$481,561, contributory \$21,994)
Staff: Research scientists 17, other professional staff 3, supporting staff 48

Fields of research:
Grape vines
- Genetic improvement—plant introduction, hybridization, clonal selection
- Virus diseases—assessment of importance, control
- Crop management and production—control of fruit set, forecasting yields, mechanical harvesting, drying, processing, physiology, and biochemistry

Fruit trees
- Physiology—photosynthesis, growth, introduction and improvement of new varieties
- Orchard ecology—spacing and shape of trees, light penetration

Parasitic nematodes (eel-worms)
- Physiology—locomotion, infection, reproduction
- Host–parasite–environment interactions
- Relationships between nematodes and viruses in plants
- Methods of control

Division of Irrigation Research

Location: Griffith, N.S.W.
Finance: $528,208 (Treasury $508,231, contributory $19,977)
Staff: Research scientists 13, other professional staff 10, 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
Climatology, hydrology of irrigated basins
Pollution—effects of residual herbicides

Division of Tropical Pastures

Location: St. Lucia, Brisbane, with laboratories at Townsville and Lawes, Qld., and field stations at Mundubbera, Samford, and Townsville, Qld.
Finance: $1,749,220 (Treasury $1,425,832, contributory $323,388)
Staff: Research scientists 42, other professional staff 17, supporting staff 164

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
Animal nutrition and pasture evaluation
Ecology and control of re-growth of woody species
Numerical taxonomy

New cultivars of Townsville stylo

After its accidental introduction in the early 1900s, the legume Townsville stylo (formerly known as Townsville lucerne) became established in many small areas in a large region of northern Australia reaching from Darwin to Townsville. It also became naturalized in some places as far south as the Lockyer valley in south-east Queensland. Gradually its value as a pasture legume became more widely appreciated and in the last twenty years it has been studied intensively. One important result of this work has been the recognition of distinct types of Townsville stylo within the naturalized Australian populations.

While some types are quite similar in appearance, research carried out at several locations by the DIVISION OF TROPICAL PASTURES has revealed variation in characters that strongly influence the persistence and productivity of the species. This work, some of which was carried out in collaboration with the

Queensland Department of Primary Industries, showed that:

- late-flowering types occur in higher-rainfall zones, while earlier flowering predominates in drier areas;
- the inheritance of flowering time and growth habit is genetically simple;
- late-flowering types grow best in areas with a long growing season, while early-flowering types are favoured where the growing season is short;
- day length is a major factor controlling flowering;
- taller-growing types are better for sowing in mixtures with grasses than more prostrate varieties.

This work has led to the selection of three erect cultivars with different flowering times: Gordon, Lawson, and Paterson. These cultivars have been released to provide the grazing industry with types suited to different regions in northern Australia.

New introductions of Townsville stylo obtained from Central and South America by plant collectors from CSIRO and State Departments of Agriculture are now being examined for variation by the Division. These introductions have a much wider range of variation than the naturalized Australian populations and show large differences in important characters such as herbage and seed production and digestibility. Several of the introductions have been crossed with Australian types in a breeding programme aimed at further improving this valuable legume.

Lucerne for the upper Shoalhaven

The upper catchment of the Shoalhaven River on the eastern edge of the Southern Tablelands of New South Wales has an average annual rainfall of about 30 inches (760 mm). However, the rainfall is irregular, sometimes intense, and pasture growth can be restricted at any time of the year by shortage of moisture. The soils are generally low in nutrients. Their upper layers are coarse-textured and have a poor water-holding capacity, but the subsoils are often permeable for several feet and contain substantial amounts of water. Because of the irregularity of the rainfall and the nature of the soils it has been difficult to find a suitable legume for the area. Given adequate nutrition, white clover and red clover can grow well, but they die out during periods of drought. Red clover is more drought-resistant than white clover, but is short-lived.

In an attempt to find a more suitable legume, the DIVISION OF PLANT INDUSTRY has been carrying out trials in the district with lucerne. At first the results were not encouraging. The lucerne plants were yellow and stunted by comparison with red and white clovers even though the soil in which they were sown had been given a dressing of superphosphate, potassium, lime, and trace elements including boron. However, application of an additional 15 pounds of borax per acre (17 kg per hectare) produced a marked response by the lucerne. The plants became healthy and vigorous. Moreover, they were able to continue growing during dry periods when the clovers were either dead or inactive. This improvement in lucerne growth was brought about by a combined action of borax and lime which has since been shown to increase the depth of root growth, so enabling the lucerne roots to penetrate the subsoil and tap the reserves of moisture there.

There are many areas of coarse-textured soils in eastern and coastal New South Wales where the environmental problems resemble those in the upper Shoalhaven. The Division is now exploring the possibility of growing lucerne in these areas when soil conditions have been improved and is studying the effects of different fertilizer combinations in promoting deeper root growth and hence greater production during dry periods.

Fattening cattle in a drought

In 1968 the DIVISION OF TROPICAL PASTURES began a major grazing experiment at its Narayen Research Station near Mundubbera on an area representative of large areas of granite country in the spear grass zone of southern Queensland. The experiment was designed to investigate pasture growth and beef production from a range of pastures including buffel grass and legume pastures fertilized with molybdenized superphosphate and potassium, and buffel grass pasture without legume but fertilized with nitrogen, molybdenized superphosphate, and potassium.

The first year of grazing, from December 1968 to November 1969, coincided with one of the most severe droughts ever recorded in the district. Between October 1968 and October 1969 Narayen received less than 9 inches (230 mm) of rain compared with the annual average rainfall of 28 inches (710 mm). Despite this, animal production per head in the first year from buffel grass fertilized with 150 pounds of nitrogen an acre (170 kg a hectare) was 450 pounds (204 kg) when stocked at 1 beast to 4·5 acres (1·8 hectares), and 350 pounds (160 kg) when stocked at 1 beast to 3 acres (1·2 hectares). Where the legumes Siratro and lucerne were grown with the grass but no nitrogen fertilizer was used, the corresponding figures were 390 pounds (178 kg) and 270 pounds (123 kg).

These liveweight increases were obtained without supplementary feed, while outside the station animals on unimproved pastures on similar soils stocked at 15 to 50 acres (6 to 20 hectares) a head were in poor condition. Some stock on the unimproved pastures died from lack of feed, and many others had to be fed supplements or sent elsewhere for agistment.

An important factor in the success of the sown pastures on granite soils was their ability to produce a flush of nutritious new growth following small falls of rain, mostly less than half an inch. These falls produced no significant new growth on unimproved pastures on the same soils or on sown pastures on the fertile brigalow clays in the region.

Superphosphate, pastures, and sheep

The response of ungrazed pasture to added fertilizer does not always give a true guide to the pasture's requirements for fertilizer under grazing. In an experiment in Western Australia in which a newly established subterranean clover pasture was top-dressed with different amounts of superphosphate, the DIVISION OF PLANT INDUSTRY found that an ungrazed plot required about 100 pounds of superphosphate an acre (112 kg a hectare) for near-maximum yield whereas a similar plot stocked at $3\frac{1}{2}$ sheep to the acre needed close to 150 pounds an acre (168 kg a hectare).

When the dry subterranean clover residues from the experiment were grazed during the summer, the sheep displayed a clear preference for the plant material from the higher-phosphate treatments, including those treatments that had received phosphate applications beyond the level needed for maximum pasture growth. The sheep showed no such preference during the growing season. Chemical analysis of the dry clover residues revealed little difference in chemical composition other than an increase in phosphorus content.

Pen feeding trials showed that the sheep not only preferred the high-phosphate material, they also ate more of it and it was better for them in terms of weight gain than the low-phosphate material. On the basis of these findings the Division has estimated that whereas the pasture under investigation needed 150 pounds of superphosphate to the acre (168 kg to the hectare) for maximum production of herbage under grazing conditions, 180 pounds of superphosphate to the acre (200 kg to the hectare) would be necessary for maximum animal production from the same pasture.

Lower crop yields from more irrigations

Impermeable clay soils present special problems in the irrigation areas of southern Australia. When wet, these soils contain much more water than lighter soils, but less than 30% of it is readily available for plant growth. The DIVISION OF IRRIGATION RESEARCH and the DIVISION OF SOILS have shown that the amount of available water stored in soil can be increased by deep cultivation and by the incorporation of gypsum in the soil. In a two-year trial at Griffith, New South Wales, the Divisions compared the lint yield of cotton grown under normal tillage with that from cotton grown under deep ripping and ploughing and added gypsum. In the first season yields were increased by 33% to 2 bales an acre and in the second season by 66% to 2·6 bales an acre. The increase in yield was attributed mainly to an increase in the amount of water stored in the soil between irrigations.

More recently the DIVISION OF IRRIGATION RESEARCH has been investigating the possibility of using more frequent irrigations as an alternative method of reducing water stress and increasing lint yields of cotton grown on impermeable clay soils. A cotton crop irrigated each time the evaporation from a free water surface reached 1½ inches (38 mm) was compared with another irrigated according to the normal schedule of 6 inches (152 mm) evaporation between irrigations. The results were unexpected. The more frequently irrigated crop suffered a reduction in plant size of 50% and a reduction in yield of 40%. Moreover, it required 90% more water than the less frequently irrigated crop.

Further research has suggested two reasons for the reduction in growth and yield. During the critical spring period the frequent irrigation depressed soil temperatures by as much as 3°C at a depth of 4 inches (100 mm) so that cotton growth was retarded early in the season. Later in the season, the frequent irrigation encouraged a shallow root system from which it leached the nutrients essential for vigorous plant growth.

Grape vines and sunlight

The ability of grape vines to manufacture the carbohydrates they need for grape production depends, among other things, on the amount of sunlight reaching their leaves and on the capacity of the leaves to use it. The DIVISION OF HORTICULTURAL RESEARCH is studying photosynthesis in grape vines so that it can develop cultural practices and techniques of spacing, training, and pruning that will enable vines to use the sunlight reaching them to best advantage.

The Division has found that photosynthesis increases with the intensity of the sunlight until the light intensity is equal to about one-third of full summer sunlight. Beyond that point, increases in light intensity do not increase photosynthesis any further. Temperature also affects photosynthesis and the greatest rates occur at temperatures between 25°C and 30°C. The photosynthetic activity of individual leaves increases during growth, reaches a peak when the leaf is fully expanded, and then declines slowly. Vines suffering from lack of water photosynthesize at normal rates until they can no longer obtain water from the soil. At this point the leaves wilt and photosynthesis stops abruptly. A strong demand by the plant for carbohydrates, either for vegetative growth or for fruit production, stimulates photosynthesis.

In the vineyard, leaf orientation governs both the interception of sunlight by outer leaf layers and the penetration of sunlight into the lower layers of the canopy. Leaves oriented parallel to the direction of the light rays can photosynthesize at about 50% of full capacity because of the presence of diffused light. Sun flecks contribute markedly to the photosynthesis of partly shaded leaves. A leaf receiving sunlight over as little as 10% of its surface for 10% of the day can produce enough carbohydrate to offset that lost through respiration. Short pulses of light are utilized almost twice as effectively as continuous illumination.

The Division has been testing several different canopy structures that modify illumination and self-shading within the vine. Using a 4 foot (1·2 m) wide T-trellis with a foliage wire placed above, the Division has been able to increase the yield of grapes from sultana vines by 25% without lowering their sugar content.

Measuring the effective illumination of foliage in an apple orchard. This is part of a study by the DIVISION OF HORTICULTURAL RESEARCH of the relations between light penetration and cropping potential in orchards. The white spheres contain a solution of uranyl oxalate which decomposes slowly in sunlight. Analysis of the contents of the spheres provides a measure of the total amount of light received at different locations in the orchard over a given period.

Livestock

Division of Animal Physiology

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

Finance: $1,958,204 (Treasury $340,061, contributory $1,618,143)

Staff: Research scientists 49, other professional staff 38, supporting staff 180

Fields of research:

Physiological basis of productive functions in ruminants

Reproduction—spermatogenesis, ovarian function, pregnancy, parturition, neonatal physiology

Body growth—hormonal control, intermediary metabolism

Wool growth—keratin synthesis, follicle development, crimp formation, hormonal control

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, and nutritional value of feeds

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 cold on young 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

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.

Finance: $1,961,714 (Treasury $1,495,516, contributory $466,198)

Staff: Research scientists 48, other professional staff 19, supporting staff 194

Fields of research:

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

Cattle tick and tick fever

Worm parasites of sheep and cattle

Animal viruses—basic studies and transmission by insects

Immunology

Livestock diseases caused by plant poisons

Division of Animal Genetics

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

Finance: $1,501,533 (Treasury $1,041,794, contributory $459,739)

Staff: Research scientists 32, other professional staff 28, supporting staff 128

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 Nutritional Biochemistry

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

Finance: $657,378 (Treasury $443,999, contributory $213,379)

Staff: Research scientists 19, other professional staff 11, supporting staff 66

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 hot climates

A good deal of the research on the effect of heat on cattle has been concerned with the physiological mechanisms used by cattle to regulate their body temperatures. Much less work has been carried out on the effects of heat on feed utilization and growth.

The DIVISION OF ANIMAL GENETICS has been comparing the performance of Shorthorn × Hereford crosses with Zebu crossbreds in the mildly tropical climate of Rockhampton, Queensland. During the warmer months some of the British cattle had their coats clipped periodically to help them control their body temperature. The clipped cattle showed an increase in body weight over this period 17% higher than their unclipped counterparts. The clipped animals, however, could not control their temperatures as efficiently as the Zebu crossbreds, which, running in the same herd, gained 27% more body weight than the unclipped British. Thus, the heat of the Rockhampton summer depresses the growth of susceptible animals, and genetic differences in susceptibility to heat account for a large proportion of the genetic differences in growth rate in this season.

Heat affects growth partly by reducing

appetite and inhibiting grazing, but it also affects the animal's metabolism in various ways. Raised body temperature causes loss of fat by way of the gut, and loss of nitrogenous compounds such as urea and creatinine in the urine. Under some dietary conditions loss of urea may increase, but an increase in creatinine excretion always occurs when body temperature rises, the amount excreted being remarkably proportional to even short-term increases in temperature. Creatinine is derived from creatine, a component of muscle tissue. An increase in creatinine excretion is generally regarded as reflecting a wastage of muscle.

When the body temperature of a 300-kilogramme steer is raised by 1 degC, creatinine excretion increases by 1·3 grammes a day. This represents about 0·25% of the creatine in the muscle tissue in the body. If this loss of creatine was accompanied by a similar percentage decrease in muscle weight, then the weight gain of the steer might be reduced by as much as 0·25 kilogramme a day. The Division is now trying to establish whether the loss of creatinine represents a loss of muscle tissue, and if so, to what extent the loss of one is proportional to the loss of the other. Depending on the outcome of this work it may be possible to use creatinine excretion as a sensitive index of the reaction of cattle to heat.

Changing the fat composition in sheep and cattle

Most of the fats found in pasture plants and in many stock feeds are polyunsaturated (soft) fats. When eaten by sheep and cattle, however, they are converted by bacteria in the rumen to saturated (hard) fats. As a result a high proportion of the fat in ruminant products such as lamb, beef, milk, cream, and butter is relatively hard.

In the past twenty years, many scientists have attempted to manipulate the proportion of soft to hard fats in ruminants, but it was not until 1969 that a satisfactory method of doing this was devised by the DIVISION OF ANIMAL PHYSIOLOGY. The method involves feeding ruminants with a special supplement developed by the Division in conjunction with the DIVISION OF DAIRY RESEARCH. The supplement consists of a fine powder made by coating minute globules of polyunsaturated vegetable oil with a skin of soluble protein such as casein. Treatment with formalin renders the protein coating resistant to attack from rumen bacteria so that the oil globules are protected while in the rumen. When the supplement reaches the acid conditions of the fourth stomach (abomasum) the protein coating is digested, releasing the oil globules. The oil is then broken down in the small intestine into its constituent polyunsaturated fatty acids. These are absorbed into the blood stream and subsequently resynthesized into polyunsaturated fats which are deposited in the animal's tissues or secreted in its milk.

When fed to milking cows, the supplement gave a pronounced increase in the proportion of polyunsaturated fat in the milk within 24 hours. Proportions of up to 30 to 40% of these soft fats were obtained compared with 2–4% in normal milk fat. The supplement has also produced polyunsaturation in the fat of lamb and beef. Lambs fed with the supplement for three weeks showed a polyunsaturated tissue fat level four to five times higher than that measured in pasture-fed lambs. Similar increases were found with beef cattle. In addition, the composition of ruminant fat was found to be influenced by the type of oil used in the supplement.

The ability to modify the polyunsaturated fat content and the fat composition of ruminant milk and meat by dietary means should enable the dairy and meat industries to offer the consumer a wider range of edible products, although a good deal more research will be needed first. It may, for example, be possible to control the composition of milk fat to provide a range of butters with different melting points. Polyunsaturated milks of different composition could be used to produce a whole range of new cheeses with distinctive characters of their own, and polyunsaturated steaks and other meats might prove attractive to some diet-conscious consumers. Other applications include the possibility of using the supplement to introduce desirable fat-soluble substances that would otherwise be broken down in the rumen. Such substances include vitamins, hormones, and flavourings and anti-oxidants that enhance the keeping qualities of fats.

Vibriosis in cattle

Vibriosis, a venereal bacterial disease causing lowered fertility and abortion in cattle, is widespread in cattle herds throughout Australia and is one of the main causes of poor breeding performance. Apart from its effect on reproduction, however, the disease produces no obvious symptoms. Because of this, many farmers are unaware of the existence of the disease in their herds. No detailed economic assessment of the disease has been made but the losses resulting from delayed calving and failure to calve would run into many millions of dollars a year.

Over the last ten years, the DIVISION OF ANIMAL HEALTH has been carrying out research on detection and control of the disease and has devised improved methods for detecting it in bulls and cows. In conjunction with the Commonwealth Serum Laboratories, the Division has developed improved methods for manufacturing a suitable commercial vaccine.

As a result of this work, prevention and control of the disease in cows through vaccination are now practicable. In beef herds, such as those in northern Australia, where the degree of management control is limited, routine vaccination is the only way of tackling the disease. Where the cattle are closely supervised, as with dairy herds, other methods of control and prevention, such as artificial insemination with semen from 'clean' bulls, treatment with antibiotics, and selective culling, can be used with considerable success.

Vaccinating sheep against foot-rot

Foot-rot in sheep is estimated to cost Australia some $16 million a year. During the 1930s the DIVISION OF ANIMAL HEALTH established effective methods for treating and eradicating the disease. Over the years these methods have been improved upon, but they still remain time-consuming and laborious. The farmer who manages to eradicate foot-rot from his flocks must be continually on the alert to prevent the disease from re-entering his property.

About five years ago, the Division's McMaster Laboratory adopted a new approach to its investigations of how the bacterium *Fusiformis nodosus* produced the disease and of the immunological reactions that the infection stimulated in sheep. The Division found that if *Fusiformis nodosus* organisms were grown artificially under special conditions and harvested with certain precautions, sheep injected with them developed a much stronger immunity against the disease than had been achieved before.

As a result of this work, the Division has developed an effective vaccine, which not only gives a high degree of protection against the disease, but also cures a large proportion of established cases. It is not known yet how long the immunity stimulated by the vaccine will last and further research will be needed to determine whether any booster doses will be required after the initial vaccination. Research is also continuing on the different strains of *Fusiformis nodosus* to determine which of them should be incorporated in the vaccine so as to give protection in all districts in which foot-rot occurs.

Before production of the vaccine can be put on a commercial basis, the laboratory techniques used for cultivating the live foot-rot organism need to be scaled up so that it can be grown in bulk. Arrangements have been made for the Commonwealth Serum Laboratories and Arthur Webster Pty. Ltd. to collaborate with the Division on the development of mass production techniques, but it may be 18 months or more before a suitable vaccine is available commercially.

Salt water and sheep

Studies by the DIVISION OF NUTRITIONAL BIOCHEMISTRY over a number of years have shown that if sheep are gradually given water of increasing saltiness to drink, they can adapt to quite high levels of salt intake. For example, they can survive for long periods on water containing as much as 1·3% sodium chloride (sea water contains about 2·7% sodium chloride). Much of the sheep's ability to adapt so successfully is due to functional changes in the kidneys and gut which enable it to excrete large amounts of salt in the urine and faeces without excessive loss of water from the body. Elimination of salt in the sweat can also be increased.

The Division has found that sheep given water containing 1·3% salt drink twice as much as sheep given rain water. Moreover, when sheep drink salt water, their food stays in the rumen for a much shorter time before passing to the abomasum or true stomach, and the microbial population in the rumen is reduced. The Division is now looking to see what long-term effects these changes have on the efficiency of food utilization and on the fat and protein content of the carcass. It seems possible, for example, that salt water might lead to better utilization of protein and so produce a carcass with a higher proportion of lean meat to fat. There may also be changes in the degree of saturation of the fat and in the moisture content of the meat. This work is being conducted in collaboration with the DIVISION OF ANIMAL PHYSIOLOGY and the Meat Research Laboratory of the DIVISION OF FOOD PRESERVATION.

More effective antibiotics

At low concentrations the antibiotic phleomycin is ineffective against the bacterium *Escherichia coli* when it is in a resting or non-dividing stage. Phleomycin can, however, kill growing bacteria by causing destruction of their DNA (deoxyribonucleic acid), the material of which genes are made. It does this by rendering the DNA susceptible to attack by certain enzymes produced by the bacteria.

The DIVISION OF ANIMAL GENETICS has found that the antibiotic effect of phleomycin is greatly enhanced by the presence of caffeine. A combination of phleomycin and caffeine causes massive destruction of DNA, not only in dividing bacteria but in non-dividing bacteria as well. Phleomycin-resistant strains are as susceptible to this combination as normal strains. At the concentrations used, caffeine alone has no effect on DNA breakdown.

According to the hypothesis put forward by the Division to explain this finding, phleomycin attaches itself to the DNA molecules of the bacteria. DNA consists of enormously long molecules, each one double-stranded and each strand twisted in a spiral around its partner to form a double helix. The attachment of the phleomycin weakens the bonding between the two strands of the DNA double helix just enough to allow the attachment of caffeine. This, in turn, further weakens the bonding between the two strands and renders them susceptible to enzyme attack.

The Division has found that two other substances, pyronin-Y and coumarin, resemble caffeine in their ability to increase the effectiveness of phleomycin, and that caffeine increases the effectiveness of another antibiotic, nalidixic acid (negram). A number of other substances are now being studied by the Division together with different antibiotics in an attempt to find even more potent anti-bacterial combinations. Such combinations could find wide use in human and veterinary medicine because of the current scarcity of antibiotics that are effective against slowly dividing or non-dividing populations of Gram-negative bacteria such as *Escherichia coli*. Moreover, the possibility of bacteria developing resistance to these combinations with any ease or rapidity is negligible since this would require the mutation of two independent genes. The antibiotic combinations tested to date are selective in their attack and bacterial chromosomes are affected by doses that are much too low to have any serious effect on the chromosomes of the host animal.

Measuring the fineness of wool

A few years ago, as part of a biochemical study of wool synthesis, the DIVISION OF ANIMAL PHYSIOLOGY injected sheep with amino acids labelled with a radioactive isotope. After the amino acids had become incorporated in the wool fibres, the radioactive count rate of the wool was measured with a liquid scintillation counter. The Division found that the count rate varied according to the mean fibre diameter of the wool sample. This finding has now been used by the Division as the basis of a novel method for measuring the mean fibre diameter or fineness of wool.

The method involves placing roughly equal weights of clean wool in glass ampoules and adding scintillation liquid containing a small amount of radioactive formic acid. After the formic acid has been absorbed by the wool the count rate, as measured by a liquid scintillation counter, provides a measure of the mean fibre diameter of the sample.

The accuracy of the radioisotope technique is not seriously affected by a moderate degree of yellowness, or by the presence in the wool of a small proportion of vegetable matter (5–10% by weight). Moreover, it can be applied without loss of accuracy to wool that has been subjected to a wide range of chemical treatments or undergone various stages of processing from scouring to top-making.

The most widely used method of determining fineness, the air flow method, is of similar accuracy to the radioisotope method, but it is slower and involves several critical steps. The radioisotope method involves only one critical step, the addition of precise amounts of radioactive solution to the samples of wool, and this can be done satisfactorily with a high-precision automatic pipette. Much less wool is required for the radioisotope method, and good results can be obtained with samples as small as 20 milligrammes.

The radioisotope method lends itself to automation and with suitable equipment it should be possible to process at least 10,000 samples a day. The possibilities for applying this method in wool marketing are now being evaluated by the Australian Wool Board and the Australian Wool Testing Authority.

Insects, fish, and wildlife

Division of Entomology

Location: Canberra, with laboratories in Brisbane, Perth, and Sydney, and field stations at Rockhampton and Townsville, Qld., at Armidale, Trangie, and Wilton, N.S.W., and at Hobart, and biological control units at Ascot, England, Montpellier, France, and Pietermaritzburg, South Africa
Finance: $2,323,586 (Treasury $1,809,466, contributory $514,120)
Staff: Research scientists 60, other professional staff 33, supporting staff 152

Fields of research:
Genetics, physiology, biochemistry, and behaviour of insects as a basis for new methods of control—sterile male techniques, meiotic drive, lures
Ecology and control of insect pests—cattle tick, locusts and grasshoppers, pasture insects, forest insects, orchard insects, bush flies, sheep blowflies, insect pests of stored products
Insecticides—insect resistance, toxicology
Insect transmission of viruses
Biological control of insect pests and weeds
Taxonomy and maintenance of National Insect Collection

Division of Wildlife Research

Location: Canberra, with a laboratory at Helena Valley, W.A., and staff located at Adelaide, Alice Springs, N.T., and Mareeba, Qld.
Finance: $873,114 (Treasury $588,225, contributory $284,889)
Staff: Research scientists 17, other professional staff 13, supporting staff 78

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

Division of Fisheries and Oceanography

Location: Cronulla, Sydney, with laboratories in Brisbane and Perth
Finance: $1,003,180 (Treasury $993,381, contributory $9,799)
Staff: Research scientists 27, other professional staff 29, supporting staff 73

Fields of research:
Biological and population studies of prawns, tuna, western rock lobster, southern rock lobster, and Australian salmon; population studies of trawl fish
Primary productivity of marine environments
Structure and circulation of ocean waters
Distribution and abundance of zooplankton
Oceanography in relation to fisheries
Metabolism of single-celled algae
High-pressure studies of inorganic sea-water systems

The Australian plague locust

The difference between locusts and grasshoppers lies in the way they respond to increasing population density. At high population densities locusts become gregarious and form dense flying swarms which often migrate over long distances. Grasshoppers either do not swarm or form only loose swarms that migrate little. At low population densities the behaviour of both grasshoppers and locusts is similar.

Of the 500 species of locusts and grasshoppers found in Australia, only six are of economic importance. The most destructive is the Australian plague locust, *Chortoicetes terminifera*. Since 1965 the DIVISION OF ENTOMOLOGY has been studying the plague locust in collaboration with a team from the Anti-Locust Research Centre of London to learn more about its ecology in both the swarming and non-swarming situations.

Although the plague locust is found throughout most of mainland Australia, swarming is confined to what are known as outbreak areas in the interior parts of eastern and northern Australia.

Research has shown that the plague locust can persist under a wide variety of climatic conditions because of its ability to migrate and because of the way its eggs can adjust their development according to the availability of water in the soil where they are laid. The eggs need water to develop. If the soil becomes too dry they can halt their development until the soil becomes sufficiently moistened again by rain.

Locusts do not migrate during the day until a high population density is reached. The locusts then move together in tight formation, flying mostly during periods of warm anti-cyclonic weather when northerly and north-westerly winds blow. Although they may fly in different directions from day to day, their displacement is broadly towards the south and the south-east. The swarms fly close to the ground below tree-top level. When they come to a river with trees along the bank they tend either to stop or to be diverted along the line of the trees. The trees operate as a trap and can provide a good opportunity to

Locusts on a railway track in central western New South Wales.

attack large numbers in a small area with insecticides.

Recently the Division has found that even at low population densities individual locusts can migrate at night. This probably explains the sudden appearances of large numbers of locusts in localities where they had not been noticed before. Providing conditions of humidity, wind speed, and temperature are suitable, individual locusts launch themselves into the air a few minutes after sunset. Unlike those that stay on the ground, the night-flying locusts have not eaten food for some time before sunset and are sexually immature. They fly at heights ranging from 40 to 150 feet or more and sometimes continue flying until the early hours of the following morning. Most of this night migration takes place during, or immediately after, the passage of a front. At wind speeds in excess of 7 miles an hour the locusts fly downwind and so cover considerable distances before appearing unexpectedly elsewhere the following morning. A high proportion of the region infested during the outbreak in central western New South Wales late in 1969 appears to have been originally populated by easterly flights of night migrants during early February when a complex slow-moving surface low-pressure system passed through the region.

Doing away with dung

Cattle dung is a breeding habitat of two fly pests, the ubiquitous and irritating bush fly and the blood-sucking buffalo fly which attacks cattle in northern Australia. Dung is also an incubation ground for worm parasites and a serious contaminant of pastures.

About 240 million cattle pads are dropped every day in Australia, and these litter the pastures for several months or even years. Each cow produces 10 to 12 pads a day and in the process covers about one-twentieth of an acre (one-fiftieth of a hectare) a year. The rich growth of grass around a pad with its high nitrogen and low carbohydrate content is shunned by cattle, so that the actual wastage may amount to as much as a tenth of an acre a year for each beast. This is a serious loss in improved pastures with high stocking rates.

In many other countries, dung does far less damage and much more of it is returned as nutrients to the soil, because of the activities of various dung-dispersing beetles. Some African dung beetles, for example, are able to bury the dung dropped by a large grazing animal within hours. Although Australia has its own native species of dung beetles, they are adapted only to coping with the hard pellets of marsupials and are relatively ineffective at dispersing the large, moist pads of cattle.

To make up for the deficiencies of our native dung beetles, the DIVISION OF ENTOMOLOGY commenced an introduction programme in 1967 to bring into Australia species of beetles that can deal with cattle dung.

So far the emphasis has been on finding beetles to use against the buffalo fly. The Division has introduced five species that thrive under moist subtropical to tropical conditions. Before releasing them, the Division studied them under strict quarantine to develop methods for producing 'clean' beetles free of any disease agents or parasites that could affect livestock.

Over the last three years, some 200,000 beetles have been released at 75 strategic points throughout northern Australia. Follow-up studies at a number of the release sites have shown that the beetles are well established and spreading. One species, the Afro-Asian *Onthophagus gazella*, is particularly successful, and has spread at an average rate of 25 miles (40 km) a year. It has colonized Magnetic Island, $4\frac{1}{2}$ miles out from Townsville, and Palm Island, 15 miles out from Ingham. Three years after its release in the Townsville area it has become so numerous that unless soil moisture conditions are unfavourable many pads are buried within 2 or 3 days. This rate of burial results in 80 to 100% control of the buffalo flies that would otherwise have emerged from the pads.

The scope for further introductions is enormous. Africa alone has well over 1000 species of dung beetles. To control bush flies in southern Australia and buffalo flies in the north, it will be necessary to introduce a wide range of species each suited to particular climatic conditions and to different soil and vegetation types. The DIVISION OF ENTOMOLOGY has therefore set up a research station in South Africa to select and send to Australia some 120 species of beetles from many parts of Africa south of the Sahara.

Cleanliness can be deadly—for rabbits

A novel technique of rabbit control now being developed by the DIVISION OF WILDLIFE RESEARCH could, if successful, be invaluable in augmenting myxomatosis and conventional control methods. The new technique stems from basic research by the Division on rabbit behaviour. This work showed that rabbits have a compulsion to keep their paws clean by licking them whenever they become wet or dirty. If, therefore, a mixture of poison and a sticky substance is laid on a trail inside the entrance to each burrow in a rabbit warren, rabbits entering or leaving the burrow will pick up the mixture on their paws and become poisoned when they lick their paws clean.

Numerous studies by the Division have shown that each rabbit population is usually made up of socially dominant animals, which occupy the more favourable warrens in any habitat, and socially unattached individuals, which live either on the surface or in inferior burrows. Use of poison trails in warrens kills off the dominant animals first. This then leaves the warrens free for occupation by the less dominant rabbits living outside. In this way, the technique produces a one-way flow of rabbits into the warrens, making it feasible to achieve a total kill of all the rabbits in an area.

Other advantages of the technique are:

- It can be used without having to remove livestock from the paddock where the poisoning is taking place.
- It can be used in hilly, rocky country where at present aerial broadcast baiting is the only practicable method.
- Placing the poison trail well down the burrow reduces the risk of poisoning other animals. In general, few native fauna (apart from reptiles, which do not groom) ever make use of rabbit burrows for shelter. The situation may be different in the more arid parts of Australia, however, and the possible risk to native fauna in these areas would need to be investigated.
- Once in disuse, warrens collapse and become grassed over, burying what remains of the poison.

Preliminary trials with the technique have given promising results but a good deal of further work will be needed to test its applicability to different regions and situations and to find the answers to such questions as what poison is best and in what concentration should it be used. A number of investigations of this kind are now being carried out by the Division and by State rabbit control authorities.

Surveys of the distribution and relative abundance of mammals and birds are an integral part of studies by the DIVISION OF WILDLIFE RESEARCH on the problems of wildlife conservation. Information on the different species living in an area and on their basic requirements for food, shelter, and living space is invaluable in the development of an adequate conservation policy for that area.
This rare mountain pigmy-possum (*Burramys parvus*) is one of three collected for study during a fauna survey which the Division has been conducting in the Kosciusko National Park, New South Wales. *Burramys parvus* was known previously only from a single living example collected at Mt. Hotham, Victoria, and from fossils dating from the last Ice Age.

Artificial seaweed aids lobster research

The western rock lobster, formerly known as the Western Australian crayfish, is the basis of Australia's most valuable fishery. There is still a good deal that is not known about the life cycle of this species and the DIVISION OF FISHERIES AND OCEANOGRAPHY has been learning more about what happens to it from the time it is hatched until it appears in the craypot four to six years later.

The western rock lobster's eggs hatch in summer in the waters surrounding inshore reefs. The newly hatched larvae then rise to the surface and are carried out into the open ocean, probably by surface wind drift. About nine months later they return and settle to the bottom again on the inshore reefs. It is thought that the larvae continue to float until stimulated to settle by contact with seaweed growing near the coast. This mechanism ensures that they settle in the environment most suitable for their survival.

The Division has developed an artificial seaweed that triggers off this settling reaction. It consists of a dense mass of fine synthetic rope fibres held in a frame. This is floated just below the surface in shallow water sheltered by reef formations. The lobsters settle on the frames at the puerulus or final larval stage. They are then about ¾ inch (19 mm) long. Settlement occurs mostly during new moon phases between September and November. Catch rates have been as high as 60 larvae per frame per month.

The artificial seaweed is used for collecting lobster larvae for aquarium studies of survival and growth. At the same time it provides a means of measuring how much settlement takes place in an area each season.

Textiles and leather

Division of Protein Chemistry

Location: Parkville, Melbourne
Finance: $1,016,200 (Treasury $67,201, contributory $948,999)
Staff: Research scientists 40, other professional staff 27, supporting staff 63

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 for wool
Binding of polymers to proteins
Flammability of fabrics
Leather manufacture and hide proteins
Enzymes and muscle proteins

Division of Textile Industry

Location: Geelong, Vic.
Finance: $1,233,170 (Treasury $70,159, contributory $1,163,011)
Staff: Research scientists 21, other professional staff 23, supporting staff 159

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

Division of Textile Physics

Location: Ryde, Sydney
Finance: Contributory $861,350
Staff: Research scientists 20, other professional staff 23, 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 pressing and sampling
Wool drying and dyeing

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

Flammability of fabrics

One of the main problems preventing the development of effective legislation to control the sale of garments made from highly flammable fabrics has been the difficulty of devising a satisfactory method for testing textile flammability. Numerous tests have been developed overseas, but they can give misleading results. One test, for example, may rank a particular fabric as less flammable than another while a different test will rank the two fabrics in reverse order.

A committee set up by the Standards Association of Australia to examine this problem has adopted a unique approach by deciding to consider a wide range of factors related to textile flammability rather than seek a single test. The DIVISION OF PROTEIN CHEMISTRY has been actively associated with the committee and has examined a number of possible tests. The committee has concluded that there are at least five important components to be considered in assessing flammability: ease of ignition, rate of burning, heat output, ease of extinction of flame, and thermoplastic behaviour of the fabric. Some of these factors have been partly or completely ignored in previous test specifications.

The committee has now prepared a draft standard specification which lays down methods for testing textile fabrics for use in clothing. The test procedures are simple and reliable and include a new method developed by the Division for assessing ease of ignition by measuring the time required for a small gas flame to ignite a sample of the fabric under carefully specified conditions. This method has given highly consistent results. In tests with cotton flannelette, for example, results were reproducible to within a tenth of a second.

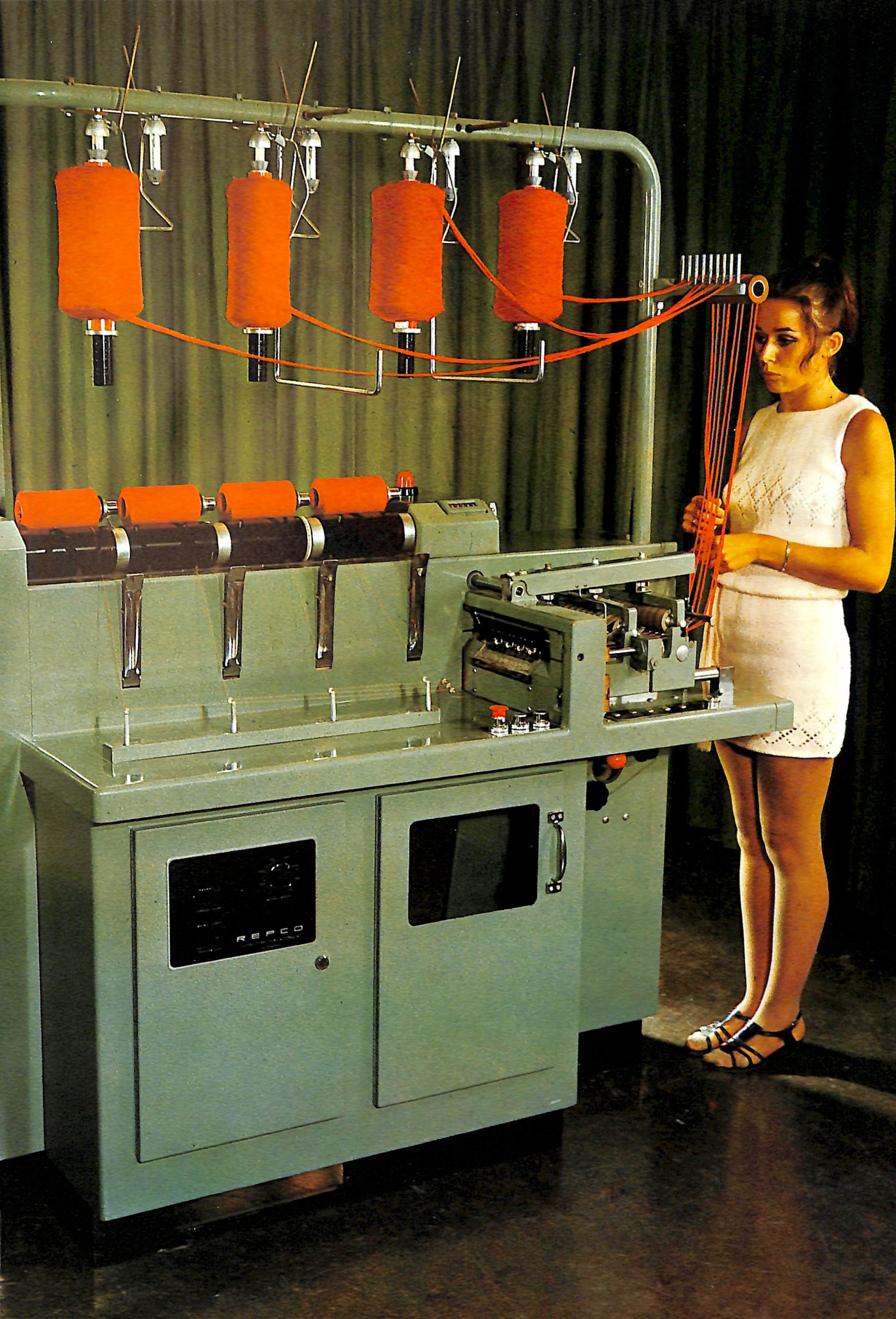
Self-twist spinning

Machines that can spin worsted yarn ten times faster than conventional spinning machines are now being manufactured commercially in Melbourne by Repco Ltd. under licence from CSIRO. The new machines incorporate an entirely new concept in textile processing known as self-twist spinning. This concept originated in the DIVISION OF TEXTILE INDUSTRY in 1961. Since then it has taken nine years of intensive research and development, including five years of close collaboration between the Division and Repco Ltd., to produce a commercial spinning machine that makes full use of the advantages offered by the self-twist method.

In conventional spinning, yarn is produced by imparting a continuous one-way twist to a strand of loosely assembled wool fibres. In self-twist spinning two strands of fibres pass between a pair of rapidly rotating rubber rollers. As the rollers rotate they move rapidly from side to side in opposite directions to each other. This results in a short section of each strand being twisted in one direction, the next section in the opposite direction, and so on. As the twisted strands emerge from the rollers they are immediately combined so that they twist about each other to form a stable two-ply yarn. In this form the yarn is not strong enough for weaving and it must undergo a further operation to give it a strong unidirectional twist. A similar twisting operation is used in making two-ply yarn from conventionally spun single-ply yarn.

Fabrics made from self-twist yarns are identical in appearance and performance

Self-twist spinning machine.


REPCO

with cloth woven from conventional yarn. Self-twist spinning is particularly suitable for producing very fine yarns for use in light-weight fabrics. Such fabrics show less dimensional change with changes in moisture content. If woven tightly, they also show high shrink resistance during washing. Fabrics like this are expensive to produce by conventional methods.

With conventional spinning, production rates are limited to about 20 metres of yarn a minute from each spindle, but with self-twist spinning, present production is 220 metres a minute, and higher rates can be achieved. The new machine has a floor area of less than 1 square metre (only one-fifth of the area of a conventional ring-frame spinning machine of comparable through-put), it uses less power, and is easier to clean and maintain. It is also much quieter and more versatile.

So far, self-twist spinning has been applied to the production of yarn for woven cloth. The Division is now working on its possible application to knitwear.

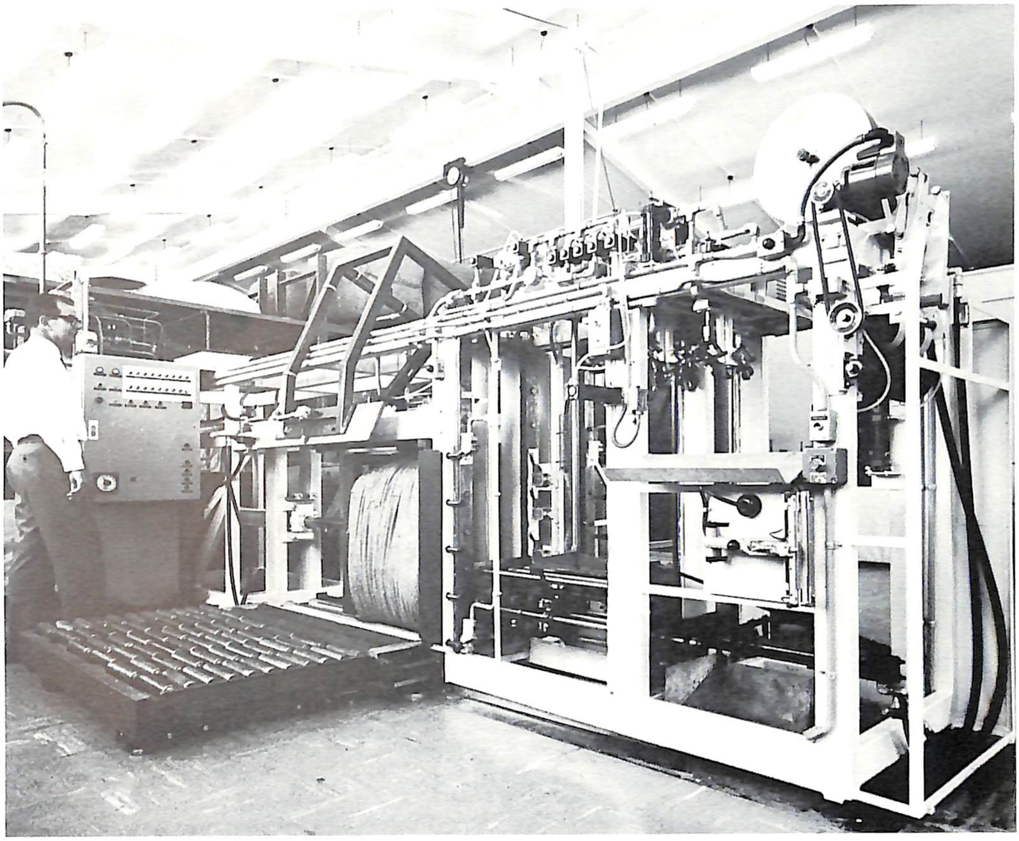
Repco has concluded an agreement with Stone-Platt Industries Limited, a leading British manufacturer of equipment for the textile industry. Under the agreement Stone-Platt will undertake the sale and servicing of self-twist machines on a world-wide basis through its extensive network of branches and agencies. The agreement also provides for the possible manufacture of machines in Britain under licence at a later stage.

Sampling wool bales

There is a growing demand from textile manufacturers for accurate descriptions of the wool they buy in terms of such measurable characteristics as yield and fibre diameter. Some 35% of the Australian wool clip is now tested in Australia by the various public testing houses. At present the most expensive part of wool testing is not the cost of the test itself but the costs associated with getting access to and sampling the wool. The bale to be tested must be located in the wool store, removed from its stack, taken to some convenient point in the store where it can be weighed, sampled with a hand-coring tool, and then returned to its stack. For this operation brokers charge an average handling fee of about 65 cents a bale, and the test houses charge 40 cents a bale for sampling. By comparison, the test houses charge about 14 cents a bale for testing, on a typical test lot of 70 bales.

Since each bale of wool is weighed when it arrives at the broker's store, a good deal of extra handling could be avoided by sampling the wool at this stage. The DIVISION OF TEXTILE PHYSICS has developed an automatic coring machine that can handle up to 120 bales an hour. This is about the rate at which bales are weighed in at wool stores. As each bale passes through the machine it is compressed. Two probes enter the bale from the bottom end and remove two $\frac{7}{8}$-inch (22-mm) cores of wool, each running the length of the bale. The two cores, each weighing about 50 grammes, are then automatically packed and sealed in polythene tubes. Identifying tags on which the weights of the samples are recorded are attached and the samples stored for subsequent testing. The position from which the samples are taken is varied for each bale to ensure random sampling.

The Division believes that the saving in handling charges associated with this sampling system could more than offset its cost, even if many of the samples taken were not required for testing. If the practice of testing growers' lots before auction is adopted by the wool



Automatic coring machine for sampling wool bales.

industry the savings will be very much greater. A prototype coring machine has been undergoing trials in a Sydney wool store since April and has performed extremely well. Arrangements are now being made for the manufacture of the machine under licence from CSIRO.

Short-term preservation of hides

Unless they are tanned soon after removal from slaughtered animals, raw hides must undergo a preservative treatment. The usual method of preservation is salting. This can cost up to about $1.00 a hide, and processing takes up to a fortnight. Moreover, the handling and disposal of waste salt present problems. Although salted hides will keep for 12 months, local tanners generally need to preserve hides for a few days only. This enables them to accumulate daily deliveries from the slaughterhouse until they have enough hides of various grades to make convenient and economical batches for tanning.

The DIVISION OF PROTEIN CHEMISTRY has shown that raw hides soaked in a solution of sodium chlorite for 16 hours will keep for 6 days at 25°C, or longer at lower temperatures. Both the labour and the material costs of the new method are only a fraction of those of conventional salting. When tanned, the chlorite-preserved hides produce leather practically indistinguishable from that made from unpreserved hides.

Food processing

Division of Food Preservation

Location: North Ryde, Sydney, with the Meat Research Laboratory at Cannon Hill, Brisbane, and a laboratory at Gosford, N.S.W.
Finance: \$1,854,767 (Treasury \$1,490,661, contributory \$364,106)
Staff: Research scientists 61, other professional staff 53, supporting staff 128

Fields of research:
Nature and control of changes in foodstuffs caused by time, temperature, and microorganisms
- Heat and mass transfer in fruit and meat storage and transport
- Chemistry of food constituents including flavours
- Physiology and ecology of food spoilage microorganisms
- Physiology and biochemistry of fruits, meats, and eggs
- Processing of foods by canning, freezing, and drying

Division of Dairy Research

Location: Highett, Melbourne
Finance: \$568,737 (Treasury \$368,988, contributory \$199,749)
Staff: Research scientists 12, other professional staff 10, supporting staff 51

Fields of research:
Cheese—mechanization of cheddar manufacture, cheese starters, enzymology of cheese ripening
Casein and other milk proteins—fundamental chemistry, commercial manufacture
Flavour chemistry
Drying of dairy products, recombined products
New foods
Oxidative deterioration of butter-fat in stored dairy products
Control of composition of milk fat

Wheat Research Unit

Location: North Ryde, Sydney
Finance: \$91,807 (Treasury \$22,351, contributory \$69,456)
Staff: Research scientists 5, 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

The flavour of green peas

The flavour of a food is a complex sensation induced by its taste, smell, and feel in the mouth. Smell is the most important of these components since it is mainly responsible for the distinctive characteristics of different foods. Smell arises from volatile chemical compounds. Although a food may contain hundreds of volatile constituents, only a small proportion of them contribute significantly to its smell, and hence to its flavour. Indeed, in some foods the characteristic smell may be due to only one or a few compounds.

During an investigation of the flavour of frozen peas, the DIVISION OF FOOD PRESERVATION extracted the volatile components from 1 ton (roughly 1 million grammes) of peas. This quantity of peas yielded 1 gramme of water-free essence containing several hundred compounds. The essence was passed through a highly sensitive gas chromatograph which separated it into its individual constituents, the chemical nature of which could then be studied with a mass spectrometer.

The isolation and identification of all the components of the essence would have been a lengthy undertaking and would have involved determining the structure of many compounds that do not contribute to the flavour of peas. The problem was greatly simplified by smelling each compound as it emerged from the gas chromatograph and assessing its probable significance. In this way two compounds were detected, each of which had an intense, characteristic smell of fresh green peas. Both compounds were present in minute amounts; 1 ton of peas gave only about 10-millionths of a gramme of each. Because of the extremely small quantities available, special techniques had to be devised to enable the compounds to be examined with the high-resolution mass spectrometer of the University of Sydney's Chemistry Department. From the information obtained with the mass spectrometer the Division was able to deduce the structures of the two compounds and to synthesize them in the laboratory. The two compounds, 3-isopropyl-2-methoxypyrazine and 3-s-butyl-2-methoxypyrazine, are believed to be responsible for the characteristic flavour of fresh peas. The Division is now investigating the possibility of using them to improve the flavour of processed green peas.

Freeze drying with helium

One method of preserving food is by freeze drying. The food is first snap-frozen, then placed in a vacuum chamber where water is removed by vaporizing the ice crystals. In this way the appearance, texture, and flavour of the food are preserved. The process is not cheap and has been used mainly for expensive foods such as mushrooms and strawberries.

In 1966 the DIVISION OF FOOD PRESERVATION developed an improved method known as cyclic-pressure freeze drying which cut drying times by up to 30% and reduced costs. In this method, air is admitted into the vacuum chamber whenever the drying rate drops. Each time a surge of air enters the chamber the pressure increases by a factor of about 100. This helps heat penetrate to the inside of the food being dried. As the air is drawn off by the vacuum, it flushes water vapour out of the tiny pores in the outer layers of the food. These cycles of alternate high and low pressure are repeated until all the ice has been vaporized and the product is dry.

More recently the Division has found that it can reduce drying times with the cyclic-pressure process still further by using helium gas instead of air. Helium can remove heat from the product much faster than air because of its greater capacity to conduct heat.

In a series of comparative trials conducted by the Division in pilot freeze-drying plants, the conventional constant pressure process enabled peas to be dried at a rate of 3 runs a day, the cyclic air process 4 runs a day, and the cyclic helium process 5 runs a day. The respective costs for processing a pound (half a kilogramme) of fresh peas were 5–6 cents, 4–5 cents, and 3 cents. Cost savings in larger commercial plants would probably be greater. Although helium is expensive the cost of the helium used in the pilot plant amounted to only a small fraction of a cent per 40-lb (18-kg) run.

Starters for cheese

In commercial cheese manufacture, 'starter' cultures of certain selected strains of bacteria are added to pasteurized milk. As the bacteria multiply they convert the lactose in the milk to lactic acid. The starter cultures are grown at the cheese factory, usually from freeze-dried seeding material prepared by the DIVISION OF DAIRY RESEARCH and distributed by State Departments of Agriculture. In spite of strict precautions in the factory, aseptic conditions are not always achieved while the cultures are being grown and starter cultures sometimes become contaminated with undesirable bacteria or with bacteriophages that attack the acid-producing bacteria. When this happens the quality of the cheese is affected.

About 200 pounds of starter culture are needed for a 1000-gallon vat of cheese (that is, about 100 kg for a 5000-litre vat), and about 130,000 such cultures containing altogether some 30×10^{18} bacteria are used in the manufacture of Australian cheese each year. If these bacteria could all be grown at one central place, elaborate technical control and checking could be applied to prevent contamination and the cultures could be distributed to cheese factories in concentrated form. The DIVISION OF DAIRY RESEARCH has been developing methods for the centralized production of concentrated cheese starters, and the work has now reached the stage where concentrated starters produced by the Division have been used successfully in the manufacture of commercial lots of cheese.

The Division's project is based on the use of continuous culture techniques and on the storage of cultures by freezing in liquid nitrogen. Continuous culture enables the number of bacteria produced in a plant of a given capacity to be increased considerably. Storage of cultures in liquid nitrogen preserves the activity of the bacteria so that they grow rapidly when added to the cheese vat. Present indications are that only 1 pound of culture would be needed to start a vat instead of the present 200 pounds.

The two species of bacteria commonly used as cheese starters are *Streptococcus lactis* and *Streptococcus cremoris*. So far the main technical problems in the production of *Streptococcus lactis* appear to have been solved, but *Streptococcus cremoris* has unusual nutritional requirements and further work is needed to develop a cheap nutrient medium suitable for its large-scale production.

Engineering and construction

Division of Forest Products

Location: South Melbourne
Finance: \$1,572,928 (Treasury \$1,464,083, contributory \$108,845)
Staff: Research scientists 40, other professional staff 43, supporting staff 148

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

Division of Mechanical Engineering

Location: Highett, Melbourne
Finance: \$686,324 (Treasury \$629,899, contributory \$56,425)
Staff: Research scientists 15, 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
Industrial aerodynamics—diffusers, fan design, acoustics, model studies
Grain storage—cooling and other methods of insect control, drying
Agricultural machinery
Design and control by computer

Division of Building Research

Location: Highett, Melbourne, with an office in Port Moresby
Finance: \$997,307 (Treasury \$958,100, contributory \$39,207)
Staff: Research scientists 21, other professional staff 39, supporting staff 59

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

Division of Applied Geomechanics

Location: Syndal, Melbourne, with a laboratory in Adelaide

Finance: $455,350 (Treasury $438,938, contributory $16,412)

Staff: Research scientists 10, other professional staff 12, supporting staff 31

Fields of research:
Engineering materials science—physical and chemical properties of earthen materials in relation to engineering
  Soil and rock fabric, soil stabilization, mechanical properties of soils and rocks, defect structure mechanics, soil thermodynamics, soil and rock dynamics
Soil and rock engineering
  Soil water, foundations on expansive soils, embankments and natural slopes, earth pressures and retaining structures, drilling and sampling, grouting
Use of land for engineering purposes
  Site investigation, terrain evaluation for engineering

Storing wheat on the farm

The difficulties currently facing Australia in disposing of its wheat have created a serious storage problem. Because of this many farmers have been forced to store their wheat on the farm. Unless proper precautions are taken, stored grain deteriorates as a result of insect infestation, growth of moulds, and migration of moisture from regions of hot grain to cooler surfaces. One method of retarding deterioration is to lower the temperature of the grain by blowing cool air through it with a fan. A simple unit for aerating farm grain storages of up to 5000 bushels has been designed by the DIVISION OF MECHANICAL ENGINEERING. The unit costs about $400 and in a normal year would use about $10 worth of power.

A feature of the unit is a time-proportioning controller developed by the Division to limit fan operation to periods of lowest atmospheric temperatures so that the grain is kept as cool as prevailing weather conditions will allow. The controller functions much like a time-switch—it operates the fan for a pre-set number of hours a week—but with the important difference that fan operation occurs during periods of lowest atmospheric temperatures.

The controller uses a thermostat to sense atmospheric temperature and operate the aerating fan when the temperature is below the thermostat set-point. The set-point is varied, however, so that it rises at a pre-set rate of a degrees a week when the fan is not running and falls at a pre-set rate of b degrees a week when the fan is running. The result is that on average over a long period the fan runs for the fraction $a/(a+b)$ of that period. If over a given length of time the fan does not run in accordance with this ratio then the thermostat setting will experience a net rise or fall so as to ensure that the running period is corrected. In a typical situation the controller might be set so that the fan operates for a total of 15 hours a week, and so that the thermostat set-point rises at 4°F (about

2°C) a week when the fan is not running and falls at 40°F (22°C) a week when the fan is running.

The controller is now being made under licence from CSIRO by Electro Chemical Engineering Pty. Ltd. of Melbourne.

Particle board for exterior use

In 1957 the DIVISION OF FOREST PRODUCTS developed glue formulations based on wattle tannin which were suitable for the manufacture of exterior-grade plywood. As a result of further work by the Division the use of these adhesives and also of adhesives based on quebracho tannin has been extended to the manufacture of exterior-type particle boards. Particle boards made with these tannin adhesives have stood up satisfactorily to immersion in boiling water for as long as 90 hours and when redried have returned to within 2–5% of their original thickness. Boards of similar durability can be made with synthetic phenolic adhesives, but their use is seriously limited by the high cost of the resin and the comparatively long curing times necessary.

The tannin adhesives are similar both in cost and curing time to the urea–formaldehyde resins widely used in Australia in the production of standard interior boards. However, the exterior boards cost about 20% more than the interior boards, because a higher concentration of tannin adhesive is needed to give the required durability.

Although at present the tannins on which these adhesives are based are imported from overseas, tannin from *Pinus radiata* bark has been found to be suitable. The Division is now investigating the feasibility of producing tannin commercially from this otherwise largely waste material.

Preserving bamboo

At the Port Moresby Office of the DIVISION OF BUILDING RESEARCH investigations have been carried out on methods of extending the useful life of bamboo as a building material. Bamboos in general are highly susceptible to insect attack, the main pest being the powder post beetle (*Dinoderus minutus*).

Only simple treatments, capable of being carried out at village level, were examined. Over a period of twelve consecutive months mature bamboo stems were selected each month and divided into three groups. The first group was left untreated, the second leached with water for four weeks, and the third impregnated with borax. Pieces of stem were then hung outdoors, but under cover, and insect attack was estimated over a period of twelve months by counting insect holes.

It was found that bamboo cut when it was low in starch and high in moisture had excellent natural durability, but no relation could be detected between these properties and the time of year. Field selection of suitable stems would therefore require the use of a moisture meter or a simple starch test or both. Where this method of selecting bamboo is impracticable, the durability of randomly selected bamboo can be greatly improved by impregnation with borax. Leaching with water gives some improvement, but much less than with the borax treatment.

Chemistry and mineralogy

Division of Applied Chemistry

Location: Fishermen's Bend, Port Melbourne, with a microanalytical laboratory at the University of Melbourne
Finance: \$1,111,306 (Treasury \$1,060,164, contributory \$51,142)
Staff: Research scientists 37, other professional staff 29, supporting staff 58

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

Division of Mineral Chemistry

Location: Garden City, Port Melbourne, with a laboratory in Sydney
Finance: \$1,971,300 (Treasury \$1,836,381, contributory \$134,919)
Staff: Research scientists 53, other professional staff 64, supporting staff 135

Fields of research:
Mineral exploration
- Ore genesis
- Carbonaceous sediments
- Borehole logging

Mineral processing and utilization
- Sulphides
- Mineral sands
- Iron ores
- Coal
- Industrial carbons

Mineral science and technology
- Reaction mechanisms and kinetics
- Solids and surfaces
- Fuel cells
- Metallurgical reagents and reaction media

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

Division of Chemical Engineering

Location: Clayton, Melbourne
Finance: \$637,806 (Treasury \$623,024, contributory \$14,782)
Staff: Research scientists 21, other professional staff 24, supporting staff 41

Fields of research:

Particle mechanics
- Grinding and classification
- Flotation
- Mineral separations
- Fluidization

Diffusional operations
- Heat transfer
- Mass transfer
- Mixing and rheology
- Reversed osmosis
- Chemical reaction engineering

Process control

Analogue and hybrid computation and simulation

Extractive pyrometallurgy

Process development
- Process design and evaluation
- Desalting of water
- Food processing
- General process development

Division of Chemical Physics

Location: Clayton, Melbourne
Finance: \$919,659 (Treasury \$914,486, contributory \$5,173)
Staff: Research scientists 32, other professional staff 15, supporting staff 48

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

Division of Applied Mineralogy

Location: Fishermen's Bend, Port Melbourne, with a mineragraphic laboratory at the University of Melbourne, and laboratories in Canberra, Perth, and Sydney
Finance: \$737,230 (Treasury \$696,544, contributory \$40,686)
Staff: Research scientists 26, other professional staff 20, supporting staff 38

Fields of research:

Geology and geochemistry of ores
- Distribution of elements in mineralized areas
- Formation of sulphide ores

Experimental mineralogy
- Mineragraphy

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

Measuring temperatures in a burning chitter dump.

Suppressing fires in coal dumps

Chitter, a waste material produced during coal-mining operations, is a mixture of low-grade coal and slate. It is usually left in heaps at the mine, but in the past it was often dumped in any available hollow or swamp in the surrounding bush. It was also used in road embankments and railway sidings.

Waste heaps of chitter can be ignited by bush fires or during periods of high temperature. The dumps burn slowly, polluting the air with smoke and sulphurous fumes. Secondary fires spreading from the dumps may destroy mine workings and properties. A dump containing 100,000 tons or so of smouldering material may burn for 20 years or more, and the mass of material forms such a vast heat reservoir that it can be extremely difficult to put out.

The problem of burning chitter dumps has been investigated by the DIVISION OF MINERAL CHEMISTRY at Cessnock, New South Wales. The Division was able to show that fires can be prevented if care is taken in the location of waste heaps, proper construction methods are used, and the entire surface of each heap is capped with a compacted layer of soil. Capping reduces the risk of spontaneous combustion by keeping air out of the dump and by protecting the combustible material against surface heating. An examination of local soils showed that they were suitable for capping provided sealing agents were added to make the soil cover resistant to weathering and erosion. Sandy clay proved to be an effective capping when treated with a material such as sodium silicate which binds the grains together.

The Division also showed that fires in burning dumps can be controlled by thoroughly spraying the burning zones with chemical suppressants. After treatment the dumps should be capped and sealed to prevent any further fires.

Industrial ceramics

Engineers are turning increasingly to ceramic materials for use in engineering components which are required to perform for long periods at high temperature under severe conditions of abrasion and corrosion. Zirconia, which is derived from zircon, a mineral found in Australian heavy beach sand deposits, has found only limited application in this field to date because of difficulties in fabricating components from it. Most of these difficulties arise from a change of crystal structure and an accompanying 9% change in volume that takes place when zirconia is heated between 1000° and 1200°C. These changes can be minimized by alloying the zirconia with certain metal oxides such as lime, magnesia, or yttria. Such alloys have good resistance to abrasion and corrosion and are widely used in high-temperature refractories. However, they have found little application in engineering practice because some of the side effects of stabilization lower their resistance to sudden changes in temperature.

For some years the DIVISION OF APPLIED MINERALOGY has been studying the factors controlling the crystal chemistry of stabilized zirconia. The Division has applied the knowledge and experience gained in this area to the preparation, by a process of coprecipitation, of a series of stabilized zirconias of extremely uniform composition which can be fabricated into various experimental components. Pressure-reducing orifices made by these techniques have performed extremely well in a soda recovery plant at the mills of the Australian Pulp and Paper Manufacturers at Burnie, Tasmania, and have given lives of 3 to 4 months under conditions of severe abrasion, corrosion, and cavitation erosion. The orifices which were used previously had an effective life of only 3 to 4 days.

Stabilized zirconias 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 a number of laboratories throughout the world to investigate the possibility of using probes made from stabilized zirconia to measure the concentration of oxygen in molten metals. The Division has fabricated a wide range of zirconia probes for evaluation by the Broken Hill Proprietary Co. Ltd.

New drugs may come from poison plants

A number of weeds, including heliotrope and various species of *Crotalaria*, contain poisons that cause liver damage in livestock. Some years ago the DIVISIONS OF ANIMAL HEALTH and APPLIED CHEMISTRY showed that these poisons, which belong to a group known as the pyrrolizidine alkaloids, interfere with the ability of liver cells to duplicate themselves, so that the liver becomes composed of a smaller number of giant cells. Further research suggested that the alkaloids or active compounds derived from them might have anti-viral or anti-tumour properties. Although several of the alkaloids were found experimentally to have some activity against tumours, the activity was not sufficiently marked relative to their toxicity to justify further testing.

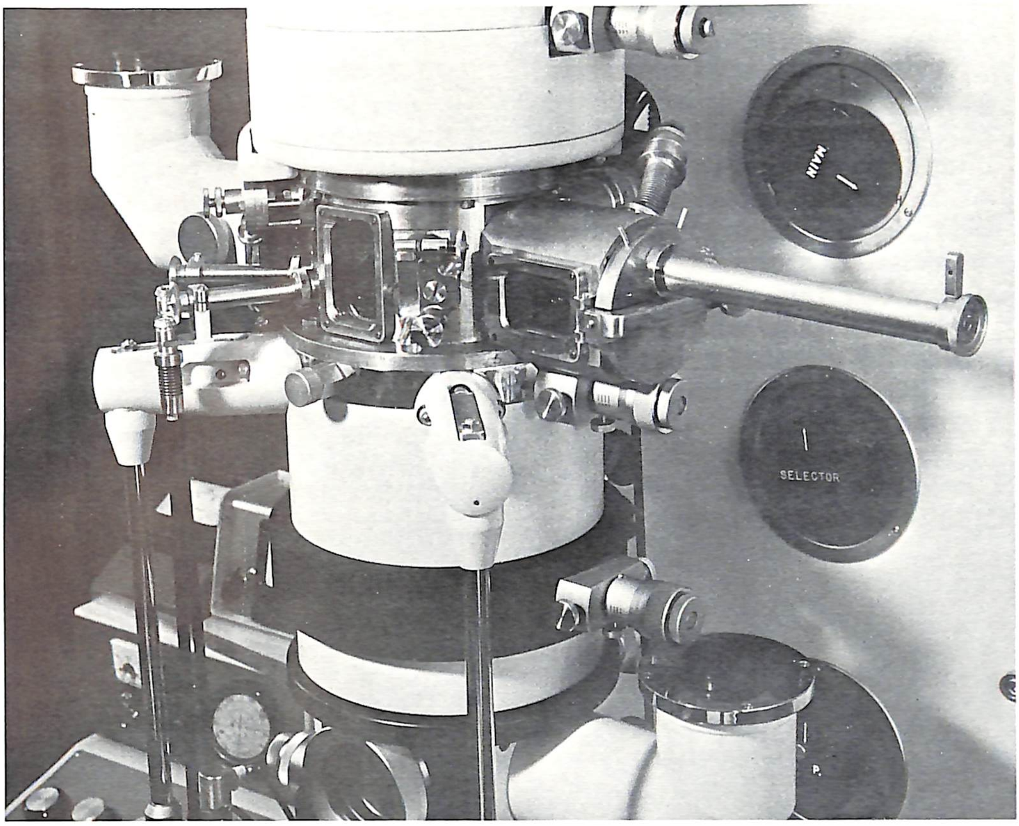
More recently, however, the DIVISION OF APPLIED CHEMISTRY has synthesized a series of pyrrolic derivatives which are more chemically reactive towards cell constituents than the alkaloids from which they are derived. Although the derivatives are toxic, they do not produce the same chronic effects as the parent alkaloids. The biological properties of these derivatives are being investigated and one of them, dehydroheliotridine (DHH), has shown promise as an anti-tumour agent. The DIVISION OF ANIMAL HEALTH has found that DHH prevents the development of Ehrlich ascites tumours in mice, while tests carried out for the DIVISION OF APPLIED CHEMISTRY at the Cancer Chemotherapy National Service Center in the United States have shown it to be active against some leukaemia systems. A good deal of further research will be needed, however, before it can be determined whether DHH warrants clinical testing. Apart from its anti-tumour activity, DHH also has immuno-suppressive and anti-viral properties and these are being investigated by the DIVISION OF ANIMAL HEALTH.

Better viewing with electron microscopes

In electron microscopy, specimens are examined with a beam of electrons travelling at very high speed, in place of the beam of light used in optical microscopy. In addition to attaining a magnification of up to about 250,000, a modern electron microscope can resolve very fine detail, equivalent in size, under the best conditions, to about two atoms.

Since the surfaces and atomic structure of specimens are three-dimensional, manipulators are needed to enable a specimen to be moved and tilted into any position for examination. To obtain the best possible results, however, the mechanical performance of the manipulators must match the magnification and resolving power of the microscope. Although various designs of high-precision manipulators have been commercially available for some years, they have all been subject to fairly severe limitations in range, accuracy, and compatibility with the conditions necessary for high resolution.

These limitations have been largely



A Hitachi 125-S electron microscope fitted with a specimen manipulator.

overcome in a manipulator designed and developed by the DIVISION OF CHEMICAL PHYSICS. It enables specimens to be moved horizontally in two directions with a fineness of adjustment of a millionth of a millimetre, and up or down with a fineness of adjustment of a thousandth of a millimetre. It also allows tilts of up to 40° about two axes at right angles. The movements are smooth and the specimen is stable to within half an atom diameter during any half-minute, even under the most extreme working conditions.

To avoid contaminating the specimen, no grease seals or lubricants are used and provision is made for cooling the specimen capsule to −140°C with liquid nitrogen to trap stray molecules. The specimen is mounted on an electrically heated palladium grid and can be heated or cooled to any temperature between −140°C and 1500°C by adjusting the electric current in the grid. The specimen capsule is less than 5 millimetres in diameter to allow it to fit into the small space between the pole pieces of the microscope.

Using the manipulator in conjunction with a Hitachi 125-S electron microscope, the Division has obtained resolutions of 3·5 ångström units. Arrangements have been made with Hitachi Ltd. of Japan, one of the world's leading electron microscope manufacturers, to make the manipulator under licence from CSIRO. At the same time, local and overseas selling rights have been reserved for potential Australian manufacturers.

Improving paints

Titanium dioxide is the main pigment used in paints to give opacity and whiteness. To obtain maximum coverage the pigment is ground finely and dispersed in a liquid medium. Since the pigment particles generally have more affinity for each other than for the dispersant medium they need to be coated with a polymer to help keep them apart. (Polymers are large chain-like molecules built up from a number of identical subunits.)

Research carried out by the DIVISION OF APPLIED MINERALOGY under the sponsorship of Australian Titan Products Pty. Ltd. has led to the development of a series of new polymers which give much better dispersion. The new polymers possess two types of reactive groups that are an integral part of the polymer itself. They are attached to side chains grafted onto a polymeric backbone.

Because of their structure, the new polymeric dispersants enable a thicker coating to be built up around each particle of titanium dioxide. This greatly reduces the tendency for pigment particles to clump together in aggregates and gives greatly improved dispersion. The better dispersion results in turn in better performance of the finished paint film, including improvements in weather resistance, gloss and gloss retention, hiding power, film strength, and stability to ultra-violet radiation.

Apart from their use in paints the new polymeric dispersants could find wide application in the manufacture of rubber, paper, and plastics where finely divided mineral particles have to be dispersed in various organic materials.

Dry rendering of offal

Over a quarter of a million tons of tallow and similar quantities of bone meal are produced in Australia each year by rendering the bone and offal from abattoirs. The rendering is normally carried out in batches in steam-jacketed cookers holding 8000–9000 pounds of offal. Heating the offal for 2–2½ hours dries off most of the moisture as steam and the molten tallow is then separated from the remaining solids. The batch handling of offal and products involves a good deal of unpleasant manual work and labour costs are high. A few continuous rendering plants, installed in some larger abattoirs, work satisfactorily and reduce labour costs, but their design is based on batch cooker techniques and they have certain limitations as regards minimum capacity and flexibility of control.

From the results of tests made on a full-scale batch cooker, the DIVISION OF CHEMICAL ENGINEERING has built up a detailed picture of the way the batch process operates. With this knowledge the Division has proposed a new continuous dry rendering process which, it is hoped, will overcome the major problems of batch operation. A re-circulating stream of hot tallow would be used to heat the feed materials by direct contact. In addition, the flow of tallow would be used to separate high-protein materials from heavy, mainly bone materials, enabling separate high-protein and low-protein meals to be produced. Various aspects of the proposed process are now under investigation by the Division.

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.
Finance: $1,933,671 (Treasury $1,919,283, contributory $14,388)
Staff: Research scientists 40, other professional staff 29, supporting staff 168

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

Division of Physics

Location: Chippendale, Sydney, with an optical observatory at the CSIRO Solar Observatory, Culgoora, N.S.W.
Finance: $1,012,225 (Treasury $967,022, contributory $45,203)
Staff: Research scientists 21, other professional staff 24, supporting staff 59

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

Division of Applied Physics

Location: Chippendale, Sydney
Finance: Treasury $1,730,632
Staff: Research scientists 37, other professional staff 50, supporting staff 129

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

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

Division of Tribophysics

Location: Parkville, Melbourne

Finance: Treasury \$430,189

Staff: Research scientists 23, other professional staff 7, supporting staff 24

Fields of research:
Identification, classification, and properties of crystal defects in metal crystals
Defects in molecular crystals and their effect on properties such as strength and plasticity
Effect of crystal defects on properties such as adsorption and catalysis on the surface of metals

Physical Metallurgy Section

Location: Parkville, Melbourne

Finance: Treasury \$61,354

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

Upper Atmosphere Section

Location: Camden, N.S.W.

Finance: Treasury \$123,166

Staff: Research scientists 4, other professional staff 2, supporting staff 10

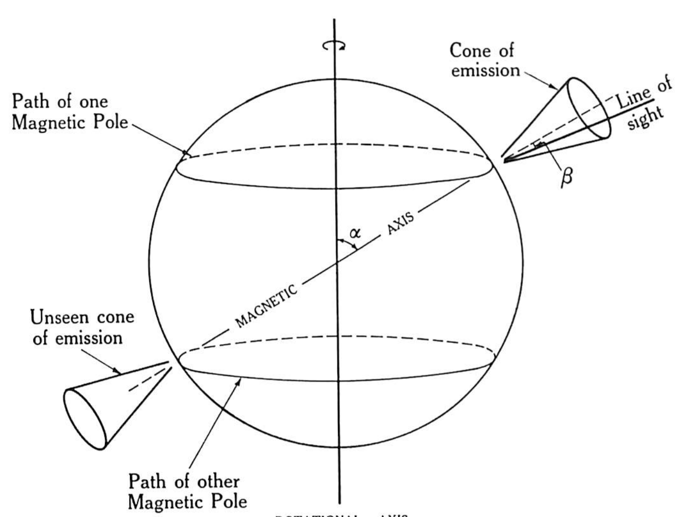
Fields of research:
Physics of the upper atmosphere and ionosphere
Chemistry of upper atmospheric gases and ions

Pulsars explained

Observations by the DIVISION OF RADIOPHYSICS with the Parkes 210-foot radio telescope have established that pulsars are the remains of stars that have collapsed to a state of immensely high density. When a star like the Sun has burnt up all its nuclear energy resources it can no longer support itself against the force of gravity. A sudden collapse occurs with such violence that the star explodes as a supernova. The outer layers are blown away to form a supernova remnant such as the well-known Crab Nebula, and theory predicts that the core will contract to become a 'neutron star'. A star like the Sun would have had, in its original state, a central density of 100 grammes per cubic centimetre, a slow rotation (say, once in 27 days), and a weak magnetic field (say, 1 gauss). After collapse, the core would have a density of 10^{15} grammes per cubic centimetre, would rotate once a second or so, and would have a magnetic field of 10^{13} gauss.

Such bizarre objects as neutron stars would have remained unobservable but for the fact that they emit short pulses of energy. These pulses were first detected at radio wavelengths as trains of regularly spaced pulses of variable height. The intervals between pulses ranged from 0·03 to 4 seconds. Observations at Parkes showed that the radiation in the pulses was linearly polarized and that the plane of polarization swept through a wide angle from the start to the end of the pulse. This observation provided the solution to how the pulses originated. Charged particles near the magnetic poles of a neutron star are accelerated to high energies along the lines of force of the intense magnetic field and radiate energy into a narrow cone centred on the pole (see below). When the magnetic axis is inclined to the rotational axis, the cone of emission sweeps around like a searchlight beam, so that we observe a pulse each time the beam passes by the Earth.

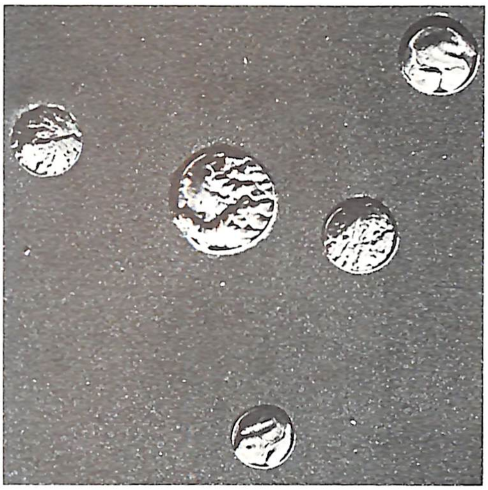
In some cases the magnetic axis is at right angles to the rotational axis and two pulses are observed each rotation. This occurs in the pulsar in the Crab Nebula. In photographs of the Crab Nebula, this pulsar looks the same as a normal star; however, all the light from it is emitted as pulses synchronous with the radio pulses. Pulsed radiation is also detected at X-ray and gamma-ray wavelengths.



Pollution in the upper atmosphere

There is no rain in the upper atmosphere to wash away pollutants and the fall-out of particles from this region is very slow. Because of this, some scientists have expressed concern at the dangers of pollution in the upper atmosphere and have warned of the possibility of a 'grey blanket of high-level smog enveloping the earth'.

This acid is thought to have been formed from sulphur dioxide discharged into the atmosphere at ground level. As the sulphur dioxide diffuses upwards through the atmosphere it becomes oxidized and reacts with water to form sulphuric acid. The presence of large numbers of acid droplets in the upper atmosphere implies an increase in the amount of sulphur dioxide relative to ammonia.



Typical particles found in 1962 (left) and 1970 (right).

There is a well-defined layer of relatively large particles in the stratosphere between heights of 40,000 and 70,000 feet. From 1962 to 1964 the DIVISION OF RADIOPHYSICS collected and examined these particles with the help of United States Air Force U–2 aircraft then based in Australia. Since 1968 sampling has been resumed and extended to altitudes of 135,000 feet using high-altitude balloons.

The particles are now more numerous than they were in 1962 and are quite different. In 1962 the particles collected at 66,000 feet were nearly all solid ammonium sulphate, but now they are almost exclusively droplets of concentrated sulphuric acid.

This increase may have had a natural cause. Enormous quantities of sulphurous gases and particles were ejected high into the atmosphere following an extremely large volcanic eruption in Indonesia in 1963. The sulphuric acid produced from these gases deposited on the pre-existing and injected particles and may have temporarily swept the lower stratosphere clean of ammonia and ammonium sulphate. Industrial activity and air traffic may also be contributing to the amount of sulphur dioxide in the upper atmosphere but the extent of this is not yet known. Only further observations will make it possible to determine whether this problem is predominantly man-made or natural.

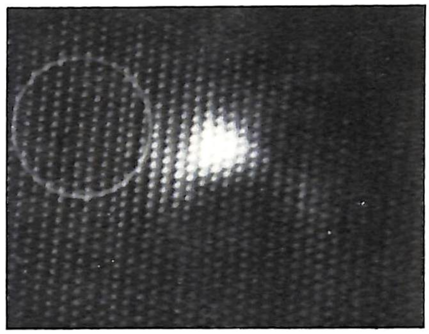
'Westward-Ho'

Since early 1968 the Sun has been observed regularly with the radioheliograph operated by the DIVISION OF RADIOPHYSICS at the CSIRO Solar Observatory at Culgoora, New South Wales. This unique instrument gives second-by-second pictures of the Sun's radio emissions at a frequency of 80 megahertz. Many solar bursts of varying sizes, shapes, complexity, and polarization have been recorded, but only twice has it been possible to follow a radio-emitting cloud of solar gas—ejected in an explosion near the surface of the Sun—to the great distance shown in the accompanying photographs.

The first of these dramatic events, nicknamed 'Westward-Ho', occurred on March 2, 1969. Optical astronomers from the University of Hawaii saw a spectacular ejection of solar gas which started explosively at about 7.30 a.m. Sydney time. The greatest visible extent of this eruption is shown in the photograph overleaf where the disk of the Sun has been artificially eclipsed.

When the radioheliograph picked up the moving cloud at 9.15 a.m. (**1**) it was already about 480,000 miles beyond the edge of the visible Sun (indicated by the white circle in the photographs). The cloud had a volume about a million times that of the Earth. For the next $2\frac{1}{4}$ hours the cloud moved outwards at a steady speed of 170 miles a second, until at 11.30 a.m. it became too faint for further detection nearly 2 million miles out from the edge of the visible Sun (**5**). During the ascent, at about 10.05 a.m., a second cloud became visible (**3**, **4**), slightly behind and above the original one; the radio emission of the two clouds was oppositely polarized, indicating that they lay in magnetic fields of opposite polarity.

How clouds of magnetized solar gas escape from the Sun is a question of



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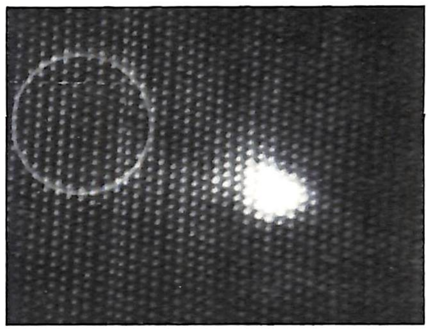

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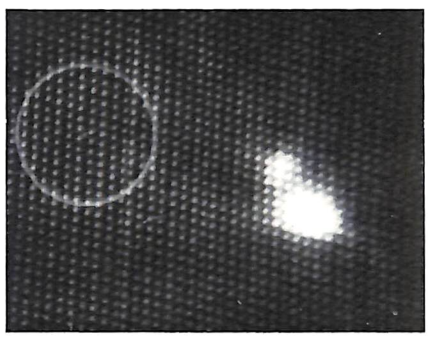

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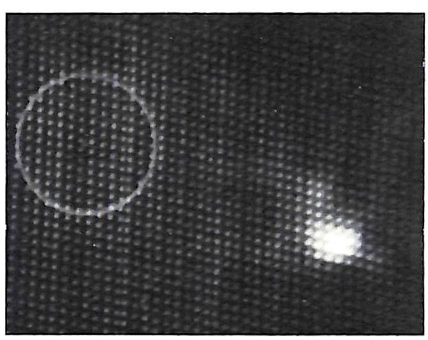

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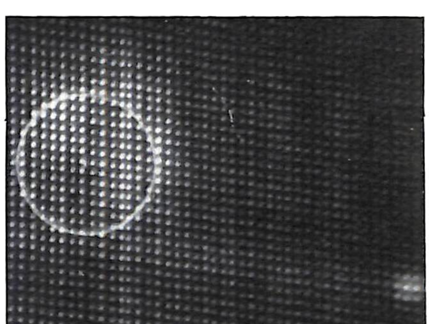

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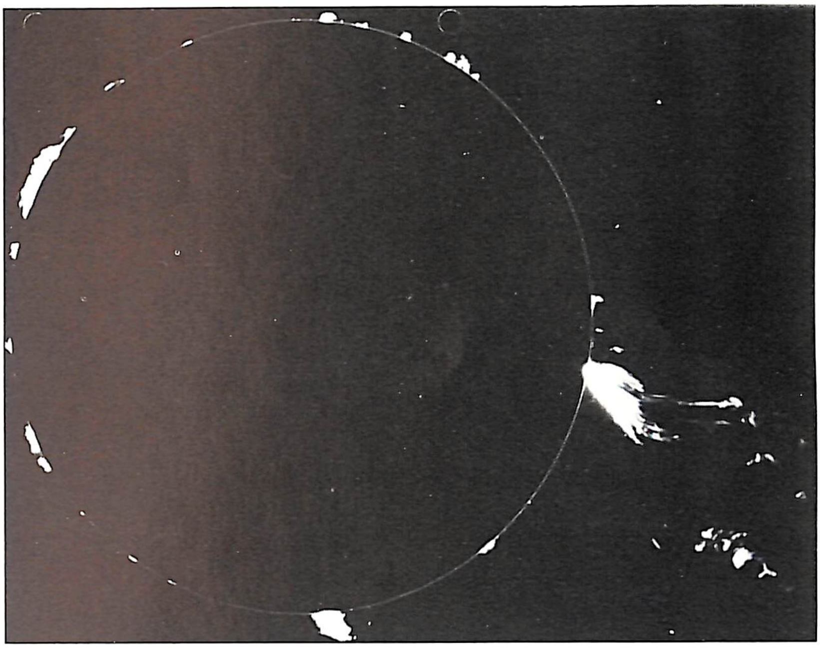

An ejection of solar gas from the Sun photographed on March 2, 1969, by the Institute for Astronomy, University of Hawaii.

great interest because these clouds sometimes impinge on the Earth's upper atmosphere, causing magnetic storms and auroras and disrupting radio communication.

Measuring heat radiation

When calculating the amount of heat radiated by a hot object, physicists use the Stefan–Boltzmann radiation constant σ. This constant can be calculated theoretically from other fundamental constants—the speed of light c, Planck's constant h, and Boltzmann's constant K. However, direct measurements of σ made over the past 50 years have consistently given a higher value, the average difference being as great as $1\frac{1}{2}\%$. This disagreement has hindered the development of more accurate standards for measuring heat radiation and has also raised doubts concerning the accuracy of temperature measurement.

Since 1967 the DIVISION OF PHYSICS has been remeasuring σ, as part of its programme for improving standards for measurement. The radiator used has been a 9 inch (230 mm) deep cavity in a graphite block, heated to the melting-point of gold which is about 1064·4°C. The radiant heat has been measured with a specially developed detector which absorbs more than 99·9% of the incident radiation and can be calibrated independently by electrical heating. Unlike the previous measurements, the value obtained for σ differs from the theoretical result by less than the experimental uncertainty, which is about 0·2%. This work has verified the fundamental laws of radiation. It has also provided an independent confirmation of the melting-point of gold, which is one of the fixed points on the International Practical Temperature Scale.

Elasticity in crystals

The resistance to elastic deformation of most metals and other crystalline materials varies with direction within the crystal. This variation, which is termed elastic anisotropy, is reflected in certain of the mechanical properties of the material. For example, the energy needed to produce a defect such as a dislocation is greater in some directions within the crystal than in others. Because of this, dislocations for which the main atomic displacements are in elastically 'hard' directions have a higher energy than dislocations for which the main displacements are in elastically 'soft' directions.

Research by the DIVISION OF TRIBOPHYSICS has shown that when the elastic anisotropy is sufficiently large, dislocations avoid certain crystal directions for which they would have high energies and follow a zigzag course rather than run in these 'forbidden' directions. Zigzag dislocations can therefore be used as gauges to measure the degree of elastic anisotropy in a crystal. The geometry of the zigzag dislocation from which the elastic anisotropy is determined can be observed with the electron microscope. Since extremely small areas can be studied, the elastic anisotropy of minute crystals can be determined. This represents a major advance over previous techniques which could only be used with large precisely oriented crystals.

Measuring lengths with lasers

In 1960 the metre was redefined in terms of the wavelength of radiation from the gas krypton-86. Using a krypton discharge lamp and an instrument known as an interferometer, lengths of up to 1 metre can be measured with a precision of a few parts in 100 million. Krypton lamps cannot be used, however, for measuring longer lengths. In theory, at least, it should be possible to use lasers in conjunction with an interferometer to measure length directly over distances up to thousands of metres with a precision comparable to that obtained over very short distances with a krypton lamp. This is because of the colour purity and high intensity of laser light.

Most lasers are of fairly fragile construction, and thermal expansion and mechanical and acoustical disturbances can cause slight variations in the mechanical separation of the mirrors at either end of the laser discharge tube. As a result the wavelength emitted may vary by several parts in a million, making precise measurements impossible. Stabilized lasers, which embody complex control elements and control systems, are available but are expensive. These lasers show a reproducibility of wavelength of about 1 part in 10 million over fairly long periods.

The DIVISION OF APPLIED PHYSICS has designed and built a simple helium–neon laser with high mechanical stability using standard precision workshop methods. The laser tube is made of fused silica and the separation of the mirrors at either end of the tube can be adjusted by temperature control in an oil bath. Wavelength stability over a period of hours is better than 1 part in 100 million and the same wavelength has been reproducible over a period of months to within 5 parts in 100 million. As the wavelength of the light emitted by the laser depends on the separation of the mirrors, it is necessary for it to be checked periodically against the primary krypton-86 standard. This is not difficult and, with the stability achieved, is not needed very often.

Statistics and computation

Division of Computing Research

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

Finance: Treasury $448,967

Staff: Research scientists 9, other professional staff 30, supporting staff 60

Fields of research:
Improvement of operating systems
Development of classification methods
Pattern recognition
Simulation techniques
Design of engineering structures
Speech recognition

Division of Mathematical Statistics

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

Finance: Treasury $562,635

Staff: Research scientists 21, other professional staff 29, 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.

Recognizing patterns

When a person looks at a picture his eye receives information about the picture in the form of light waves. Within the eye this information is coded into nerve impulses which are transmitted to the brain. Just how the brain decodes these impulses and organizes the information so that different shapes and patterns and their relationships to one another can be perceived in a meaningful way is not yet understood.

Experience gained in the DIVISION OF COMPUTING RESEARCH over the past few years on pattern recognition and picture interpretation indicates that our lack of fundamental knowledge about the way the brain handles visual information is responsible for our failure to be able to build a general computational model that could be applied to many types of recognition problems. For example, the Division has developed programs that enable its computer to recognize characters drawn on the graphic display screen with a light-pen and has also developed a language, called RAMOS, with which it is possible to talk about objects, their attributes, and their relationships with other objects.

To try to uncover the common ground shared by the various types of recognition problems, the Division has embarked on a long-term project to develop programs that simulate human visual perception of a single arbitrary figure by investigating various relationships that can be computed on the boundary of the figure. With knowledge of this sort it would be possible for computers to handle new processes and for the range of their tasks to be greatly extended.

Executive appointment

Mr. V. D. Burgmann, B.Sc., B.E., was appointed to the Executive in May 1970. A graduate in science and electrical engineering from the University of Sydney, Mr. Burgmann joined the Division of Radiophysics in 1939 to work on radar. During the war he spent some time as liaison officer in London and Washington where he was responsible for collecting information for Australia on developments in radar research. He also spent a period at the Radiation Laboratory of the Massachusetts Institute of Technology.

After the war Mr. Burgmann led a research team which developed navigation aids for civil aviation. The team's main achievement was Distance Measuring Equipment, which is now a standard installation in all domestic aircraft. Mr. Burgmann shared the 1951 Bronze Medal of the British Institute of Navigation.

In 1949 he became Officer-in-Charge of the Physics and Engineering Unit of the Wool Textile Research Laboratories. The Unit became the Division of Textile Physics in 1958 with Mr. Burgmann as its Chief. He was appointed an Associate Member of the Executive in March 1969.

Textile Physics Chief

Mr. J. G. Downes, B.Sc., was appointed Chief of the Division of Textile Physics in November 1969.

Mr. Downes has been engaged in wool textile research since 1951 when he joined the Physics and Engineering Unit, now the Division of Textile Physics, of the Wool Research Laboratories. In recent years he has pioneered research on the objective measurement of wool for marketing. This research has led to the development by his team of a number of novel instruments for the rapid testing of raw wool, including pressure coring instruments and other wool bale sampling devices, yield and fineness testers, and a direct reading regain tester. Mr. Downes has also worked on the sorption properties of wool fibres, the electrical properties of wool, and the compression characteristics of greasy wool.

Mr. Downes worked in the Division of Radiophysics from 1945 to 1951, and played a major role in the development of Distance Measuring Equipment for aircraft. From 1938 to 1945 Mr. Downes was a design and development engineer with Amalgamated Wireless (A/asia) Ltd. and in 1946 he graduated B.Sc. with honours from the University of London.

Tribophysics Chief

Dr. J. R. Anderson, B.Sc., Ph.D., was appointed Chief of the Division of Tribophysics in May 1970. He succeeded Dr. W. Boas who retired the previous year. Dr. Anderson graduated B.Sc. with first-class honours from the University of New South Wales in 1950. He was awarded a Royal Dutch/Shell Commonwealth Post-graduate Scholarship and gained his Ph.D. from the University of Cambridge in 1954.

In 1955 and 1956 he was Lecturer in Physical Chemistry at the University of New South Wales and from 1957 to 1964 Senior Lecturer and Reader in Physical Chemistry at the University of Melbourne. He was appointed Professor of Chemistry at Flinders University in 1965 and Chairman of the University's School of Physical Sciences in 1967.

Dr. Anderson was Visiting Scientist at the General Electric Research and Development Center in the United States in 1968/69, and worked there on the application of low-energy electron diffraction to metal surfaces. During 1969 he was Visiting Professor at the University of Caen, France.

Most of Dr. Anderson's research has been directed towards obtaining a better understanding of the reactions of gases at and with metal surfaces.

Deaths

Mr. K. J. Fogarty, CHEMICAL RESEARCH LABORATORIES
Dr. D. F. Martyn, UPPER ATMOSPHERE SECTION
Mr. C. J. Sumner, METEOROLOGICAL PHYSICS
Mr. S. M. Sykes, FOOD PRESERVATION
Dr. G. F. Walker, APPLIED MINERALOGY

Retirements

Mr. W. D. Andrew, PLANT INDUSTRY
Dr. C. Barnard, PLANT INDUSTRY
Mr. T. G. Campbell, ENTOMOLOGY
Miss Alma Culey, ANIMAL HEALTH
Mr. J. Freiheiter, APPLIED PHYSICS
Mr. T. Gelb, BUILDING RESEARCH
Mr. N. P. Graham, ANIMAL HEALTH
Mr. S. G. Gray, TROPICAL PASTURES
Mr. J. Hanna, APPLIED PHYSICS
Dr. F. E. Huelin, FOOD PRESERVATION.
Dr. A. G. Nicholls, FISHERIES AND OCEANOGRAPHY
Mr. F. Penman, CONSULTANT TO THE EXECUTIVE (IRRIGATION)
Mr. R. B. Withers, FOOD PRESERVATION

Professorships

Dr. J. B. Langridge, PLANT INDUSTRY, has been appointed Professor and Head of the Department of Genetics in the Research School of Biological Sciences at the Australian National University. Under an arrangement between the University and CSIRO, Professor Langridge will combine his university role with his duties in CSIRO.

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

Dr. J. Ferguson, APPLIED PHYSICS; Professorial Fellow, Research School of Chemistry, Australian National University.

Dr. R. T. Leslie, MATHEMATICAL STATISTICS; Professor of Mathematical Statistics, University of Strathclyde, Glasgow, Scotland.

Dr. M. J. T. Norman, LAND RESEARCH; Professor of Agronomy, University of Sydney.

Mr. R. G. Pearson, FOREST PRODUCTS; Associate Professor of Wood Mechanics, North Carolina State University, Raleigh, United States.

Dr. K. J. Reid, CHEMICAL ENGINEERING; Associate Professor of Mining Engineering, McGill University, Montreal, Canada.

Honours and awards

Mr. C. S. Andrew, TROPICAL PASTURES; Doctor of Agricultural Science, University of Queensland.

Dr. C. Barnard (retired), PLANT INDUSTRY; Member of the Order of the British Empire.

Mr. H. P. Black, HEAD OFFICE; Polar Medal.

Mr. E. E. Bond, WHEAT RESEARCH UNIT; President of the International Association for Cereal Chemistry.

Mr. W. W. Bryan, TROPICAL PASTURES; Doctor of Agricultural Science, University of Queensland.

Mr. C. S. Christian, MEMBER OF THE EXECUTIVE; Farrer Memorial Medal.

Dr. P. J. Claringbold, ANIMAL GENETICS; Fellow of the Australian Computer Society.

Mr. I. F. B. Common, ENTOMOLOGY; Doctor of Agricultural Science, University of Queensland.

Mr. R. V. Dunkle, MECHANICAL ENGINEERING; Mechanical Engineering Prize, Institution of Engineers, Australia (shared).

Mr. C. A. Gladman, APPLIED PHYSICS; Jack Finlay National Award, Institution of Production Engineers.

Mr. J. F. Hayes, DAIRY RESEARCH; Silver Medal, Australian Society of Dairy Technology.

Dr. A. K. Head, TRIBOPHYSICS; David Syme Research Prize (shared).

Mr. D. E. Henshaw, TEXTILE INDUSTRY; Member of the Order of the British Empire.

Dr. H. G. Higgins, FOREST PRODUCTS; President, International Association of Scientific Papermakers.

Mr. F. G. Hogg, MECHANICAL ENGINEERING; Fellow of the Institution of Mechanical Engineers.

Dr. R. D. Hughes, ENTOMOLOGY; Doctor of Science, University of London.

Dr. E. M. Hutton, TROPICAL PASTURES; President, Eleventh International Grassland Congress.

Mr. H. Kobler, PHYSICS; Fellow of the Institution of Engineers, Australia.

Mr. M. Kovarik, MECHANICAL ENGINEERING; Fellow of the Australian Computer Society.

Dr. J. J. Kowalczewski, MECHANICAL ENGINEERING; Fellow of the Institution of Engineers, Australia.

Dr. G. N. Lance, COMPUTING RESEARCH; Fellow of the Australian Computer Society.

Dr. A. McL. Mathieson, CHEMICAL PHYSICS; Member of Executive Committee, International Union of Crystallography.

Dr. A. J. Millington, LAND RESEARCH; Fellow of the Australian Institute of Agricultural Science.

Dr. F. H. W. Morley, PLANT INDUSTRY; Medal of the Australian Institute of Agricultural Science.

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

Mr. R. Muncey, FOREST PRODUCTS; Doctor of Applied Science, University of Melbourne.

Dr. J. N. Olley, FOOD PRESERVATION; Fellow of the Institute of Food Science Technology, Britain.

Dr. G. W. Paltridge, METEOROLOGICAL PHYSICS; Marconi Premium of the Institution of Engineers, Britain (shared).

Mr. T. Pearcey, COMPUTING RESEARCH; Fellow of the Australian Computer Society.

Dr. H. R. C. Pratt, CHEMICAL ENGINEERING; Vice-President, Institution of Chemical Engineers, Britain.

Dr. J. R. Price, CHAIRMAN; Leighton Memorial Medal, Royal Australian Chemical Institute.

Dr. C. H. B. Priestley, METEOROLOGICAL PHYSICS; Chairman, National Committee for the Global Atmospheric Research Programme, Australian Academy of Science.

Dr. A. L. G. Rees, CHEMICAL PHYSICS; President, International Union of Pure and Applied Chemistry; Secretary (International Relations), Australian Academy of Science.

Dr. A. F. Reid, MINERAL CHEMISTRY; Doctor of Science, Australian National University; David Rivett Medal of the CSIRO Officers Association.

Dr. D. S. Roberts, ANIMAL HEALTH; Doctor of Veterinary Science, University of Sydney.

Mr. K. A. Robeson, MECHANICAL ENGINEERING; Mechanical Engineering Prize, Institution of Engineers, Australia (shared).

Mr. R. R. Rochford, PLANT INDUSTRY; British Empire Medal.

Dr. D. H. Solomon, APPLIED MINERALOGY; Doctor of Science, University of New South Wales.

Mr. G. M. Stiff, CHEMICAL PHYSICS; Member of the Order of the British Empire.

Mr. W. C. Swinbank, METEOROLOGICAL PHYSICS; Fellow of the Australian Academy of Science.

Miss Helen Newton Turner, ANIMAL GENETICS; Doctor of Science, University of Sydney.

Professor E. J. Underwood, MEMBER OF THE EXECUTIVE; Fellow of the Royal Society.

Mr. R. A. Wallis, MECHANICAL ENGINEERING; Institution Award, Institution of Engineers, Australia.

Dr. A. Walsh, CHEMICAL PHYSICS; Foreign Member, Royal Academy of Sciences, Stockholm, Sweden; Honorary Doctor of Science, Monash University; Honorary Member, The Society for Analytical Chemistry, London.

Mr. D. V. Walters, HEAD OFFICE; Fellow of the Australian Institute of Agricultural Science.

Dr. D. F. Waterhouse, ENTOMOLOGY; Companion of the Order of St. Michael and St. George.

Sir Frederick White (retired); Honorary Doctor of Science, Australian National University; Chairman of ANZAAS.

Dr. G. K. White, PHYSICS; Fellow of the Australian Academy of Science.

Dr. J. P. Wild, RADIOPHYSICS; Fellow of the Royal Society.

Mr. H. H. Wilson (retired), ANIMAL HEALTH; Imperial Service Medal.

Mr. E. R. Wishart, RADIOPHYSICS; Polar Medal.

Dr. R. A. Wooding, PLANT INDUSTRY; Doctor of Science, Victoria University of Wellington, New Zealand.

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E. E. Tomlinson
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W. R. Wallace, Dip.For.
Professor H. H. Waring, D.Sc., F.A.A.
J. P. Brophy (*Secretary*)

Staff

The following is a list of professional and senior administrative staff of the Organization as at June 30, 1970.

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MEMBERS OF THE EXECUTIVE
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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)

Secretariat

Administrative Branch

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ASSISTANT SECRETARY (WORKS AND BUILDINGS)
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R. B. Fuller, A.R.A.I.A.
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Upper Atmosphere Section

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Division of Wildlife Research

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Wool Research Laboratories

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Division of Protein Chemistry

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Division of Textile Industry

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G. C. West, A.G.Inst.Tech.

Division of Textile Physics

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

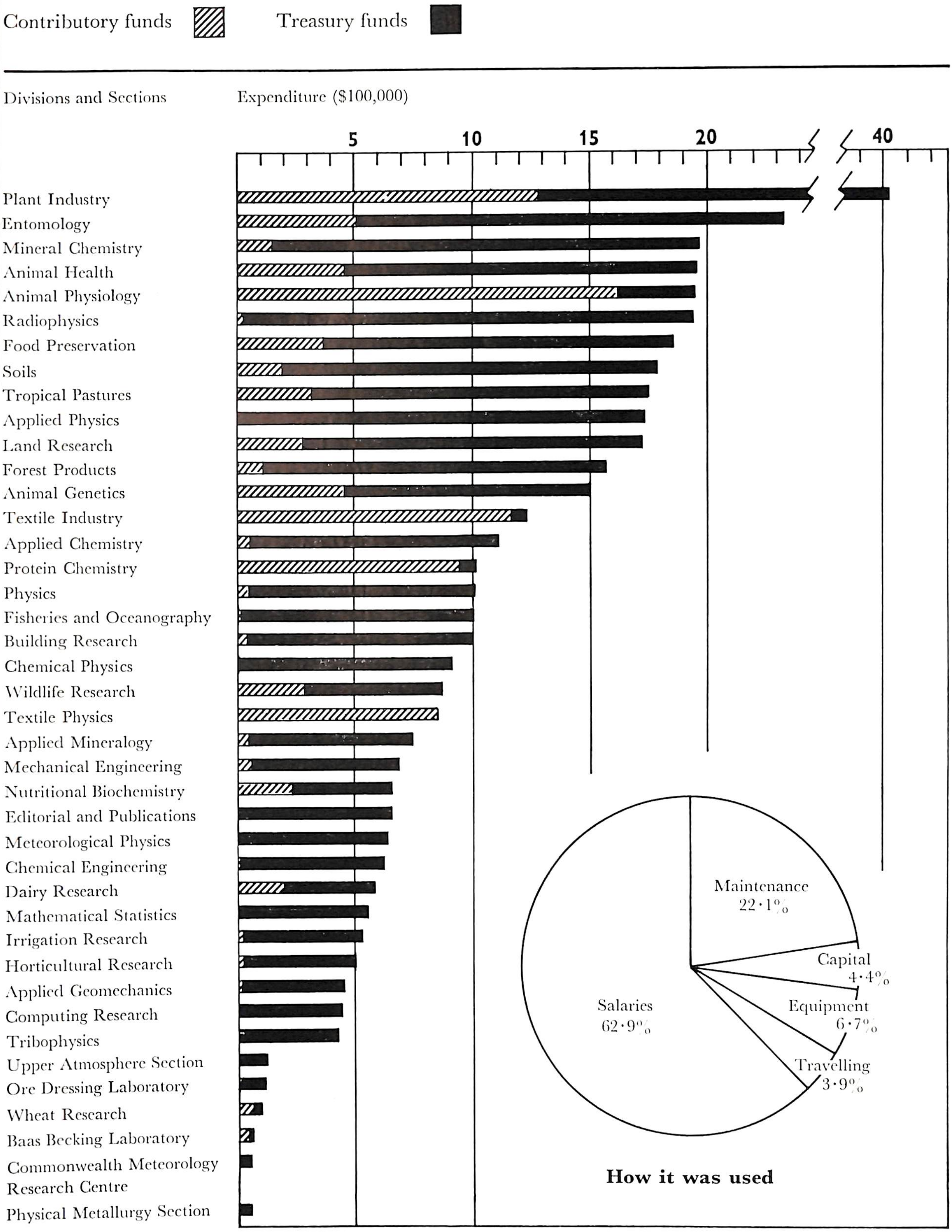
G. B. Gresford, B.Sc., A.R.M.T.C. (*seconded to United Nations as Director for Science and Technology, Department of Economic and Social Affairs*)
F. G. Nicholls, M.Sc. (*seconded to the International Union for Conservation of Nature and Natural Resources, Switzerland*)
SENIOR PRINCIPAL RES. SCIENTIST
D. B. Williams, B.Sc.Agr., B.Com., Ph.D. (*seconded to University of Melbourne*)
PRINCIPAL RESEARCH SCIENTIST
Miss S. H. Allen, B.Sc.

Finance

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	38,092,004	1,445,471	1,659,549	41,197,024
Wool Research Trust Fund	6,451,842	—	378,063	6,829,905
Meat Research Trust Account	1,035,038	—	104,543	1,139,581
Wheat Research Trust Account	253,380	—	1,993	255,373
Dairy Produce Research Trust Account	311,522	—	4,312	315,834
Tobacco Industry Trust Account	209,988	—	—	209,988
Other contributors	1,692,977	—	124,445	1,817,422
Total	48,046,751	1,445,471	2,272,905	51,765,127

Expenditure on investigations by Divisions and Sections 1969/70



Annual Expenditure

The following summary gives details of expenditure by CSIRO Divisions and Sections on other than capital items from July 1, 1969 to June 30, 1970.

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.	3,005,680	29,991	3,035,671
Research Programmes			
Animal Health and Reproduction			
Animal Genetics	1,041,794	459,739	1,501,533
Animal Health	1,495,516	466,198	1,961,714
Animal Physiology	340,061	1,618,143	1,958,204
Nutritional Biochemistry	443,999	213,379	657,378
Plant Industry	2,748,998	1,275,544	4,024,542
Entomology and Wildlife			
Entomology	1,809,466	514,120	2,323,586
Wildlife Research	588,225	284,889	873,114
Soils	1,615,585	183,718	1,799,303
Horticulture and Irrigation			
Horticultural Research	481,561	21,994	503,555
Irrigation Research	508,231	19,977	528,208
Tropical Pastures	1,425,832	323,388	1,749,220
Land Research			
Land Research	1,249,367	274,247	1,523,614
Rangelands Research	198,899	—	198,899
Processing of Agricultural Products			
Food Preservation	1,490,661	364,106	1,854,767
Dairy Research	368,988	199,749	568,737
Wheat Research	22,351	69,456	91,807
Textile Industry	70,159	1,163,011	1,233,170
Textile Physics	—	861,350	861,350
Information and Publications			
Central Library	269,179	—	269,179
Editorial and Publications Section	656,879	—	656,879
Film Unit	89,171	2,881	92,052

Chemical Research of Industrial Interest			
Administration of Chemical Research Laboratories	457,747	—	457,747
Chemical Engineering	623,024	14,782	637,806
Applied Chemistry	1,060,164	51,142	1,111,306
Chemical Physics	914,486	5,173	919,659
Protein Chemistry	67,201	948,999	1,016,200
Fisheries and Oceanography	993,381	9,799	1,003,180
Processing and Use of Mineral Products			
Mineral Chemistry	1,836,381	134,919	1,971,300
Applied Mineralogy	696,544	40,686	737,230
Physical Metallurgy	61,354	—	61,354
Ore Dressing Investigations—Melbourne	106,913	4,682	111,595
Baas Becking Geobiological Group	8,000	59,859	67,859
Physical Research of Industrial Interest			
Physics	967,022	45,203	1,012,225
Applied Physics	1,730,632	—	1,730,632
General Physical Research			
Radiophysics	1,919,283	14,388	1,933,671
Meteorological Physics	648,976	—	648,976
Upper Atmosphere	123,166	—	123,166
Radio Research Board	40,000	45,975	85,975
Commonwealth Meteorology Research Centre	62,197	—	62,197
General Industrial Research			
Building Research	958,100	39,207	997,307
Tribophysics	430,189	—	430,189
Applied Geomechanics	438,938	16,412	455,350
Mechanical Engineering	629,899	56,425	686,324
Processing of Forest Products			
Forest Products	1,464,083	108,845	1,572,928
Research Services			
Computing Research	448,967	—	448,967
Mathematical Statistics	562,635	—	562,635
Western Australian Laboratories	231,815	—	231,815
Extramural investigations	59,015	—	59,015
Australian Mineral Development Laboratories	59,990	—	59,990
Development projects	130,264	—	130,264
Miscellaneous	441,036	12,371	453,407
Grants			
Research Associations	314,173	—	314,173
Research studentships	359,803	—	359,803
Other grants and contributions	771,495	—	771,495
Total expenditure	39,537,475	9,954,747	49,492,222

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	1,701	—	1,701
Animal Health and Reproduction			
Animal Genetics	63,013	38,804	101,817
Animal Health	103,588	—	103,588
Animal Physiology	14,600	50,447	65,047
Nutritional Biochemistry	1,428	23,127	24,555
Plant Industry	110,093	18,039	128,132
Entomology and Wildlife			
Entomology	23,080	8,187	31,267
Wildlife Research	8,967	23,186	32,153
Soils	46,139	—	46,139
Horticulture and Irrigation			
Horticultural Research	50,304	49	50,353
Irrigation Research	19,106	—	19,106
Tropical Pastures	146,504	15,798	162,302
Land Research			
Land Research	32,565	—	32,565
Rangelands Research	18,631	—	18,631
Processing of Agricultural Products			
Food Preservation	82,706	32,920	115,626
Dairy Research	8,697	50,000	58,697
Wheat Research	—	1,492	1,492
Textile Industry	11,034	153,567	164,601
Textile Physics	—	112,254	112,254
Information and Publications			
Central Library	105	—	105
Editorial and Publications Section	10,192	—	10,192
Chemical Research of Industrial Interest			
Administration of Chemical Research Laboratories	1,964	—	1,964
Chemical Engineering	138,840	—	138,840
Applied Chemistry	59,597	—	59,597
Chemical Physics	22,745	—	22,745
Protein Chemistry	—	58,621	58,621
Fisheries and Oceanography	2,800	—	2,800
Processing and Use of Mineral Products			
Mineral Chemistry	34,692	—	34,692
Applied Mineralogy	70,734	13,266	84,000
Physical Research of Industrial Interest			
Physics	54,505	—	54,505
Applied Physics	40,848	—	40,848
General Physical Research			
Radiophysics	180,808	—	180,808
Meteorological Physics	3,132	—	3,132
Upper Atmosphere	13,500	—	13,500
General Industrial Research			
Building Research	22,632	—	22,632
Applied Geomechanics	27,086	—	27,086
Mechanical Engineering	34,925	13,599	48,524
Processing of Forest Products			
Forest Products	57,736	—	57,736
Research Services			
Computing Research	111,879	—	111,879
Western Australian Laboratories	21,010	—	21,010
Miscellaneous	7,663	—	7,663
Total capital expenditure	1,659,549	613,356	2,272,905

Contributions

This table summarizes receipts and disbursements during 1969/70 of funds provided by contributors and recorded in a special account entitled 'Special 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 1969/70 and balances brought forward ($)**	**Expenditure 1969/70 ($)**
Animal Genetics		
Wool Research Trust Fund	371,628	345,270
Meat Research Trust Account	86,404	79,843
Other contributions	91,478	73,430
Animal Health		
Wool Research Trust Fund	268,139	252,846
Meat Research Trust Account	202,022	177,055
Dairy Produce Research Trust Account	17,767	17,398
Other contributors	32,377	18,899
Animal Physiology		
Wool Research Trust Fund	1,588,863	1,555,009
Meat Research Trust Account	87,000	69,982
Dairy Produce Research Trust Account	—	7,590*
Other contributors	47,531	36,009
Nutritional Biochemistry		
Wool Research Trust Fund	220,196	213,379
Meat Research Trust Account	28,900	23,127
Plant Industry		
Wool Research Trust Fund	1,302,474	915,557
Meat Research Trust Account	549	535
Wheat Research Trust Account	24,693	22,987
Dairy Produce Research Trust Account	15,250	16,557*
Tobacco Industry Trust Account	238,895	209,988
Other contributors	200,382	127,959
Entomology		
Wool Research Trust Fund	48,351	36,726
Meat Research Trust Account	190,500	182,406
Wheat Research Trust Account	57,612	55,897
Other contributors	445,547	247,278
Wildlife Research		
Wool Research Trust Fund	219,496	218,440
Meat Research Trust Account	113,552	86,019
Other contributors	4,169	3,616
Soils		
Wheat Research Trust Account	54,517	46,882
Other contributors	172,776	136,836
Horticultural Research		
Other contributors	28,790	22,043
Irrigation Research		
Other contributors	62,244	19,977
Tropical Pastures		
Meat Research Trust Account	165,798	158,371
Dairy Produce Research Trust Account	84,413	83,413
Other contributors	142,323	97,402
Land Research		
Meat Research Trust Account	27,464	20,232
Other contributors	310,629	254,015
Food Preservation		
Meat Research Trust Account	382,708	332,704

* Expenditure in excess of receipts will be recovered in 1970/71.

DIVISION OR SECTION	Receipts 1969/70 and balances brought forward ($)	Expenditure 1969/70 ($)
Wheat Research Trust Account	5,987	4,604
Other contributors	87,168	59,718
Dairy Research		
Dairy Produce Research Trust Account	202,275	190,875
Other contributors	60,000	58,874
Wheat Research Unit		
Wheat Research Trust Account	83,343	70,948
Textile Industry		
Wool Research Trust Fund	1,375,894	1,300,373
Other contributors	39,554	16,205
Textile Physics		
Wool Research Trust Fund	1,038,972	961,916
Other contributors	3,425	11,688*
Film Unit		
Other contributors	2,883	2,881
Administration of Chemical Research Laboratories		
Other contributors	1,121	—
Chemical Engineering		
Meat Research Trust Account	11,549	9,309
Other contributors	30,110	5,473
Applied Chemistry		
Wool Research Trust Fund	42,050	36,001
Other contributors	59,689	15,141
Chemical Physics		
Other contributors	29,272	5,173
Protein Chemistry		
Wool Research Trust Fund	1,058,187	963,647
Other contributors	28,150	43,973*
Fisheries and Oceanography		
Other contributors	14,132	9,799
Mineral Chemistry		
Other contributors	247,362	134,919
Applied Mineralogy		
Other contributors	108,920	53,952
Ore Dressing Investigations		
Other contributors	5,915	4,682
Baas Becking Geobiological Group		
Other contributors	107,767	59,859
Applied Physics		
Other contributors	6,736	—
Physics		
Other contributors	45,788	45,203
Radiophysics		
Other contributors	153,933	14,388
Radio Research Board		
Other contributors	57,317	45,975
Building Research		
Other contributors	101,086	39,207
Tribophysics		
Other contributors	4,521	—
Applied Geomechanics		
Other contributors	21,224	16,412
Mechanical Engineering		
Wheat Research Trust Fund	60,980	54,053
Other contributors	53,896	15,971
Forest Products		
Other contributors	169,165	108,845

* Expenditure in excess of receipts will be recovered in 1970/71.

DIVISION OR SECTION	Receipts 1969/70 and balances brought forward ($)	Expenditure 1969/70 ($)
Mathematical Statistics		
Other contributors	1,253	—
Head Office—agricultural liaison		
Wool Research Trust Fund	35,885	29,991
Miscellaneous		
Wool Research Trust Fund	1,600	750
Other contributors	413,012	11,621
	13,105,558	10,568,103
Cash advance received to meet expenditure in July 1970 against 1970/71 allocations for research financed from joint Commonwealth-Industry Research Funds:		
Wool Research Trust Fund	521,656	
Meat Research Trust Account	105,937	
Wheat Research Trust Account	19,422	
Dairy Research Trust Account	26,977	
Tobacco Industry Trust Account	20,291	
Total contributions	13,799,841	10,568,103

* Expenditure in excess of receipts will be recovered in 1970/71.

General Revenue

During 1969/70, general revenue amounting to $1,013,129 was received by the Organization. Details of the receipts are as follows:

Sale of publications	33,201
Sale of equipment purchased in former years, and other receipts	88,929
Sale of produce, including livestock	179,558
Royalties from patents	144,997
Testing fees	73,904
Computing charges to outside users	36,311
Miscellaneous receipts	456,229
Total	1,013,129

Of the above sum $877,475 was spent as part of the general estimates for 1969/70 approved by the Minister for Education and Science and the Treasurer.

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

14 August, 1970

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 1970 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, 1969 ($)	Receipts ($)	Total funds available ($)	Payments ($)	Funds held June 30, 1970 ($)
Special Account					
Parliamentary Appropriation: Operational	—	38,660,000.00	38,660,000.00	38,660,000.00	—
	(—)*	(34,141,000.00)	(34,141,000.00)	(34,141,000.00)	(—)
Parliamentary Appropriation: Capital	21,442.34	1,665,000.00	1,686,442.34	1,659,549.09	26,893.25
	(—)	(1,250,000.00)	(1,250,000.00)	(1,228,557.66)	(21,442.34)
Revenue and Other Receipts	20,127.20	1,013,128.75	1,033,255.95	877,474.90	155,781.05
	(—)	(801,717.35)	(801,717.35)	(781,590.15)	(20,127.20)
Total: Special Account	41,569.54	41,338,128.75	41,379,698.29	41,197,023.99	182,674.30
	(—)	(36,192,717.35)	(36,192,717.35)	(36,151,147.81)	(41,569.54)
Specific Research Account	2,239,504.10	11,560,336.95	13,799,841.05	10,568,102.61	3,231,738.44†
	(—)	(12,680,630.45)	(12,680,630.45)	(10,441,126.35)	(2,239,504.10)
Other Trust Moneys‡	52,392.45	302,396.92	354,789.37	322,135.99	32,653.38
	(—)	(395,407.89)	(395,407.89)	(343,015.44)	(52,392.45)
Cafeteria Account§	13,863.06	110,658.13	124,521.19	114,955.23	9,565.96
	(—)	(126,205.16)	(126,205.16)	(112,342.10)	(13,863.06)
Total	**2,347,329.15**	**53,311,520.75**	**55,658,849.90**	**52,202,217.82**	**3,456,632.08**
	(—)	**(49,394,960.85)**	**(49,394,960.85)**	**(47,047,631.70)**	**(2,347,329.15)**

* Figures in parentheses refer to 1968/69 financial year.
† Includes investments totalling $1,070,950.00.
‡ 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

1968/69 $		1969/70 $
	Head Office (including Regional Administrative Offices)	
1,859,032	Salaries and allowances	2,135,687
175,426	Travelling and subsistence	216,925
188,048	Postage, telegrams, and telephone	188,579
385,284	Incidental and other expenditure	494,480
2,607,790		3,035,671
	Research Programmes	
	Agricultural research	
5,302,451	Animal health and reproduction	6,078,829
3,773,368	Plant industry	4,024,542
2,816,003	Entomology and wildlife	3,196,700
1,524,460	Soils	1,799,303
923,831	Horticulture and irrigation	1,031,763
1,489,443	Tropical pastures	1,749,220
1,462,520	Land research	1,722,513
4,178,359	Processing of agricultural products	4,609,831
1,006,359	Information and publications	1,018,110
3,664,719	Chemical research of industrial interest	4,142,718
757,011	Fisheries and oceanography	1,003,180
2,631,430	Processing and use of mineral products	2,949,338
2,549,855	Physical research of industrial interest	2,742,857
2,461,865	General physical research	2,853,985
2,172,594	General industrial research	2,569,170
1,403,041	Processing of forest products	1,572,928
1,720,754	Research services	1,492,686
338,937	Miscellaneous	453,407
40,177,000		45,011,080
	Grants	
326,500	Research associations	314,173
337,043	Research studentships	359,803
689,948	Other grants and contributions	771,495
1,353,491		1,445,471
	Capital Works and Services	
1,575,564	Buildings, works, plant, and developmental expenditure	1,005,963
—	Scientific computing equipment	371,245
787,827	Other equipment	769,819
90,602	Development of Queensland cattle station	67,179
—	Development of Ginninderra field station	58,699
2,453,993		2,272,905
	Other Trust Moneys	
238,412	Remittance of revenue from investigations financed from Industry Trust Accounts	217,309
104,603	Other miscellaneous remittances	104,827
343,015		322,136
	Cafeteria Account	
112,342	Operating expenses of CSIRO cafeterias at Melbourne and Sydney	114,955
47,047,631	**Total Payments**	**52,202,218**

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

Statement of Payments—Special Account*

1968/69 $		1969/70 $
	Head Office (including Regional Administrative Offices)	
1,836,461	Salaries and allowances	2,115,162
172,401	Travelling and subsistence	215,697
184,548	Postage, telegrams, and telephone	188,579
378,630	Incidental and other expenditure	486,242
2,572,040		3,005,680
	Research Programmes	
	Agricultural research	
2,759,641	Animal health and reproduction	3,321,370
2,530,761	Plant industry	2,748,998
2,105,024	Entomology and wildlife	2,397,691
1,396,626	Soils	1,615,585
875,199	Horticulture and irrigation	989,792
1,202,219	Tropical pastures	1,425,832
1,202,391	Land research	1,448,266
1,727,758	Processing of agricultural products	1,952,159
1,004,132	Information and publications	1,015,229
2,702,763	Chemical research of industrial interest	3,122,622
727,737	Fisheries and oceanography	993,381
2,431,042	Processing and use of mineral products	2,709,192
2,485,454	Physical research of industrial interest	2,697,654
2,415,446	General physical research	2,793,622
2,072,544	General industrial research	2,457,126
1,311,689	Processing of forest products	1,464,083
1,720,754	Research services	1,492,686
325,879	Miscellaneous	441,036
30,997,059		35,086,324
	Grants	
326,500	Research associations	314,173
337,043	Research studentships	359,803
689,948	Other grants and contributions	771,495
1,353,491		1,445,471
	Capital Works and Services	
413,443	Buildings, works, plant, and developmental expenditure	507,242
—	Scientific computing equipment	371,245
724,513	Other equipment	655,184
90,602	Development of Queensland cattle station	67,179
—	Development of Ginninderra field station	58,699
1,228,558		1,659,549
36,151,148	**Total Payments**	**41,197,024**

* 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

1968/69 $		1969/70 $
	Head Office (including Regional Administrative Offices)	
22,571	Salaries and allowances	20,525
3,025	Travelling and subsistence	1,228
3,500	Postage, telegrams, and telephone	—
6,654	Incidental and other expenditure	8,238
35,750		29,991
	Research Programmes	
	Agricultural research	
2,542,810	Animal health and reproduction	2,757,459
1,242,607	Plant industry	1,275,544
710,979	Entomology and wildlife	799,009
127,834	Soils	183,718
48,632	Horticulture and irrigation	41,971
287,224	Tropical pastures	323,388
260,129	Land research	274,247
2,450,601	Processing of agricultural products	2,657,672
2,227	Information and publications	2,881
961,956	Chemical research of industrial interest	1,020,096
29,274	Fisheries and oceanography	9,799
200,388	Processing and use of mineral products	240,146
64,401	Physical research of industrial interest	45,203
46,419	General physical research	60,363
100,050	General industrial research	112,044
91,352	Processing of forest products	108,845
13,058	Miscellaneous	12,371
9,179,941		9,924,756
	Capital Works and Services	
1,162,121	Buildings, works, plant, and developmental expenditure	498,721
63,314	Other equipment	114,635
1,225,435		613,356
10,441,126	**Total Payments**	**10,568,103**

J. R. Price (*Chairman*)

R. W. Viney (*Finance manager*)

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