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Financing Scientific Research in Australia

Federal funds and research agencies play a dominant role in the national research effort.

S. Encel

The character of scientific research in Australia must be understood in relation to a continent presenting enormous natural difficulties for European settlement. It is far from Europe and North America (Sydney, the largest city, is 12,000 miles from London). Two-thirds of its area of nearly 3 million square miles is virtually uninhabitable. In 1939 the population was close to 7 million; in 1959, after a decade of the most rapid growth in its history, the figure reached 10 million—less than that of Greater New York. The combination of geographical remoteness, difficult terrain, limited rainfall, limited natural resources, and sparse population has meant a slow rate of growth. In particular, it meant a slow rate of industrialization up to 1939, with primary production (of minerals and of pastoral and farm products) greater than the total output of secondary industry. Since World War II, secondary industry has come to account for a higher proportion of gross national product than primary industry, but Australia's prosperity still depends heavily on exports of wool and farm products, which provide 75 to 80 percent of export income. This income has generally been sufficient to support a high standard of living, especially since it has occurred in conjunction with a pattern of governmental economic intervention sometimes described as "state socialism" (*1*), whose effect has been to maintain a high level of wages (surpassed only in North America).

Industrial growth, hampered by the small internal market, by limitations in raw materials, and by remoteness from possible export markets, has been particularly dependent on high tariffs and on the large-scale investment of

The author is a senior lecturer in political science and public administration at the Australian National University, Canberra City, in the School of General Studies.

capital from overseas, mainly from Britain. Investment funds for public utilities such as railways, electricity, urban transport and water supply have been raised very largely through government action. As noted in W. W. Rostow's *Stages of Economic Growth*, mass consumption was reached before industrial maturity.

According to the official "White Paper on National Income and Expenditures," the gross national product for 1958–59 amounted to £A6250 million ($14,000 million), and national income, to £A5069 million ($11,400 million). Farm income for that year was £A458 million ($1030 million), representing 8 percent of total disposable income. According to the latest census, 13.4 percent of the work force was in agriculture, forestry, and fishing, compared with 12.5 percent in the United States and 19.3 percent in Canada, and 30 percent was in manufacturing and in power and water supply. These figures underline the importance of farm production in providing the export income which is needed for economic growth, as compared with its share in national income. Wool, moreover, normally accounts for between 40 and 50 percent of export income.

Political Background

Familiarity with the economic factors just sketched is indispensable to an understanding of the way in which scientific research in Australia has developed, largely under the auspices of the federal government (normally referred to in Australia as the Commonwealth government). An understanding of the political and constitutional framework is, however, equally important.

The federal constitution, which came into force in 1901, was framed by colonial politicians who were anxious to give away as little power as possible to a federal body whose establishment they could block no longer. They thought the American pattern the most suitable for their purpose, but to give even greater safety to the states (which the six colonies then became), the new Commonwealth government was given only certain enumerated powers, without even the general power to make laws for the peace and good government of Australia. All other "residual" powers remained with the states.

The actual development of Australian politics has largely made nonsense of this constitutional division of functions. The principal reason for this is that the financial predominance of the Commonwealth government—a predominance which has become steadily greater since federation—has given it the real power within the federal structure.

Until 1939, however, successive federal governments had done comparatively little to extend the functions of the Commonwealth into fields which the states neglected because of lack of funds, and state premiers were quick to oppose proposed extensions of Commonwealth functions on the grounds that these would involve "overlapping" or "duplication" of state activities. When the Commonwealth finally did enter the field of research, great care was taken to provide for consultation with state bodies to prevent duplication of effort. In education, now the greatest single area of state expenditure, resistance to "intrusion" of the Commonwealth government has been long drawn out.

The central role of governmental intervention in economic and social affairs has been taken for granted in Australian politics for more than two generations. In the name of the principle of "national development," even conservative groups have not only acquiesced in but have actively fostered government action in fields where, in the United States at least, such action is still considered "socialistic" (*2*). Policies of "development" may require the government not only to provide the conditions under which private enterprise can operate effectively but also to go into business on its own account. In the process, traditional distinctions between the proper spheres of public and private effort tend to vanish. Research, which may be viewed as an aspect of "developmental" policy, is a case in point. The institutions established by the Commonwealth government since 1916 have been devoted to "scientific and industrial" research, or, to use more up-to-date jargon, "pure and applied" research. In part, this represents a pragmatic recognition of the fact that Australian industry was not likely to undertake any significant amount of research on its own account, but it also involves the principle that governments have a positive role to play in the economic life of a modern community (*3*).

Public Institutions of Research

In brief, the constitutional and administrative status of the various public bodies carrying out research is as follows.

Agriculture. Each of the six states possesses a department of agriculture, whose functions include regulation, extension services, testing and inspection, agricultural education, and research. These bodies are all within the normal departmental framework—that is, they are staffed by permanent civil servants, a minister is politically responsible for their activities, and they are financed through annual budgetary appropriations. Their research activities, carried out mostly on experimental farms, account for about 15 percent of their total expenditure, which was £A10.5 million in 1958–59. In 1934 the Commonwealth government was instrumental in setting up a federal-state consultative body, the Australian Agricultural Council, which comprises all the state ministers of agriculture under the chairmanship of the federal Minister for Primary Industry. The council is served by a standing committee comprising the permanent heads of the state agriculture departments and officials representing interested Commonwealth agencies. Between them, the two bodies exercise considerable influence on research policy in agriculture.

Universities. Until 1946, all universities, with one unimportant exception, were state foundations. The federal constitution does not give the Commonwealth government any powers in regard to education except in the federal territories, which include the Australian Capital Territory, the site of Canberra. All state universities are set up under acts of parliament which are designed to give them the maximum degree of autonomy. Each university is administered by a council (in some cases called senate) whose composition is prescribed by the statute. These governing bodies are given corporate status, with perpetual succession, a common seal, the right to own and administer property, and the power of making regulations and rules on all matters pertaining to the functions of the university. None of these powers is subject to approval by the government, which has no statutory power to direct the university council in any way. On the other hand, as the bulk of university support comes from annual

appropriations in the state budget, the government's influence over general policy can be considerable. In addition, a number of members of the university council are chosen by the government, and in some cases this can lead to a degree of influence which does not meet with the approval of the academic staff.

Before World War II, university research funds and facilities were small. Universities were regarded primarily as schools for training professionals required by the community—doctors, engineers, lawyers, teachers, chemists. As a result, a significant number of the most talented graduates have always been attracted abroad, mostly to Britain, and their research work has been done overseas. The names of Florey, Oliphant, Massey, Lawrence Bragg, Raymond Dart, and Samuel Alexander are among the best known (*4*). World War II brought a sharp awareness of this problem, and in 1946 the Commonwealth government established the Australian National University in the Australian Capital Territory. This institution was originally conceived as being devoted entirely to research and postgraduate study, somewhat on the lines of Johns Hopkins (*5*). Research in the natural sciences is concentrated in three sections of the university—the Research School of Physical Sciences, directed by Sir Marcus Oliphant, with emphasis on the study of high-energy particles; the John Curtin School of Medical Research, with emphasis on research in biochemistry and medical chemistry; and the Commonwealth Observatory on Mount Stromlo, now directed by Bart J. Bok, formerly of Harvard. In 1958–59, the Australian National University spent about £A1 million ($2.25 million) on scientific research, including capital expenditure. In addition, astronomical observation is carried out by foreign universities at the observatory; typical of such programs is a joint Yale-Columbia project.

In addition to establishing the National University, the Commonwealth government has entered the field of university finance on a large scale. Until 1936, the Commonwealth had made small *ad hoc* research grants to the universities. In 1936 a 5-year program was inaugurated by which £A30,000 ($100,000 at the then current rate) was to be spent annually for grants to support research in the physical and biological sciences. By 1950 the amount had reached £A100,000 ($225,000) annually, but such grants have since been absorbed in much larger general grants. In 1950 a new era in university finance opened with the passage of a federal act of parliament authorizing the Commonwealth to make grants to the states for payment to the universities. (Under section 96 of the federal constitution, the Commonwealth is empowered to make grants to the states on such terms and conditions as it thinks fit.) Until 1958 these grants were made on the basis of a formula which provided for both an outright grant and a "second level" grant, depending on the amount of state expenditure up to a certain maximum. In 1957–58, the total Commonwealth grant under this formula was £A3 million ($6.75 million), representing less than one-fifth of total university expenditure. In 1957 the federal government appointed a committee of inquiry into university education (itself a step which would have been almost unthinkable 10 years earlier), headed by Sir Keith Murray, chairman of the University Grants Committee of Great Britain. The committee recommended a large increase in Commonwealth financial assistance and the setting up of a permanent committee on the British pattern to advise the federal government on future grants. This body, the Australian Universities Commission, was established in 1959. In 1958–59, Commonwealth expenditure on universities rose to nearly £A7 million ($15.5 million), a figure which represented 35 percent of the universities' total income of £A20 million. Of the remainder, 45 percent came from the states, 15 percent from fees, and 5 percent from other sources, including private benefactions (*6*).

This revolution in university finance is the result of a remarkable expansion of university education. In 1939 there were approximately 12,000 students enrolled at Australia's six universities and two university colleges (institutions of university status but without degree-granting powers). In 1959 there were ten universities and two university colleges, with a total enrollment of almost 50,000. This rapid growth is still, however, not accompanied by a parallel growth in university research. The Murray report drew attention to the relatively small numbers of postgraduate students and pointed out that Australian universities produced, in proportion to the population, only one-quarter as many Ph.D.'s as the United Kingdom and only one-fifth as many as the United States (*7*).

University research is financed partly from the general budget, partly from private benefaction, and partly from grants which come principally from the federal government. In 1958–59, the universities spent approximately £A1 million for "research and other special purposes." In Britain and the United States it is customarily assumed that half the sum expended on salaries is actually research expenditure. The proportion is certainly lower in Australia and may be tentatively set at one-quarter. Salaries make up about 60 percent of all university expenditure, so we arrive at an estimated figure for research of £A3 million for 1958–59, which probably errs on the generous side. The total research expenditure for 1958–59, then, was £A4 million ($9 million). Full-time university staffs in that year numbered about 2000.

A number of university research establishments have been set up by public agencies or by private benefaction, the universities being thus relieved of the burden of capital expenditure. In such instances the head of the institute is often a professor of the university. In other instances the work of a university laboratory may be supported by private or public funds. An interesting case is the Nuclear Research Foundation, which has raised money from both private and public sources to support the work of the School of Physics at the University of Sydney. The Biochemistry School at the University of Melbourne has benefited in recent years from grants made by food-processing firms. Research at the University of Melbourne into the production of town gas from lignite, which occurs in vast deposits in the state of Victoria, is supported by the Gas and Fuel Corporation, a state-government agency. It should be emphasized, however, that this is not the equivalent of "contract research," which is not common in Australia. In this respect Australian universities follow the British pattern rather closely (*8*).

The Commonwealth Scientific and Industrial Research Organization. The CSIRO is by far the largest and most important research body in Australia, dating from World War I. In 1916, the federal prime minister, W. M. Hughes, visited Britain and was stimulated by the British government's action

in setting up the Department of Scientific and Industrial Research to establish a similar organization in Australia. An Advisory Council for Science and Industry was established, and by an act passed in 1920 a permanent body was set up, called the Institute of Science and Industry. The institute had an annual budget of only £A25,000, and most of its activities were devoted to supporting research in the universities. In 1925 a conference of scientists was called to discuss the reconstitution of the institute, which became, in 1926, the Council for Scientific and Industrial Research (CSIR).

The initial budget of the new organization was £A45,000, and the amount rose slowly until the last few years before the outbreak of war in 1939.

Until 1938, CSIR's research program was concentrated on problems relevant to primary industry. With the approach of war, the industrial side of its activities expanded rapidly and made possible the local production of many industrial items that previously had been imported (*9*). In 1939, CSIR had a budget of £A350,000 and a total staff of 400. In 1946–47 the budget had risen to £A1.4 million, and the staff to 2300.

In 1949, CSIR was again reconstituted by act of parliament and given its present name of Commonwealth Scientific and Industrial Research Organization (CSIRO). Among changes made at this time were the transfer of its activities in defense research to other government agencies. In 1959 the act was amended to allow further organizational changes. Administratively speaking, CSIRO is a public corporation and thus has greater freedom of action than a normal department, especially in regard to financial management, staffing, and ministerial control (*10*). Like most public corporations, it is administered by a board, called in this case the Executive, whose members are appointed for terms specified in the statute and can be removed only for cause. The 1959 act provides that the Executive shall consist of five full-time and four part-time members, and that five members must be scientists.

The functions and expenditure of CSIRO have continued to grow apace. By 1958–59 its expenditure was £A8.5 million ($19 million) and its staff had grown to 4000, of whom over 1300 were classified as "research" and "experimental" officers. Its activities are now distributed among 27 divisions and 17 smaller "independent sections." There are divisions of animal research, building research, industrial chemistry, plant industry, fisheries, food preservation, entomology, forest products, electrotechnology, radiophysics, soils, solid-state physics, and wool research, among others.

CSIRO has also entered into cooperative research arrangements with industry, on lines similar to the "research associations" set up by the Department of Scientific and Industrial Research in Britain, with both parties contributing to the cost of research, usually carried on in laboratories set up for the purpose. The research staff is mainly provided by CSIRO, and information is made available to the industry concerned under an agreement with CSIRO. Four such institutes are currently in operation, for the bread, wine, coal, and tobacco industries; a research association for the leather industry was recently dissolved. CSIRO also carries out research at the request of industrial firms, which normally provide funds to cover the cost of the particular investigation, and at the request of government agencies, both federal and state. In 1958–59 CSIRO received a total of more than £A200,000 in this way, mostly from public sources. An example of a more formal arrangement is the program undertaken by CSIRO in the important Murrumbidgee irrigation area in southern New South Wales, where the work of the research station is supervised by a joint committee representing CSIRO, the local farmers, and the New South Wales Water Conservation and Irrigation Commission.

Although complaints have sometimes been made in university circles that CSIRO has a "monopoly" of research, the relations between CSIRO and the universities have been close and generally cordial (*11*). Not only is there considerable interchange of personnel between CSIRO and the universities, but contact has been facilitated by the establishment of a number of CSIRO laboratories on university campuses. In some cases the heads of such laboratories are professors of the university; in others, senior members of the laboratory staff have been given honorary university appointments, with the rank of associate professor.

In view of the importance of the wool industry to Australia it is not surprising that CSIRO's activities have had particular relevance to woolgrowing. Between 1945 and 1959, wool production increased by 50 percent—an increase made possible largely by CSIRO discoveries. Research on pasture improvement brought about a 100 percent increase in high-quality pasture in the decade 1948–58, and the successful program of rabbit control that followed CSIRO's work on myxomatosis brought about a spectacular rise in the sheep population during the same period. In spite of this, the woolgrowers have not shown themselves eager to contribute financially to wool research, apart from making a few large individual gifts to the Science and Industry Endowment Fund, established by act of parliament in 1926. This situation has changed only very recently. About 15 percent of CSIRO's annual income now comes from the Wool Research Trust Account, established by the federal government in 1945. This fund originally consisted of undistributed moneys from the sale of wool during the war (when sale of wool was completely under government control) and from the sale of wool by the joint organization set up by the wool-producing countries and Great Britain to dispose of accumulated stocks at the end of the war. The continuing income of the Wool Research Trust Fund comes from a levy on each bale of wool sold. Originally, 2 shillings per bale, paid by the growers, was to be used for sales promotion, and an equal amount paid by the government was to be used for research. These amounts were later doubled. In 1960, the woolgrowers agreed, under pressure from the government, to raise their contribution to 5 shillings per bale for promotion, and to pay 2 shillings per bale in addition for research; the government's contribution remains at 4 shillings per bale for research.

Defense research. Research and development in connection with guided missiles, aircraft, and other weapons are concentrated almost entirely within the Department of Supply and Defense Production. This department, whose functions date entirely from World War II, has three main research divisions: the Defense Standards Laboratories, the Weapons Research Establishment, and the Defense Research and Development Laboratories. The Weapons Research Establishment, where the pilotless aircraft known as "Jindivik" and "Malkara" were developed, was set up in 1947, in conjunction with the British Ministry of Supply (now the Ministry of Aviation),

whose contribution to the cost of the Weapons Research Establishment is not included in the figures given here. In 1958–59 the total expenditure of the Department of Supply was £A11.7 million ($26 million), and the total number of scientific, experimental, and engineering staff members was 635. Officers of the scientific and experimental staffs are organized within the Australian Defense Scientific Service, whose system of classification and terms of employment are based on those of CSIRO.

A few years ago the Royal Australian Navy established an experimental laboratory. This remains a small establishment, whose expenditure in 1958–59 was £A70,000.

Atomic energy. Australia's interest in atomic energy originated with the discovery of radioactive minerals. Prospecting for uranium was begun in 1944 at the request of the British government, and the first extensive deposits were found in 1949. In 1946, the Atomic Energy (Control of Materials) Act gave the federal government control of radioactive minerals under its defense power. Advisory committees were established, and in 1952 the Atomic Energy Policy Committee recommended that a new operating organization be set up. This recommendation was made in response to a request from the Combined Development Agency in Washington that uranium production be expanded, and the Australian Atomic Energy Commission, established by act of parliament in 1953, was for several years concerned mainly with this problem. In 1954 the commission decided to set up its own research establishment, and a site was chosen at Lucas Heights, near Sydney. The nucleus of staff for the research program came from CSIRO and the Supply Department.

The Australian Atomic Energy Commission is also a public corporation, administered by a board of five members, one of whom is a full-time member. Its structure was slightly altered by a subsequent act, passed in 1958. Although it has control over its own staff, its research personnel are employed under conditions similar to those for CSIRO.

The first reactor to be installed at Lucas Heights was a research reactor of the DIDO type, known as HIFAR (high-flux Australian reactor). It has been in full operation since 1958. HIFAR is primarily a materials-testing reactor, but it is used also for the manufacture of radioisotopes. The metallurgical and chemical behavior of reactor materials under extreme conditions of radiation and temperature are being investigated. Early in 1960 it was announced that a second low-power reactor of the high-temperature, gas-cooled type would be installed. This new reactor will be characterized by its use of a mixture of fuel and moderator, and its extensive use of beryllium as fuel "can," moderator, and reflector. It will be used to investigate the U^{233}-thorium fuel cycle instead of the more common plutonium-U^{238} cycle.

Between 1955 and 1959 the commission spent more than £A13 million ($31 million), and its expenditure in 1958–59 was £A2.7 million ($6 million). In 1959, research and engineering staff numbered 165; total staff, 484. With the rapid expansion of research activities, these numbers will probably double within 3 years.

The commission has let a small number of research contracts to universities and hospitals and has also undertaken other forms of cooperation. It was responsible for the installation of a cyclotron at the University of Melbourne in 1955; research is conducted by members of the university staff. The commission has also established, in conjunction with the universities, an Institute of Nuclear Science and Engineering, with headquarters at Lucas Heights. The institute will be mainly concerned with administering a scheme of fellowships for research in nuclear energy.

Health. In the field of health, the federal constitution gives the Commonwealth power only over "quarantine," but in 1925, after the report of a royal commission, a Federal Health Council was set up representing both the Commonwealth government and state governments. In 1936 this was replaced by the National Health and Medical Research Council, which comprises the permanent heads of the state and federal health departments, together with a number of experts. In 1937 an act was passed setting up the Medical Research Endowment Fund, financed by an annual appropriation, to assist government departments, universities, institutions, or persons carrying out medical research. A small number of scholarships is also offered annually. Over 50 institutions have been approved for grants, and £A210,000 was expended by the fund in 1958–59. In addition to this federal aid, a number of state-supported and of privately endowed medical research projects are in existence.

The Commonwealth Health Department also operates a number of laboratories, including the Acoustic Laboratories, the X-Ray and Radium Laboratory, Biological Standards Laboratories, Dental Standards Laboratories, Commonwealth Serum Laboratories, and the School of Public Health and Tropical Medicine. In 1958–59 the total cost of these activities was approximately £A1.5 million ($3.4 million), and the total staff of medical and scientific officers was 240.

Miscellaneous. A small amount of research is done by state-government agencies such as museums, forestry departments, and the like, in addition to state-government research in agriculture. In 1958–59 the states spent approximately £A10.5 million on agriculture, £A5.5 on "science, art and research" (the official statistical category), and £A5.5 million on forestry. Agricultural research accounts for an estimated £A1.5 million, so the total figure for state research expenditure is probably between £A2 million and £A2.5 million.

Research activities are also carried out by Commonwealth departments such as the Bureau of Meteorology, the Forestry and Timber Bureau, the Ionospheric Prediction Service, and the Bureau of Mineral Resources. The total expenditure of these agencies in 1958–59 was more than £A3 million ($7 million), and their total staffs numbered nearly 500.

Expenditure by Industry

For the reasons already indicated, private industry has not made any notable contribution to research in Australia, and its backwardness has been the subject of frequent criticism. Although the rapid growth of industry since 1939 has brought a greatly increased demand for scientists and technologists, the Murray committee observed that the need for greater effort in research had been "expressed by the development of government agencies such as CSIRO, rather than by the participation of private industry in research and development . . . individual companies, with a few notable exceptions, have shown little tendency

Table 1. Commonwealth government expenditures for research, 1958–59.

Agency	Amount (£A, millions)
CSIRO	8.5
Supply Dept.	11.7
AAEC	2.7
Health Dept.	1.5
Bur. of Mineral Resources, Bur. of Meteorology, etc.	3.0
Total	27.4*

* $62 million.

to provide for their own research needs or to foster the establishment, on a co-operative basis, of industrial research associations" (*12*).

Partly because industry's research effort is still limited, data are scanty, and only an incomplete picture can be given here. The main branches of industry in which research establishments exist, apart from the institutions set up cooperatively with CSIRO, are steel, chemicals, sugar, pharmaceutical products, paper and pulp, food processing, electronics, gas production, nonferrous metals, and textiles. The largest effort is to be found in the steel industry. Iron and steel production in Australia is monopolized by one large industrial complex, the Broken Hill Proprietary Company Limited, whose activities have expanded greatly since the war. In the five years ending in 1956, the company invested £A60 million ($135 million) in steel production and planned to double the amount in the succeeding five years. Its total output of iron and steel products has more than doubled since 1939. In 1955 the company embarked on a research program which has involved a capital cost of over £A400,000 ($1 million) to date, and its annual expenditure is now about £A100,000. It employs about 90 scientists, engineers, technicians, and geologists. The sugar industry is also dominated by one large concern, the Colonial Sugar Refining Company Limited. The company's activities extend into other branches of secondary industry, especially chemicals and building materials. The total annual expenditures of CSR's own laboratories, and of those of other establishments in the sugar industry, is now about £A500,000 (*13*).

On the basis of this information and a few other scraps of data which are available (*14*) it can be said with some assurance that the total amount spent by industry under present conditions does not exceed £A5 million ($13 million) annually. Almost all of this is for "development" rather than "research." Some reasons for this backwardness, apart from the general background already sketched, may be suggested briefly. The relatively small scale of much of Australian industry is one important factor, since size of firm is highly correlated with research effort. Second, a large number of local enterprises are subsidiaries of overseas firms, predominantly British but also American. In such cases, techniques developed by the parent firm are applied with little change, although in some cases a modicum of "development" is required to bring the product into line with local needs. There may be some justice in the assertion sometimes made that the much-advertised backwardness of British industry in the field of research has its effect on British-owned firms in Australia. It is true that, in many cases, industrial firms are more likely to ask for tariff protection against imported manufactures from Europe, Japan, or North America than to embark on developmental schemes to make their products more competitive. As the effect of such protection is usually to increase prices, the Commonwealth government has perpetually to weigh the cost of living against the advisability of encouraging local industry. The volume of industrial research carried out by CSIRO has from the beginning, and increasingly in recent years, been part of a general attempt to improve industrial efficiency and thus reduce the need for tariff protection. The work done by CSIRO that is of direct or indirect benefit to manufacturing industry is still much more important than industry's own research effort, and CSIRO's discoveries are readily available. It recently established an industrial liaison branch to promote the use of new techniques by industry. Only a few CSIRO discoveries have been patented (for example, processes for making woolen textiles); in such cases the patent belongs to CSIRO and only small fees are charged.

Tabulation of Expenditure

All figures given in Tables 1 and 2 relate to the budgetary year 1958–59. In that period the Commonwealth government spent directly a total of £A29 million ($65 million). (This excludes expenditure in the form of university and other grants.) The breakdown of this amount, in terms of the spending agencies, is given in Table 1.

Table 2. Aggregate of private and public expenditure for research, 1958–59.

Sector	Amount (£A, millions)
Commonwealth government	27.4
State governments	2.5
Universities (estimated)	4.0
Industry (estimated)	3.0 to 5.0
Total	37 to 39*

* $83 to $88 million.

Table 2 attempts to give a total picture for the same year. In both cases, the amounts are linked with the spending body and not with the original source of funds. Duplication has been avoided as far as possible.

This estimated total represents approximately 0.6 percent of gross national product for the budgetary year 1958–59, as compared with National Science Foundation data which give the U.S. figure as something over 2 percent. (Whether these figures are strictly comparable is, of course, not certain.) In the same year the number of people employed in research and development work, if we exclude university teaching staffs, was probably in the vicinity of 4000; of these, about 3000 were employed by the Commonwealth government.

Research and development occupied a significantly larger part of the federal budget in 1958–59 than it did in 1939. In 1938–39, the Commonwealth government allotted only 0.5 percent of its expenditure from consolidated revenue to research and development; in 1958–59, out of a total expenditure of £A1,300 million from consolidated revenue, the proportion had risen to 2.2, with grants to other bodies not included.

Civil, nonmedical, research accounted in 1958–59 for a total of £A24.5 million ($55 million). About one-quarter of this amount was spent on research connected with the agricultural and pastoral industries. To attempt a further breakdown into "basic" and "applied" research would be an unprofitable exercise. It may be observed, however, that because of the preponderance of governmental research institutions like CSIRO, where scientists are fairly free to define their own problems, a relatively large proportion of "basic" research is represented in the general picture.

References and Notes

1. See N. Butlin, "Colonial socialism in Australia," in *The State and Economic Growth*, H. G. J. Aitken, Ed. (Social Science Research Council, New York, 1959), for a historical analysis of state economic action.
2. J. D. B. Miller, *Australian Government and Politics* (London, ed. 2, 1958), pp. 200 ff.
3. For a discussion of this point see S. Encel, *Australian J. Politics and History* **6**, No. 1 (1960).
4. The "export of talent" is bitingly discussed by a leading zoologist, A. J. Marshall, in a wartime pamphlet entitled *Australia Limited* (Sydney, 1942).
5. In 1959, the Commonwealth government decided to amalgamate the Australian National University with the Canberra University College, a small teaching institution set up in 1930, most of whose students until recently were civil servants taking part-time courses. The Australian National University, as reconstituted by an act passed in 1960, consists of an Institute of Advanced Studies and a School of General Studies.
6. These and other figures, unless specifically indicated, are drawn from the annual budget papers and from the official *Commonwealth Yearbook*.
7. This problem is discussed by J. Gani and A. Blakers, *Universities Quart.* **1959**, No. 1 (1959) and *Scientific and Technical Manpower in Australia* (Australian Academy of Science, Canberra, 1957).
8. An analysis of the sources of university research funds in Britain is to be found in G. L. Payne, *Scientific and Technological Manpower in Great Britain* (Stanford, London, 1960).
9. D. P. Mellor, in *Official History of Australia in the War* (Sydney, 1957).
10. See G. Sawer, in *The Public Corporation*, W. Friedmann, Ed. (Toronto, 1954), and S. Encel, *Public Administration* **38**, No. 3 (1960).
11. See *Science in Australia* (Australian National Univ., Canberra City, 1951) for a discussion of these and related problems.
12. *Report of the Committee on Australian Universities* (Canberra, 1957), pp. 27–28.
13. See A. G. Lowndes, Ed., *South Pacific Enterprise* (Sydney, 1958), for an account of the company's activities.
14. In 1955 the Institution of Engineers, Australia, surveyed 104 large firms with an annual output of £A500 million, and found that they spent £A1.7 million on research and development; this amount represented 0.3 percent of turnover.

Arnold L. Gesell: "Behavior Has Shape"

"In countless American homes the name of Arnold L. Gesell was better known than that of the President of the United States. And to great numbers of the occupants of those homes Arnold Gesell was a far more important man than the occupant of the White House. . . . His work over many years in the fields of pediatrics and child development paved the way to health and success for thousands, mayhap millions. Dr. Gesell was a pioneer, one who traced uncharted paths to charted conclusions." So commented an editorial in the New Haven *Register* at the time of Gesell's death on 29 May 1961.

The application of his findings to the everyday child in the everyday home was the fruit of half a century's painstaking study—half a century of careful analysis of the behavior patterns of human infants and children as these patterns grew and changed with the child's increasing age.

A single central concept—brilliant in its simplicity and one to which he clung in the face of often strong opposition—was the basis of all of Gesell's work on age levels from fetal ages on through adolescence. This was the concept that developing behavior has as much structure as does the developing physical organism, that behavior develops in a patterned, highly predictable manner, and that it is measurable. "Behavior has shape. Mind manifests itself." These are two statements which his students and colleagues were to hear over and over again.

While environmentalists were going to great lengths to measure the extent to which environmental forces determine behavior and even individuality, Gesell reminded us again and again that "environmental factors support, inflect, and modify, but they do not generate the progressions of development. Growth is an impulsion, and a cycle of morphogenetic events is uniquely a character of the living organism."

Gesell's first work at Yale, in 1911, when he founded his clinic which after several changes of name came to be known as the Yale Clinic of Child Development, was with retarded school-age children. However, at that time he was "in auditory communication at least," as he used to say, with a well-baby clinic across the corridor. And very soon he began to feel that the place to start a study of human behavior was with infants, and with normal infants at that.

And so for 20 years he carried on a painstaking and step-by-step analysis of infant behavior, chiefly as expressed in normatively controlled test situations as these infants responded to simple stimulus objects such as cube and pellet and bell. From this analysis he not only established the fact that infant behavior does develop in a patterned, orderly manner through stages which are alike in quality and sequence (even though not in exact time of occurrence) from child to child, but also described these stages.

Gesell tracked down the patterned behavior changes in infant and child through the age of 16 years—an endeavor which he completed in 1956 with the publication of *Youth: The Years from Ten to Sixteen*. From this base, the application of his findings spread into two widely diversified fields.

Clinically these findings were applied in the field of practical pediatrics. Gesell was perhaps the first to insist that "development as well as disease lies clearly in the province of clinical pediatrics." It was largely as a result of his untiring efforts that in the early 1940's the American Academy of Pediatrics changed its admittance examination to include a section on the development of infant behavior. Many pediatric clinics now quite routinely give the Gesell Developmental Tests to infants and preschool children in an effort to determine not so much their I.Q. as their D.Q. (developmental level or developmental quotient). In his last ten years at Yale, Gesell and his staff trained pediatricians not only from all over the United States but from all over the world (in fact his work at times found more ready acceptance in European countries than in our own). Gesell considered that the developmental examination was in fact a neuro-