THE ADVENT OF STRATEGIC MANAGEMENT IN CSIRO: A HISTORY OF CHANGE*

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Australia's major government research agency, the Commonwealth Scientific and Industrial Research Organization (CSIRO), has recently changed its style of management. This paper traces the development of CSIRO from an institutional research organization to a body taking responsibility for Australia's strategic civilian research, from an organizational perspective. The problems that this change might create in disturbing the organizational balance are outlined. Possible remedies to counter-balance and stabilize the strategic bureaucratic trend are innovative forms of organizational structure, the strengthening of individual incentives to perform applied work, increased exposure of CSIRO scientists to external influences, and improved community involvement in CSIRO's decision-making structure.

Keywords: science, organization, strategic research, CSIRO

INTRODUCTION

State research organizations are subject to many of the pressures of any other organization. But some considerations are unique to research. The desire for autonomy and the conflict over relevance and accountability are more keenly felt within research organizations than most others. The extent to which research should concentrate on applied problems, or follow its own natural disciplinary development, is a constant source of concern. Virtually all debates about science organization or policy are conducted on these issues.

Most science policy authors have taken a managerialist or public administration view of science and science organizations, regarding science as a somewhat anomalous instrument in the production of public wealth. The effects on science conducted as an organized social activity within the environment of state support have not been much discussed. Few authors — apart from scientists — have allowed that

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science is an independent activity with its own capacity for action and ability to recognise and respond to external stimuli or internal demands for growth.

Table 1 shows pairs of terms referred to in the text and which relate to the organization or management of science. These dichotomies may be used as a typology of research organizations, or to describe the principal tensions acting within organized research. The first two pairs of terms describe the task of research according to its type and broad objective or rationale. Basic research is traditional scientific research undertaken for its contribution to knowledge. This normally has as its objective the advancement of an academic discipline. But often, basic research has some broadly defined mission under which it is conducted or funded. Applied research is research directed towards some specific external goal: either towards some objective that is deemed to be socially useful, or more usually towards the conversion of knowledge into private gain.

Table 1. Tensions in Research

TASK		STRUCTURE		
Research Type	**Broad Objective**	**Distribution of Power**	**Administrative Structure**	**Management Style**
Basic	Disciplinary	Decentralized	Organic	Institutional
Applied	Mission-oriented	Centralized	Bureaucratic	Strategic

The instrumental goal-seeking of applied research fits poorly with the internal ethos and Mertonian norms of science, which inspire a conscious belief in the absolute value of a form of activity entirely for its own sake. In the twentieth century, instrumental principles have taken increasing precedent over creative or craft-based productive activities. In science, the general movement has been towards applied research, as traditional scientific patterns have been eroded in favour of maintaining the industrial base. The means of encouraging scientists to work on practical problems without compromising the quality of research has perhaps been the critical concern of applied science administrators.

The organizational structure of research may be described by the next two pairs in Table 1. The power to make decisions over tasks or resources can be either centralized or decentralized. The administrative structure can be run bureaucratically; that is, according

to a fixed set of rules and positions with defined responsibilities. The alternative, which, following Weber, is called 'organic', is people-based rather than rule-based structure, where members of the organization do not have fixed positions, and are empowered to perform their tasks according to their perception of circumstances. The often-used term 'autonomy' (for individuals, not organizations) refers to organic decentralized decision-making; that is, organizational decisions are made by individuals as they think best (usually subject to appropriate restraints).

Rational bureaucracy seeks to minimize arbitrariness and uncertainty in organizations, eliminating uncertainty and messiness wherever possible. Research is a creative activity of individuals who specifically aim to find new ways of doing things. A considerable potential for discord has existed whenever science has come into contact with bureaucracy, which is widely considered to stifle innovation. This conflict of aims has been recognized in most of the dialogue between science and the state.

Finally, Weinberg describes two types of science administrator: the institutionalist, who sets up institutes and staffs them with the best available people; and the strategist, who sets detailed goals and organizes available resources to meet these.

> [Although institutionalists] formulate goals, which derive from the most general aims of their research institutions, they view their primary function as the establishing and nurturing of their institute. Thus they focus first on recruiting good scientists and providing them with support . . . The detailed research strategy develops after the fact and is the result of many small decisions taken by individuals, rather than being laid out in advance by the research director himself . . . to the strategist, the plan is primary, the persons secondary; to the institutionalist, the persons — that is, the institution — are primary, the plan secondary. The strategist devotes his mind to thinking about his substantive scientific problems; the institutionalist spends his time thinking about how to strengthen his scientific institute.[1]

So an institutional style implies support for autonomy, while a strategic style implies centralized direction, less individual freedom, and probably more bureaucracy in the long run, because of accountability requirements. Conversely, bureaucrats favour strategic management because of the ease of stating objectives and costing alternatives in advance.

Most of this paper is devoted to describing CSIRO and its development, with reference to the organizational perspective above. CSIRO is arguably the first and most complete example of a truly institutional national science body, yet in recent years its Executive has adopted a style that is far more centralized and strategic. The history of this major change in direction occupies the body of the

paper. However, the nature of the organization, and its growth pattern as it has threaded a balance between pure and applied research, and between internal and external pressures, is equally important.

BEGINNINGS AND EXPANSION

The consciousness in industry and government that research had implications for profitability or bureaucratic efficiency was slow in growing (and is still not fully accepted in more traditional industries and departments). Technical and military advances during and following World War I led many governments to establish advisory councils related to scientific and technical matters, and to support research on the more painfully apparent national needs. In Britain, Henderson pressed for "new machinery and for additional State assistance in order to promote and organise scientific research with a view especially to its application to trade and industry".[2] A permanent scientific institute, the Department of Scientific and Industrial Research (DSIR) was established, which has been considered to be the blueprint for similar institutes throughout the British Commonwealth.[3]

The then Australian Prime Minister, W.M. Hughes, supported a similar Australian venture with great eloquence.

> [Science should] act as a beacon of industry. It has to cure the existing diseases of the body economic and be its striking and producing power . . . We could gather round us men in all branches of science and use their capabilities in an application to industry . . . There must be a combination of science and business capacity.[4]

> Science can make rural industries commercially profitable, making the desert bloom like a rose; it can make rural life pleasant as well as profitable. Science can develop great mineral wealth of which, after all, only the rich outcrop has yet been exploited. It can with its magic wand turn heaps of what is termed refuse into shining gold; and by utilization of by-products make that which was unprofitable to work profitably. Science will lead the manufacturer into green pastures by solving for him problems that seemed insoluble. It will open up a thousand new avenues for capital and labour, and lastly science thus familiarized to the people will help them to clear thinking; to the rejection of shams; to healthier and better lives; to a saner and wider outlook on life . . . Spiritual truth is the living force that turns the face of man towards the towering peaks of a true civilization: science the lamp by which he can guide his feet towards this distant goal.[5]

Not all concerned parties were convinced that a central scientific institute had anything to offer. Opposition persisted from the States

and industry, who disliked the expansion of Commonwealth power, and from universities, who sought increased support for existing research institutions. The Commonwealth had no specific direction on whether it had the right to legislate in this area, and was hesitant to do so. The embryonic Advisory Council for Science and Industry of 1916 struggled on with limited resources until 1926, when the Science and Industry Research Act established the Council for Scientific and Industrial Research, CSIR, a permanent institute directed to "the initiation and carrying out of scientific researches in connexion with or for the promotion of primary or secondary industries in the Commonwealth."[6] The new organization was to be a "corporation sole, scientifically and not politically directed", with "laboratories properly staffed by highly trained scientific investigators and research men."[7] Control was vested in a Council which represented industry and academic interests from all States, supported by a working Executive Committee of three.

State Departments of Agriculture had very limited expertise in veterinary work or plant diseases at this time, and most of the resources of the new institute were devoted to these topics. During the following years a number of separate Divisions dealing with aspects of agricultural work were gradually built up. Modest successes were recorded in the control of diseases such as bunchy-top, blue mould of tobacco, and coast disease; the control of pests such as prickly pear by biological means; and in developing improved methods of food storage and handling.[8]

The "great turning point for government-science relations" came after World War II, following the success of organized research in developing radar and weapons systems.[9] A large-scale excursion into sponsored basic science was started, with strong links to defence and industry as the prime justification for increased expenditure. In Australia, the government decision of 1936 to expand the activities of CSIR to include scientific assistance to industry permitted the formation in subsequent years of the National Standards Laboratory, Division of Aeronautical Research, Radiophysics Laboratory and Division of Industrial Chemistry. These new research groups played a useful role in wartime industry development. As well, existing agricultural Divisions expanded, and by the end of the War the resources available to CSIR had doubled. In 1949, after a political controversy over the incompatibility of secrecy and scientific research, reflecting the worldwide fear of communist espionage at the time, all classififed military work was dropped from CSIRO, leaving the newly reconstituted body free to concentrate on applied industry research and basic science.

CSIRO was established under the Science and Industry Research Act of 1949.[10] During the following period of growth (1949-1975)

many more separate Divisions were set up, extending CSIRO's realm of interest to virtually every aspect of agriculture and industry, while permitting a good deal of basic research where eventual applications might be demonstrated.

THE INSTITUTIONAL TRADITION

It was clear from the beginning that the organization was to be mission-oriented, and run institutionally, with strong support for individual autonomy. The Executive Council would designate those areas in which research would be performed, and then establish a Division and appoint a Chief, to whom virtually all power over the research programme was delegated. The best available research staff were then chosen, and their appointment and subsequent research progress was carefully examined in full session of the Executive. Each research officer was expected eventually to take full responsibility for the conduct of his area of research, and was provided with support staff and material resources as necessary.

The Executive retained control of all administrative matters. As well as approving Divisional recommendations for the appointment or promotion of research staff, the Executive concerned itself with salary determinations, conditions of employment, negotiations with other agencies and approvals for quite minor pieces of equipment. Peres describes this period as one of

> . . . very tight administrative control, but very loose and widely distributed policy-making responsibilities. For the whole of this period reasonably high quality science programs were pursued, irrespective of their relevance to the national economy.[11]

The reasons for this peculiar inversion of functions relative to most other organizations were entirely institutional: to ensure that the scientific reputation of the organization did not suffer because of exigencies at the Division level; and above all to stop goals and policies being imposed on individual research workers.[12]

The post-war Chairman of the Executive Committee of CSIR, David Rivett, held views that were uncompromisingly anti-strategic. In 1945 he said,

> . . . certain members of the Council, with little to do and no real conception of the intellectual state of a genuine seeker after truth, are wanting to push their way into the details of work which is the prime responsibility of Chiefs of Division . . . characteristic of most engineers who have the workshop idea of running research. They want to lay down just precisely what each man is to do and would, if they were perfectly honest, probably attach a time schedule and a summary of results

> desired . . . Chiefs of Division, if rightly chosen, are the right people to determine their own programs without anything in the way of super-chiefs at Head Office to see that they never deviate from the straight and narrow path . . .[13]

Rivett was deeply concerned about Public Service Board involvement in staffing procedures in the new organization in the Act of 1949, which had been a necessary concession for the exclusion of secret military work from CSIRO's charter.[14] He wrote,

> . . . the fact that the new law changes its name to C.S. & I.R. Organisation is a little ominous. These political bureaucrats are so sure they can organise everything . . . There seems to me to be in it all a determination to bring C.S.I.R. closer to industry and to little *ad hoc* problems . . . We have to build our own foundations, as you know. The politicians think we can rely on other countries to supply them for us, but they are shortsighted.[15]

Despite these misgivings, CSIRO retained its management structure and its strong institutional and anti-bureaucractic bias. Subsequent Chairmen of the Executive and other administrative spokesmen for CSIRO maintained the institutional style while supporting basic research. Clunies-Ross (Chairman 1949-1959) stated,

> No organization can expect to recruit men of first-class scientific calibre unless it provides an environment in which they are able to give full expression to their capacity for original research of the highest order.[16]

Frederick White (Chairman 1959-1970) spoke of a natural hierarchy of leadership arising among the "men at the bench", and said, "We are therefore determined that within the laboratory there will be no predetermined hierarchy of senior and junior people."[17] He suggested also that an avenue of research should not be embarked upon unless a scientist was available with original ideas on the subject. Gillespie said, "no matter what the field, the purpose, or the sources of financial support, the research staff decide, devise and direct their own research programmes."[18] And the Annual Report of 1963/64 stated that,

> Even when a problem of great practical significance is known to exist it is clearly unwise to embark on extensive research activities unless the scientists can see the possibility of an individual discovery . . . The role of the individual scientist is vital.[19]

In general, funds and staff positions were plentiful and there was little interference in the research programmes of Divisions or of individual scientists, although much informal discussion and colleague review took place. This proved remarkably successful in maintaining morale and eliciting a good deal of useful work on

peculiarly Australian problems. The Executive retained powers unheard of in the Public Service proper; almost complete control over budget allocation, staff deployment and research programmes. It was, and is still, possible for the Executive to transfer staff to any location without notice. Other draconian powers, which reflected the post-war security controversy, included the opening of all inward and outward mail, and severe penalties of up to two years imprisonment for revealing the internal workings of CSIRO (repealed in 1978).

A more general insistence by many Divisions that all staff in their outward communications represent the policies and intentions of CSIRO, and in particular of Chiefs of Division, rather than their own professional opinions, remained a general damper on freedom of expression. This practice was, and still is, widely supported on the grounds that a single careless act could ruin the reputation of particular Divisions with industry.[20] The powers of the Executive or Chiefs were seldom used in a manner that might cause offence. In fact relations between staff were cordial and informal. Considerable rewards were available to individual scientists in terms of personal autonomy in designing and executing research. This freedom was supplemented by institutional recognition through the merit promotional system, and by public status through industry contact. Perhaps as important as the stated intention of administrators in maintaining the institutional model was the fact that promotion was attained strictly by merit. Little status or financial reward accrued solely from administrative responsibility. Scientists had to satisfy the Executive that sufficient excellence in research and publication had been attained, before crossing efficiency bars at certain stages of their careers. In practice, promotion was slow and steady up to certain points, and depended largely upon publication in prestigious journals.[21]

The almost total delegation of power over the organizational tasks of research to Chiefs meant that Head Office retained a service and not a management role. Of necessity each Division developed its own individual character, reflecting the Divisional interest and the predilections of the Chief. Some Divisions had well-integrated work programmes, others had a liking for hare-brained schemes. Some had strong industry contacts, others retreated into ivory castles of pure research. Divisions divided fairly naturally into 'disciplinary' Divisions which investigated promising areas of research within the context of an academic discipline,[22] and 'industry-based' Divisions with a mandate to attend to the general problems of an industry. The usual pattern of growth was to establish smaller Sections within an existing Division or relating to a new activity, then to accord this Section full Divisional status once it reached a sufficient size. The large scale dismantling of the Divisions of Industrial Chemistry and

Textile Research in 1959 into what were later to become nine separate Divisions was of this type. An organizational feature that developed from this sort of split was the association of several Divisions with a historical structure of co-operation under a general heading: Chemical Research Laboratories, Wool Research Laboratories, National Standards Laboratories, Animal Research Laboratories. These groupings were run by a Management Committee of senior officers from the Divisions concerned. Annual Reports and Programmes of Research were then issued jointly, and various other administrative functions were shared, although individual Chiefs retained control over funding and research.

While co-operative research between Divisions or with universities was common, the administrative structure was rigidly maintained. Few staff interchanges took place, and a village atmosphere became the rule within each Division. A strong organic network of social contact and support developed, dependent on tradition over innovation to a greater extent as CSIRO aged. Something of a conflict-free class division arose, with research workers in white coats, technical workers in grey coats, and workshop staff in overalls; but in general each group was given autonomy and credit for performing its designated task as a speciality, and working conditions were considerably better than those obtaining in the government or private sectors. Chiefs ruled rather like local squires, usually universally respected, and regarded as charismatic figures and the final authority on research or many administrative matters.[23] Up to the present, scientific staff have shown a general conservatism and insularity (although perhaps not more than others in the community of a similar age) coupled with a fair modicum of elitism. The union of professional staff, the CSIROOA, has preferred to operate behind the scenes in consultation with management, and has felt itself constrained by the membership to act only on matters internal to CSIRO.[24] The indignation of staff has been reserved for threats to the integrity of the Organization.

Probably the most obvious characteristic of CSIRO is its heterogeneity, arising from the separate development of Divisions. For this reason it is difficult to generalize about problems or tensions in the Organization as a whole during this period. Whatever disputes existed remained internal matters. Until recently, most publicly available material stressed the value of scientific accomplishments rather than possible conflicts in priorities, limited attention being paid to programme assessment or rationale for performing work.[25] A few recurring problems can be distinguished, however.

During most of the 1950s and 1960s the only pressure for resources was for capital expenditures and for qualified staff. It was difficult to obtain funds for modern research premises, and many Divisions

remained in temporary or ageing accommodation long beyond the scheduled date for moving to new laboratories. It was also difficult to find researchers appropriately qualified to the task, and high autonomy and high wages relative to universities were considered necessary inducements. Even so, a large number of scientists were retrained to work in areas quite different from their original academic speciality.

Certain chronic structural conflicts have remained evident. Clearly there has been resentment of Public Service Board control over appointments and over overseas travel, which severely restricts the numbers of quota trips.[26] At one point concern arose over a now defunct practice of automatically including section leaders' names as joint authors of papers. The Experimental Officer grade has consistently shown its dissatisfaction with research autonomy and promotional possibilities relative to the elite Research Scientist grade, and has pressed for a single research classification.[27] Technical staff have complained they receive little credit for the work they do, and secretaries that they have no promotional possibilities at all. But in general, as long as funds were plentiful and research unencumbered, complaints, conflict and political machinations were very much less than might be encountered in government or the universities, and CSIRO remained a model organization for the conduct of medium-scale mission-oriented science.

RELATIONSHIOP WITH INDUSTRY

In terms of its function or task, CSIRO was directed in all its programmes towards the aiding of industry, while structurally it was a loose conglomerate of pure research organizations united by common terms and conditions of employment, by central scrutiny of all administrative practices, and by the communality of science and the scientific ethos. The business of management in the organization was to preserve and strengthen the institute, allowing research to proceed unencumbered, in accordance with the maxim that "a director has much more power to stop research than to cause it to be done."[28] The manner in which this was to be achieved was a walk along a balanced path between basic and applied science. Applied science was the business of CSIRO and research programmes had to be capable of being justified to the Executive or outside observers in terms of the mission of the Division. Basic science was the natural business of scientists, and necessary if the Organization and the workers within it were to attain any scientific credibility. To attract scientists of high quality to a remote outpost like Australia, it was necessary to allow them to advance their careers through properly conducted research.

A genuine concern for basic research motivated administrators. Rivett wrote in 1945,

> . . . we are not going to count very much in twenty years time . . . unless quite 50% of our effort is directed to finding out how the machine of Nature works, without a thought as to whether that knowledge may or may not be useful in this decade or next century, in showing farmers how to save 6d. or politicians how to increase revenue from taxation . . . [29]

Clunies-Ross declared,

> The Organization is convinced that if its work is not to become pedestrian and in the long term largely sterile, there must be a firm day-to-day association of applied investigations with those of a basic scientific character.[30]

According with overseas practice in government laboratories, the majority of work carried out by CSIRO was in fact 'objective basic research'; that is, basic research falling within the general objectives of the Division concerned.[31]

The primary direction of CSIRO to work for agriculture and industry was a considerable restraint on the pursuit of scientific excellence, requiring that almost half the Organization's resources be devoted to longer-term service functions for capital. By keeping industry at arm's length and satisfied with the many small industry-wide applications for which CSIRO had become famous, while giving industrialists extensive representation on Advisory Boards, good if somewhat formal relations were maintained. The agricultural, food processing and building research Divisions developed a particularly strong relationship with their industries. These provided a substantial and powerful constituency for these Divisions and for CSIRO in times of external threat.[32]

For other industries, the level of contact and support was not as great as had been hoped. Early CSIRO agricultural successes had occurred when industry groups had specifically approached the Organization with pressing and well-defined problems. Later attempts to perform the same role for the expanding mining and manufacturing industries involved CSIRO approaching industry cap in hand, searching for useful research problems. Management boards of large mining companies were less patient than primary producers in accepting the long gestation times necessary for basic research. The fragmented manufacturing industry lacked central points of contact, and small companies were more interested in getting the job done than in finding new ways of doing things. CSIRO's difficult and patchy relations with manufacturing industry have been a constant source of worry to administrators.

The disinclination of scientists to engage in 'relevant' work has probably been exaggerated, and in fact most scientists are only too happy to see their work put to use.[33] However, even in those Divisions with a history of strong industry contact there was a disinclination to

'get one's hands dirty', and a feeling that developing theory was more scientific than solving engineering problems. This was exacerbated by the promotional structure, which was based on the production of scientific papers. It was difficult to assign paper-equivalents to patents, standards and other applied work. In this way CSIRO provided a strong disincentive for staff interchanges or industry consultancies, as promotion was normally delayed. Manufacturing industry itself was at least as much to blame as CSIRO in failing to develop fruitful contacts that would encourage innovation. Most companies after 1945 were happy to engage in the superficially attractive strategy of import substitution under the tariff umbrella, and concentrated on the local adaptation of imported technology. Economies of scale under which development technology might flourish were not available, and risk capital almost nonexistent.[34] A number of Australian inventions had to be developed and marketed overseas.

For CSIRO the general rule for engaging in industry-related research was the existence of a substantial research component, and a no-strings agreement on the provision of funds to CSIRO. Efforts were made to prevent CSIRO acting as a free service facility for industry. A feeling existed that secondary industry asked for a great deal and gave very little back in terms of research material or development facilities, or even marketing of fully tested processes.[35] While some attempts were made to elicit industry funding, this was kept to a minimum in order to retain control over the research process. Conversely, the habit of some Divisions of doing absolutely everything in-house, down to trivial service tasks and manufacturing office furniture, supported the isolation of the Organization from the commercial world.

Contributory funding was far more prevalent in agriculturally related work, and several textile Divisions were almost entirely funded from such sources as the Wool Research Trust Fund. This fund, and several others relating to primary industry, were created by a levy on production, matched by a Commonwealth grant. The administration of such funds caused the Executive some concern:

> Experience over many years has shown that in planning the research programme a broad approach to a problem leads to much greater efficiency in the use of resources, and undoubtedly enhances the quality of the results. The responsibility for the detailed scientific planning of the programme should rest with the Chief of a Division and his senior research staff, who ensure that the needs of industry are kept constantly under review through consultation with industrial leaders. The industry fund Committees, on which there is a majority of producer representatives, tend to place considerable emphasis on individual projects and use these to build up a programme . . . [These committees]

> seek a large amount of detailed information [and] extensive financial controls, which have the effect of placing an undesirable limitation on the freedom of manoeuvre in the conduct of the scientific work of the laboratories. As a result the research worker is left both with less time for his research and with less flexibility in his activities. This is beginning to have an adverse effect on morale.[36]

Perhaps the most significant aspect of CSIRO's relations with industry is the lack of any real controversy. It is difficult to believe that CSIRO's activities were so well integrated with the needs of an industry that no powerful groups were offended over a sixty year period, yet this seems to be the case.[37] CSIRO has certainly been anxious to avoid making inaccurate statements, or statements about specific companies that would cause offence. Also it has followed the current mood in an industry in the studies it has undertaken and the conclusions it has published. On the other hand, perhaps CSIRO's contributions were so broad that they never constituted an obvious threat to anyone. However it has been done, industry has remained at a very useful distance, and has been a powerful ally for CSIRO when needed.

PRELUDE TO CHANGE

In 1964 a Labour government came to power in Britain on a science and technology platform designed to appeal to a new constituency of educated voters. Committed to a "scientific and technological revolution" which would "harness forces released by science in the service of the community",[38] it discarded the old elitist research council system in favour of more sophisticated policy apparatus. It was found that "the various agencies did not, in the aggregate, constitute a coherent and articulated pattern of organization."[39] This could not be said so readily of Australia's single major agency, CSIRO. Neither the general demise of the autonomous research council system, nor later attempts to encourage applied research, such as Rothschild's customer-contractor system in Britain, had any overt effects. Brooks' comments on the effects of American-style contracted research — "instability of funding, lack of concern for the integrity and viability of scientific institutions, the wasteful competitions, the confusion of technical virtuosity with science . . . "[40] were generally accepted.

In 1969-1974 a number of important international events occurred. First, the US government downgraded its space effort and threw thousands of aerospace engineers out of work. Secondly, incomes had improved to the point where the effects on the environment of the industrial base were considered as important as further increases in productivity. The Vietnam War, the Torrey Canyon oil spill and the

Thalidomide scandal had not been good publicity for the social usefulness of technology, and suddenly the media were filled with ominous pronouncements from the environmental and the Limits to Growth movements, along with various other alarms about the adverse effects of technology. Science had specifically extricated itself from the political process, and therefore had few means of defence against this attack. At any rate, when the economic downturn of 1974 arrived, political leaders had no scruples about cutting the budgets of the least economically necessary sectors, of which science was one of the more obvious. Real support for the physical sciences in the United States halved between 1967 and 1978.[41]

In Australia CSIRO weathered the storm rather well. Its budget remained undiminished for years following the squeeze on the universities and on other government departments. Elsewhere,

> The 'statesmen of science', in close touch with government thinking, found they were unable to influence the new official attitude towards support of research. Then they began to urge their colleagues to accept the new situation — of general economic retrenchment combined with popular and political disillusionment towards science — and make the best of it.[42]

This did not happen in Australia until the late 1970s. One reason was the relatively small size of the research sector in Australia. As Peres explains,

> There has been no great demand for the products that science and technology might produce. Without social demand, and competing social demands, allocation problems can hardly exist . . . The politics of Australian science has not been about the allocation of resources.[43]

CSIRO's policy of medium-scale application to practical industry use was seen as non-partisan and appealed to both political parties. The Prime Ministers (Gorton, Whitlam and Fraser) who held office during most of the 1970s were known supporters of research and of CSIRO in particular, and it must be suspected that their personal support helped stabilize CSIRO's political environment during these stormy years. The new Labor government of 1972 showed no inclination to follow the British example, and had in fact already reaffirmed the necessity to restrict bureaucratic intervention in the management of research. Whitlam suggested,

> guidance and management rather than direction and control . . . work should not be channelled through a massive bureaucracy. The concept of a massive department of scientists and technologists is inappropriate to the nature and traditions of western science and inappropriate to the nature and traditions of democracy . . . The CSIRO acquired its structure as a result of a judicious blending of overseas advice and experience with local insight [44]

before mentioning the poor morale of the bureaucractically managed Bureau of Mineral Resources, which should be more like CSIRO.

So while major changes were taking place worldwide in the interface between science and government, CSIRO was unaffected. Structural changes were largely internally generated, through the pressures of organizational and policy change. These were of two types; institutional and broadly strategic. Reorganizations of the institutional type were usually performed in such a way as to avoid antagonizing existing personalities and to minimize conflict by waiting, for instance, until the retirement of senior personnel. For instance, the Division of Animal Nutrition, formed in 1927, was renamed in 1935, 1944 and 1965 with the appointment of new Chiefs.[45] Often the need to appoint a new Chief was handled by merging two Divisions under an existing Chief; for example, the amalgamation of the Divisions of Organic Chemistry and Physical Chemistry in 1967.

In 1971 the most comprehensive set of Divisional reorganizations to date took place. A number of older Divisions had essentially solved the outstanding problems of their designated industries. While the Division of Forest Products had completed first-rate work in, for example, the pulping of eucalypts, by 1970 a noticeable amount of long-term 'low science' experimental work of limited significance was being performed. Following the retirement of the Chief of the Division of Building Research, the two Divisions were amalgamated in 1971. The Division of Dairy Research in Melbourne was amalgamated with the Division of Food Preservation in Sydney under similar circumstances. As the first reorganization required the movement of staff, and the second the downgrading of dairy research, both created long-term resentment, some of which was directed towards the incoming Chiefs.

Strategic changes at this time were carried out on laboratories rather than research programmes, and were really an adjustment of unsatisfactory or inadequate missions with a poor institutional performance, rather than an attempt to impose strategy. For example, the small Sugar Research Laboratories and Fodder Conservation Section were abolished and staff were redeployed in 1965. Two years later, a decision was made to downgrade coal research, somewhat prematurely in the light of the subsequent energy crisis. The Division of Coal Research was subsumed within the Division of Mineral Chemistry under Newnham. Over the next seven years the scientific establishment of the former laboratory dropped by a third while the establishment of the latter increased by 28 per cent.[46]

Externally generated threats to the Organization, while sparking violent indignation in CSIRO, turned out to have more threat than substance. The Public Service Board, given responsibilities regarding

staffing in CSIRO in 1949, showed little interest in pursuing its powers, and was content to contain wage rises within CSIRO that might flow on to the whole Public Service.[47] The incorporation into the Public Service of an anomalous, highly qualified and potentially vocal group of scientists with its own established procedures held little appeal. The Executive co-operated by standardizing its administrative practices and structure wherever possible. Occasionally CSIRO was seen as a potential mine of talent by Ministers or government departments. The overtures by the Department of Munitions and Supply to the Division of Industrial Chemistry in 1944 were rebuffed.[48] The Connor Affair of 1975, in which it appeared for a time as if the Mineral Research Laboratories and the Solar Research Unit were to be appropriated by the Department of Minerals and Energy in a new statutory authority, rapidly subsided in the face of violent protest.[49]

In 1975 the Coombs Royal Commission on Government Administration appointed a Task Force on Science to examine Australian science administration as a whole. The report of this Task Force was tabled in November 1975 during the constitutional crisis,[50] and was largely ignored. It came out strongly in favour of the institutional model, and recommended that all government research wings be reconstructed as statutory bodies along the lines of CSIRO, loosely structured under the new policy advisory body, the Australian Science and Technology Council (ASTEC). The Task Force Chairman gave CSIRO's virtues as

> the promotion of scientists exclusively on the basis of academic performance, with no fixed establishment of positions; the readiness to fit organisational arrangements to business rather than vice-versa; and provision for ideas to flow upwards from the individual scientists actually engaged in research.[51]

By 1975, he reported, most of the elements of tradition had receded and a widespread sense of frustration had developed. Chronic waste, inefficiency and low morale were evident throughout the science sector. Both the managerial and financial practices of the public service were unsuited to science and technological research. Deviations from the ethos of science were a warning of danger.

Ronayne described the report as

> the most recent example we have of the rearguard action being fought by scientists against the encroachment by government into the area of decision making in science. The issues involved in the confrontation between the scientists and the bureaucrats are important, for they represent a clash of opposing ideologies.[52]

He distinguished between scientific autonomy, or the freedom to pursue the accepted methodology of science, and subject autonomy,

which was the business of policy review. Gross added that, "it is not clear that the CSIRO model of an Executive linked to some forty disparate and independent Divisions, will be capable of being sustained in CSIRO,"[53] let alone the whole of government research under ASTEC. The declaration by the incoming government of an Independent Inquiry into CSIRO ensured the Task Force report would have no administrative repercussions.

THE STRATEGIC UNDERCURRENT

Political figures, such as Hughes, promised and expected a great deal from science, yet they were content to leave the management of science almost entirely in the hands of scientists until the 1970s. From the beginning, the style of management of CSIR and CSIRO was to select new directions by commissioning committees or review reports to enumerate broad missions, then to seek an institutional solution through the creation of institutionally run Divisions. The style of CSIR was such that even when strategic determinations of a problem were made, an institutional solution was found. In 1930 and 1937 Rivett presented reports to Parliament on the potential of coal hydrogenation research.[54] This subject remained on the agenda for a good while. In 1948 a Coal Research Section was formed in Sydney. Another report in 1937 into the establishment as a strategic priority of Aeronautical Research Laboratories in Australia recommended that staff be administered by CSIRO because

> scientific research is mainly a matter of intense individual enterprise. Men found to excel in this direction must be encouraged by special promotion just as freely as they would be in a private organization.[55]

Some administrators necessarily had a more strategic bent than others. This particularly applied to engineers, who were more accustomed to applied work and either *ad hoc* or strategic approaches than scientists, who were trained to apply rigorous scientific method. The engineer Julius (Chairman of CSIR 1927-1945) had a more strategic approach than the chemist Rivett, who at the time was Chief Executive Officer. The Report of the Julius Committee of 1937, which investigated the form of involvement of CSIR in secondary industry, used strategic economic language uncommon in other documents of the period.

> The economy to the nation of expenditure on scientific work which will stimulate manufacture, maintain its efficiency and assist it in meeting competition, has been fully realized elsewhere. A country such as Australia, which desires to maintain a high standard of living, is particularly in pressing need of such economy. It is therefore essential for our prosperity that secondary industry be given the assistance of organized scientific investigation . . . [56]

The principal impact of the Report on the future development of CSIRO was the provision of a research service for secondary industry in the form of the Division of Industrial Chemistry (DIC). The Divisional offshoots and the former staff of this Division had a strong impact on the development of strategic research in CSIRO. Yet the first Chief of this Division, Wark, was a strong institutionalist. Sections were set up around disciplines rather than industries. The management style was to

> . . . seek advice but to shun permanent advisory committees, to encourage the scientific and personal development of each individual, to hold few formal meetings, to avoid introducing rules, and to restrict to a minimum the number of non-producers.[57]

The conditions for the men at the bench were described as utopian.

> Individual freedom and initiative were not only permitted; they were actively encouraged: a bold failure was more highly regarded than a cautious advance. Red tape and bureaucratic nonsense were totally absent. The working conditions bore no relation whatsoever to the popular concept of a government-controlled organization.[58]

However, several aspects of Wark's management of DIC were to set the scene for future developments in CSIRO. CSIRO practice was not to allow any Division to "grow beyond the stage where its Chief could conduct personal research and keep closely in touch with all research projects."[59] Wark believed it was possible to co-ordinate numbers of sections consisting of diverse disciplines, by the appointment of Assistant Chiefs. While the Executive rejected this idea, and broke the Division in 1959 into a number of pieces, larger Divisions were later to adopt this practice. In 1951 a Committee of Review examined the terms of reference of DIC, to see if the research programme was relevant, comprehensive and adequately balanced between pure and applied research. The broadly strategic submission to the review set out major areas of research in progress or contemplated. This set the style of later triennial reviews of all CSIRO Divisions. Broad research descriptions obtained in this manner were actually mission-determining rather than truly strategic. They were used as objectives and constraints for project selection by scientists, or else indicated the type of research men who were to be recruited. There was little question of detailed allocation of resources on a program basis. Specific research topics were almost always generated at a low level.[60]

In the late 1960s mild interest was shown by the Organization in assessing its economic contribution, and a cost-benefit analysis of CSIRO's premier invention in the instrumentation field, the atomic absorption spectrophotometer, was conducted.[61] However, the first significant move away from the institutional model came in 1970 with the appointment of Price as Chairman. Following the trend of the

times, the Executive now placed emphasis on the adverse effects of a technological society and on changing research priorities in the light of the social and economic environment.[62]

In the meantime, the process of bureaucratization had proceeded apace in CSIRO. In the period 1960-1975 the number of scientists per administrator had decreased from 2.4 to 1.3.[63] Divisions were growing to such a size that their functions were beginning to overlap, and more centralized direction seemed inevitable. The move of CSIRO Head Office from Melbourne to Canberra in 1967 was seen by many to accelerate the process of centralization. Whereas formerly Head Office had acted as a clearing house for Divisional operations, now it was seen as a central focus of the Organization, with Divisions as provincial satellites. Divisional Administrative Officers, who at first had acted as envoys for their Divisions to the growing cental administration, were gradually integrated into that structure through interdivisional exchanges, and came to see their function as carrying out the policy of the Executive within their Divisions.

A major strategic initiative in 1971 was the disbanding of the Chemical Research Laboratories and the formation of the Mineral Research Laboratories (MRL). The latter grouping, which eventually contained five Divisions, was part of a strategy of expansion in the now highly significant mineral export industry. In what later turned out to be a significant precedent, Newnham was appointed as overall Director of MRL, with power to distribute funds and to set up cross-Divisional projects. This represented a considerable centralization of power relative to the older Laboratory groupings, which were later also reorganized in this way.

By 1974 CISRO had formulated an attitude to planning:

> . . . research results cannot be planned. Planning consists rather of identifying objectives, establishing their priorities, allocating resources for their pursuit and evaluating the results. A second general tenet is that the quality as well as the quantity of resources allocated to a particular objective is critically important. This is why in CSIRO so much importance is placed on the quality of research staff.[64]

The increasing demands for accountability by the Public Service were major forces in encouraging centralization. Chiefs of Division had to be seen to be observed and accountable in carrying out their functions and controlling expenditure. Requests for information by government departments through the Executive became more frequent, and adequate replies could not readily be obtained without stronger links with individual Divisions, which were the general repositories of subject knowledge. CSIRO became too large for the Executive to carry out the scrutiny of administrative minutiae to which it had been accustomed. To delegate these administrative matters while embracing

a greater co-ordinating or strategic role would require a radical form of reorganization. The Executive had already investigated the possibility of instituting a two-tiered management structure.[65] The opportunity to put this into practice came in 1977 with the first full scale examination of CSIRO's organization and practices.

The Committee responsible for the Independent Inquiry into CSIRO conducted a wide-ranging public investigation, which attracted submissions from many sources. The eventual recommendations contained in the Birch Report[66] tended to reflect the *status quo* and general direction which the Executive had been pursuing.[67] The Science and Industry Amendment Act of 1978 incorporated these recommendations: that Divisions should be clustered in five Institutes under the control of a Director appointed by the Executive, following the prototype of MRL; that the powers of the Chairman should be delineated and extended; that CSIRO's involvement in manufacturing industry should be strengthened by several means; that research functions should be extended to cover "community interests" and "national objectives". The Report was well received in senior circles. Stubbs said, "The reorganization of CSIRO is an attempt to improve its accountability to broader public interest criteria, without compromising its unique identity and ethos."[68] Moyal wrote,

> The Birch Report, in its careful explication and recommendations, cut a significant swathe of potential reform through Australia's premier scientific institution. An innate resistance to external decision making remains central to bureaucratic response. Will the bureaucracy then 'absorb the changes', and thus dilute the real potential of a major experiment in institutional science policy making?[69]

In contrast, staff viewed the unashamedly centralist changes with disquiet, especially the creation of a new level of management clearly intended to institute project management and financial review at the level of individual programmes. Complaint about the distance and unavailability of the Executive had been long-standing, and it was clear that while CSIRO was to become a vehicle for passing information and directives downwards, information in the reverse direction, which was felt to be even more critical for establishing long-term projects on a secure basis, was likely to be filtered and channelled through uncertain intermediaries. The suggestion of the Birch Report that social and economic topics should be excluded from the mandate of CSIRO added to this fear among those who agreed with Peres that,

> The wide range of issues that arise out of broad social welfare and the quality of life in its most general sense are barely represented (in Australia's research effort). It is in these areas . . . that there is the strongest need and the strongest justification for expanded research programmes.[70]

Public service ceilings on staff positions came into effect in 1975-1980. There were now many unemployed graduates on the market, and up to two hundred applicants for any advertised position. The need to provide incentives, such as research autonomy or high salaries, had passed. Scientists' salaries dropped by up to 20 per cent in real terms before tax in the period 1971-1979.[71] Entry into the higher professional grades became more difficult as the scientific population aged. Promotion to Senior Principal Research Scientist now required a significant international reputation, which advantaged those with overseas experience, and theoretical workers. The zero-sum game of resource allocation under low growth coincided with the appointment in 1978 of a 'high science' Executive under Wild. Administrators at many levels in CSIRO came to feel that, in the current climate, if changes were not made, they would be made for them. Rather than tolerate the steady whittling-away of research across the board, the Executive decided to designate certain priority areas which would expand at the expense of the remainder. Initially these were to be the two-hundred mile fishing limit, the synthesis telescope, biotechnology and secondary industry. Subsequently the priority directions were extended to more general topics.[72] Those Divisions not connected with these endeavours became understandably uneasy, as it appeared they were to be slowly quarried for staff positions through natural wastage.

In August 1981, CSIRO was embarassed to receive about half of the establishment of the Atomic Energy Commission. A rationalization of energy-related research became imperative. In a whirlwind tour on 31 August 1981, Tegart, then a member of the Executive, announced to general meetings of bewildered staff the closure of the Division of Mechanical Engineering, contrary to the recommendations of a newly completed Divisional Review; and the ceding of a third of the Division of Building Research to a new Division of Cellulose Technology. Chiefs were not informed in advance, and mention was made of probable retrenchments. Several weeks later, rumours of a further reorganization by the Director of the Institute of Industrial Technology led staff of the Division of Building Research to telex the Executive requesting that no further changes be made pending a promised review of the Division. This was followed by a hectic general meeting of the CSIRO Officers' Association at the Division of Mechanical Engineering.[73] As an internal CSIRO matter, little publicity was given to these disturbances. For the Executive to make these changes in a manner so foreign to the traditions of the Organization, creating general hostility and disturbance, must be regarded as not just a muscle-flexing exercise in significantly extended responsibility and mandate, but as a response to a very real fear of significant external threat to the future of the Organization. As a

result, the considerable organizational solidarity which had been shown in the Connor upset was shaken.

Proposals in Parliament in 1981 for the creation of a new Water Research Institute prompted the Executive to reorganize the rather scattered work performed by several Divisions. A special study and review of water resource research identified priority areas, and a subsequent submission regarding general organizational arrangements for government was endorsed by the Australian Water Resources Council. Subsequently, three CSIRO Divisions were reorganized and renamed. While staff found consultation quite inadequate, and Divisional submissions were ignored,[74] at least there was considerably more evidence of planning than had been apparent in previous reorganizations by the Executive, which had seemed more a tactical repsonse to circumstances or to personalities than the result of "a system of program management, priority assignment and resource allocation which is continuous, comprehensive and sufficiently detailed for effective and comparative decision making."[75] Reviews at the Divisional level clearly carried little weight relative to bureaucratic exigencies or subject reviews. The acceptance of the strategic model was now virtually complete, and the institutional model apparently a thing of the past.

THE NEED FOR REORGANIZATION

CSIRO has been regarded as the model organizational structure for conducting government-sponsored scientific and industrial research.[76] The Organization has steered a remarkably unproblematic and successful course between science and industry; between internal demands for scientific excellence and external demands for relevance. Up until the present, legitimacy has been maintained by the ethos of science, the merit system of promotion, and the appointment of senior scientists only to the full-time Executive. Until 1970 the institutional model had been sufficient to maintain harmony and still satisfy external demands. Yet since 1970 a complete changeover from the institutional to the strategic model as the dominant ideology of research management has taken place, propelled by economic stringencies and by the recommendations of the Birch Report.

In 1930 CSIR was a small group of 116 professional staff clustered in a few Divisions and Sections. Its *Annual Report* and *Journal* described simple practical matters couched in elementary experimental terms. By 1982 CSIRO had about 2500 professional staff (with little change since 1975), in 5 Institutes consisting of 40 Divisions and 6 Units, together with service and strategic planning apparatus. Its *Annual Report* was a sophisticated policy document describing large-scale manpower deployments, with no detailed reference to on-going

scientific activity.[77] Perhaps internal factors, such as administrative overload or Divisional overlap, were not as significant as external factors in precipitating the system crisis of change from one model of research to another more typical of corporate management than science. The first of these was the growing sophistication of industry and the general public with respect to scientific matters. While the record of Australian industry in performing its own R&D was notoriously poor, the numbers of highly qualified staff employed by industry and government had increased enormously, and the necessity for maintaining isolated bodies of researchers to keep each other company became less evident. The Australian National University and other graduate schools took on an increasing responsibility for basic research. The growth of science policy machinery (in ASTEC and the Commonwealth Department of Science) raised the question of who should be organizing and directing strategic research.

The possible strategies suggested in the *Annual Report* of 1981/82 to cope with a hostile environment were two: to aim for a more commercial and self-supporting organization largely involved in short-term sponsored work; or to take responsibility for Australia's strategic civil research. The latter option was the only one to accord with CSIRO's experience and tradition, and the one recommended by the Birch Report. The aim, therefore, was to consider only the large-scale; to reject piecemeal industry applications in favour of "infrastructure support benefitting wide sections of industry".[78] Large systems investigations within the context of a research programme were beyond the capacity of universities or industry, and were henceforth to be the responsibility of CSIRO. Personnel management, which had previously been all-important, was to be decentralized to lower levels of the hierarchy.[79]

Unfortunately, the response within the Organization to the changes of 1978 has, on the whole, been defensive. Many of the rearrangements of the 1980s must be seen as an attempt to maintain the institution; to preserve control and the integrity of existing work programmes while being seen to satisfy external demands for change. The 'double-guessing' that has gone on as each administrator has tried to meet the demands of his superior before they were ever made (thus appearing to be progressive and dynamic) has not been a successful alternative to the cautious evaluation of broad objectives that has been CSIRO's traditional style. It has certainly not been a substitute for visible and bold advances in new areas, which most researchers would find an acceptable justification for closing down existing lines of research.

However, perhaps because of the successive encapsulation of power as reorganizations at each level have smoothed out the disruptions above, work programmes have not so far been noticeably disrupted,

and the low morale, high staff turnover and miniscule output which typified the reorganization of other government research bodies, such as, for example, the Bureau of Transport Economics in 1976, has not occurred. Contributing to this stability is the long history of steady performance of the Organization, and the high autonomy of researchers who are not necessarily dependent on superiors for work opportunities.

THE PROBLEMS OF REORGANIZATION

In the longer run the effects of strategic management could be profound. Unlike earlier institutional or mission-based reorganizations, the change could affect not only **what** is done, but **how** it is done. Some of these effects are already problematic. The first question to be asked is whether organizational changes actually do anything except interfere with productivity. The work of the Organization consists of individual projects, and if few new projects are initiated, all that has happened is the creation of new levels of management and longer chains of command. The inevitable committees and other administrative paraphernalia proliferate, leaving scientists less and less time for actual work. Eventually this could lead to more bureaucracy and the decay of organic work environments. The reasons for this are given by Mintzburg.

> The more an organization is controlled externally, the more centralized and bureaucratic it tends to become. This can be explained by the fact that the two most effective means to control an organization from the outside are to hold its most powerful decision maker, the chief executive officer, responsible for its actions and to impose clearly defined standards on it (performance targets or rules and regulations). Moreover, because the externally controlled organization must be especially careful about its actions — often having to justify these to outsiders — it tends to formalize much of its behaviour and insist that its chief executive authorize key decisions.[80]

When responsibilities are formally delineated, staff tend to do exactly that amount and no more. Where work is already intrinsically satisfying, the desire of self-motivated staff to work long hours and take on varied responsibilities is discouraged by bureaucratic arrangements. Lessened organizational effectiveness may result.

The second effect of reorganization might be to upset the balance between pure and applied work. Strategic management is useful for applied work, where detailed goals and timetables can be realistically set. But incentives to perform this kind of work are declining. Industry oriented Divisions are now in a minority situation in competing for staff promotions at the Institute level. The staff of these Divisions are now required to meet the higher rates of

publication in refereed journals to which basic science Divisions have been accustomed. Formal rules for promotion within Institutes are taking the place of the more flexible Divisional recommendations of the past. Scientists are finding their applied contributions and conference or industry journal papers substantially discounted. This concern is heightened when the need for industry collaboration requires a degree of confidentiality, thus limiting published output. Over the past few years scientists have turned their attention more to the type of work which academic journals publish; that is, basic disciplinary research. Or else they have dressed up their work to make it look more scientific, removing it from the industry audience where it would do most good.

The third danger is that strategic management will lead to substantial holes being created in Australia's research effort that no other authority is capable of filling or willing to fulfil. If CSIRO is to restrict itself to strategic work in the interest of justifying its existence, who is to perform the remainder of the research task? Universities are today indirectly government-funded bodies with no accountability requirements, and their contributions remain random and haphazard. Industry has shown itself unwilling and unable to carry out development on even fairly reliable prospects. State governments are not set up to perform research or dissemination tasks relating to small-scale science and technology, in which CSIRO has specialized, and the cost of assembling this kind of expertise would be enormous.

While resources are stationary or shrinking, unfashionable Divisions will be starved of funds and staff positions. In these Divisions, it is probable that risky or marginal activities, or those favoured by junior staff, will vanish from the agenda. The more exciting possibilities of research may be curtailed because they do not fit in with restrictive work programmes. On the other hand, more failures can be expected in the Divisions designated for expansion, if these are also to be more strategically managed. The allocation of priorities in advance is a risky business in research, as quite reasonable prospects can turn out to be either technically or economically infeasible. A few well-publicised failures can damage careers and Divisional reputations faster than anything else.

Expert strategic committees are unlikely to come up with as varied and relevant a range of projects as autonomous researchers well-versed in their missions and discipline. Usually these committees are too far from the research face to know what is really feasible, or what the many small needs of users are likely to be. They tend to generate either conservative topics that support the *status quo,* or else trendy topics, and tend to favour larger-scale applications. Some balance or input at a low level is needed if industry-related Divisions are not to be divorced from their missions. In general there is no substitute for

direct contact between those with a perceived research need and those capable of, and interested in, solving the problem. Philip says,

> Little reliance can be placed on remote contacts arranged in a roundabout manner. When communication must find its way upwards through one agency, travel horizontally at a high level between agencies, and then find its way downward in the second, the outcome is seldom fruitful.[81]

The fourth problem concerns exactly who the research of CSIRO is for. CSIRO's applied work has been directed almost entirely towards producer and not consumer interests. Little or no consciousness that labour as well as management and ownership is involved in the production process is evident from the composition of research programmes and advisory committees, or from the stated objectives of the Organization and its Divisions. Almost all research may benefit one group at the expense of others, but if a consistent bias exists in a national organization, it cannot be said to be serving the public interest. Evans' opinion that "the charter of CSIRO is, in broad terms, to carry out research for the benefit of the community," must be seriously questioned.[82]

At the time CSIR was formed, the state was interested in the provision of infrastructure services for capital. By 1970, it was prepared to devote part of the social product to quality of life issues. In concert with the worldwide trend in science at that time, CSIRO introduced a small number of people-oriented topics into its programme.[83] The Birch Report recommended that this work continue subject to certain limitations, and subsequently research "furthering the interests of the Australian community" was included as one of CSIRO's functions. Contrary to this direction, the strategic model has diverted sources away from such 'peripheral' work.

The present Executive has clearly interpreted national interest in the narrow sense, and has selectively implemented those parts of the Birch Report which it intended to develop anyway. The response to the community interest mandate until now has been to lump together under this heading all those programmes which cannot be conveniently slotted under rural or manufacturing industry or resources, rather than actually to encourage work in this area. There still remains an enormous imbalance between work on producer interests and basic science, and work on consumer interests. An examination of the allocation of resources in 1981/82 shows that just under half the budget went to research on manipulation of the environment for private profit, and almost all the remainder on basic research. Some $4m out of a total research budget of $226m was devoted to consumer-related topics such as bushfires, air pollution, nutrition, ecology and the built environment.[83] Even these studies were justified by a substantial commercial interest, and most of them have come under threat in the present period of stringency.

The employer bias has never been mentioned in the context of CSIRO's research programme, probably because it is implicit in CSIRO's charter, and is much more strongly institutionalized in many other forms of state investment. Many of CSIRO's inventions have been labour-replacing, but this has usually been incidental to the development of research knowledge. Employer groups have commissioned some studies in CSIRO and universities that are blatantly intended to replace labour. One of the most interesting of these is automated sheep shearing, a special project funded and directed by the Wool Research Trust Fund.

This invention has been hailed as the world's most advanced industrial robot. Originally the Wool Board approached CSIRO and several universities complaining that the biggest single outlay of wool producers was for shearing labour (although in fact is was a small part of total costs), and that this was crippling international competitiveness. CSIRO agreed to conduct a feasibility study of a prototype shearing machine which maintained the correct distance from the sheep's skin by measurement of electrical capacitance. Difficulty was found shearing around the various contours of the sheep, and CSIRO felt it did not have the necessary experience in electronic control systems to develop the machine further. Finally a cost-benefit analysis was undertaken which showed that it would cost up to $500 000 to replace one shearer, that the machine was slower, and that it did not shear heads or crutches so sheep came off the ramp looking like poodles. To CSIRO's credit, it passed on the machine to the University of Western Australia, where work is still in progress. CSIRO has restricted its research to biological and chemical defleecing, which, despite early difficulties, appear to hold some promise. CSIRO felt its three-year involvement in this bold failure was justified, as sometimes it was just as important to show that something could not be done as that it could be done. It did show that CSIRO was prepared to reject an infeasible externally-funded problem of some scientific merit, where several universities were not so fussy. What is surprising is that the Wool Research Trust Fund continued to support this project after CSIRO had rejected the invention.[85] While only the most tentative references to the project occurred in the reports of the Division of Textile Industry, it has since been widely publicised without reference to its unsatisfactory features.[86]

Another point here is the lack of consideration for the workforce that was to be displaced by the invention. Apart from the technological and economic problems, a basic question which should have been asked was, should CSIRO be working on inventions which are not intended to create any new process or facilitate work, but simply to replace labour? Wider social criteria, such as the cost of

retraining labour, need to be considered in cost-benefit studies and other formal methods of feasibility analysis. CSIRO needs to consider its attitude to technological unemployment, deskilling and the adverse consequences of technology much more carefully than has been done in the past.

PRESCRIPTION FOR DECENTRALIZATION

The Executive will continue to pursue more centralist policies and this may prove to be the only realistic strategy. Such changes will create their own stresses. Some of these are tolerable, but action will need to be taken on others. Many of the answers to the four problems outlined above in maintaining a productive balance between strategy and autonomy are contained in the minor (and so far ignored) recommendations of the Birch Report. CSIRO still has an extremely decentralized decision-making structure. It is still generally accepted that the necessary conditions for maintaining successful scientific research are the same as ever, basically an absence of standardization and bureaucracy. It will be some time before programme development and management by objectives affect Divisional activity to more than a nominal degree, because of the long lead times in winding up projects. Even then change will normally occur through individual perceptions of a different environment, rather than through administrative direction.

There are other organizational possibilities than simply extending the professional bureaucracy. The other currently fashionable organizational structure in research is 'adhocracy', a structure of interacting project teams.[87] This type of organization has many different kinds of manager with limited spans of control, no real line/staff distinction, and the production of non-standard outputs in a changing and complex environment. The Division of Building Research attempted to restructure in this way in 1981 in preparation for a Divisional Review, through a system of matrix management. This was endorsed by the Committee of Review, but the appointment of an Institute Director who favoured line management put an end to this promising experiment. The subsequent reorganization followed familiar lines of amalgamation, centralization and delegation, and less flexibility in the directions of research. Whereas formerly work programmes had been designed around projects undertaken, now projects had to conform to programme directives, which reflected the research interests of senior staff.[88] A typical concession to the pressures of rationalization was the cessation of an innovative telephone Building Advisory Service to the public. This was henceforth restricted to industry callers, as it did not have an identifiable scientific role.

Much attention has been paid recently to the deficiencies in Australia's applied development effort. The second question, of providing organizational incentives to applied work, has been extensively studied in CSIRO. So far, little has actually been done to reform the criteria for promotion.[89] However, several organizational intermediaries have been set up to improve the possibilites for applied work. The legislative changes of 1978 made it possible for CSIRO to negotiate collaborative research agreements with other bodies. A number of positions are now funded in this way rather than through traditional direct industry funding. The formation of the joint venture company SIROMATH, which performs mathematical consulting work, has made it possible for CSIRO Divisions to sell software and tender competitively for outside funds in such a way that the proceeds do not vanish into general revenue.[90] The new company SIROTECH should eventually provide a major avenue for the commercial development of CSIRO inventions, especially by contracting out development work in which CSIRO has no demonstrable expertise or resources.[91]

The Executive has taken its strategic responsibilities very seriously, although its method of acting upon these leaves a lot to be desired. Its strategic planning studies and subject reviews have been responsible attempts to grapple with Australia's research priorities. What is in question is whether strategic direction can really succeed in an institution like CSIRO that was set up for an entirely different purpose. If it does succeed, will the unique character of the Organization and its ability to carry out low-level investigations that benefit a whole industry be damaged? It would seem that in the first flush of using its new powers the Executive has forgotten its original function, the preservation of scientific autonomy and the institution. A number of minor recommendations of the Birch Report encouraged freedom of action of individual workers. So far these have not been seriously implemented. First, staff exchanges with universities, industry and other bodies, which would significantly improve the standing of individuals and the integration of CSIRO into the community, have rarely eventuated. Joint-funded projects move only part of the way towards this goal, as control over staff is not relinquished. Secondly, partnerships for the purpose of the commercial development of a discovery, invention or improvement are in their infancy. CSIRO contains a wealth of expertise and talent, and the marketing of its intellectual skills through intermediaries such as SIROMATH would transfer this resource more directly to the community and to industry.

It is the author's belief that most scientists could structure their work so as to perform 10 per cent of short term project work on questions of national or community interest without endangering

research progammes. In fact, these would be enhanced through researchers bringing a greater depth of responsibility and experience to the task. Individual scientists are the best qualified to decide what work of this type is most relevant, once they become aware of the possibilities available. CSIRO is eminently well set up to perform work on small-scale activities which people can do themselves. Such innovation would have a considerable market in developing countries. Birch has said, "only about 2% of the world's resources in science and technology are devoted to the problems of developing countries. [Scientists and technologists] might be encouraged to include such problems in their work."[92] Following a recommendation of the Birch Report, a Centre for International Research Co-operation was established, with responsibility for co-ordinating overseas-related research. But, typically of the administrative interface type of response, little has filtered down as yet to project level.

With regard to the fourth question, there is considerable room for improvement in the area of community interests and participation. Participation practices as adopted in Northern European countries,[93] are untried in Australia. The Advisory Boards of CSIRO consist almost entirely of establishment industrialists, academics and representatives of other government agencies. While representatives of unions or community groups have not been excluded, the problem has been to find people with sufficient sophistication and breadth of interest not to be discouraged by the broad range of narrow topics covered by CSIRO.

The general theme of this paper is that the institutional science administrators quoted above were right: that research is done by individuals, and institutes exist to help them in otherwise unequal negotiations with funding bodies. Strategic direction is useful only in basic research as a broad, mission-oriented constraint on activity. In applied research, methodology and time schedules are best settled in direct consultation with users or funding bodies, subject to programme resource constraints. If real change is required, this has to be accomplished by changing the perceptions of researchers; by providing incentives and guidance, not control and committees. The institution of CSIRO should consist of professionals trained in recognizing and responding to social needs within the context of one or several academic disciplines. This is already the case to a fair extent in the more applied parts of CSIRO, where scientists receive good informal on-the-job training in negotiating with users. But recent strategic developments have hampered and not accelerated this trend. There is room for a considerably more critical attitude at all levels, rather than a passive acceptance of undesirable change. Scientists should protect their autonomy constructively when projects that are genuinely in the national interest are threatened in the name of

austerity or of narrower research programmes dictated from above. Scientists and their administrators must see themselves as actors rather than as acted upon. In the words of Rivett:

> The main danger as I see it is that people will knuckle under to the bureaucratic regime and, by avoiding fight and seeking comfort, they will gradually reach a condition of tolerant acquiescence in what they formerly knew to be wrong. A generation will arise that knows not freedom and will be content to do without it. Then some day an old battle will be fought over again.[94]

CONCLUSION

In almost sixty years of existence, CSIRO has changed from a research body of the institutional type to a large and complex organization in which strategic considerations are the determinants of policy. It has done this in response to internal pressures and external demands for accountability. It is perhaps surprising that CSIRO still exists at all, and that a single body is responsible for Australia's longer-term practical research. Management has steered a remarkably successful course between basic and applied research with what might be regarded as minimal concessions to demands for increased bureaucracy. In so doing it has retained control of the subject matter of science in the hands of scientists, and maintained most of the organic character of scientific work, but lately management has damaged the rather formidable unity of the Organization. Strategic management has directed funds away from small-scale research on techniques or inventions that might find application in small business or in the community, towards larger-scale applications, and in the process the public interest has not been well served. Increased centralization of control brings the attendant danger that research will take on a narrower and more sectarian quality, and come to reflect the interests of an even smaller section of the community than has been the case in the past.

Significant countervailing pressure may be exerted by the adoption of more flexible modes of organization, and by providing avenues for public participation. The possibilities for individual scientists engaging in applied community work and in 'small' science applications need to be substantially improved. The flexibility of movement of scientists needs to be improved so that they may come in contact with a greater variety of social experience. Staff need to be adequately consulted before changes at the Divisional level are instituted, and before work programmes are tampered with. To a fair degree CSIRO Divisions are insulated from the outside world and the possibility of contacts at a much lower level needs to be increased. This may be made possible through organizational intermediaries such

as SIROMATH. These can take on the non-scientific responsibilities of matching researchers to low-level external research needs not requiring the strategic intervention of formal organization. Community groups need better access to the expertise and knowledge of CSIRO, which is currently dominated by industry and basic science interests. While in theory other organizations, such as State governments, are responsible for consumer-related technical information, in practice they cannot provide the level of technical expertise which CSIRO contains. To restrict CSIRO researchers entirely to long-term strategic interests of a purely technical nature is to deny the community the benefit of its investment in one of the most successful and innovative government research organizations in the world.

NOTES AND REFERENCES

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2. A. Henderson, 'Scheme for the organization and development of scientific and industrial research' in G. Currie and J. Graham, *The Origins of CSIRO,* CSIRO, Melbourne, 1966, Appendix I.
3. For example, J. Ronayne, 'Further thoughts on diversity and adaptability in Australian science policy', *Minerva,* 17, 1979, p. 452. There were, in fact, differences between DSIR and CSIR that later turned out to be highly significant. CSIR was run as a government department; that is, in a bureaucratic Scientific Civil Service with fixed positions. Its Council was not run by scientists from the institution, and consequently DSIR did not command much loyalty from its scientists. It was responsible only for manufacturing industry research; other councils dealt with agriculture, medicine, and conservation, and these were constructed more like CSIRO. See Office of the Minister for Science, *The Management and Control of Research and Development,* HMSO, London, 1961.
4. Currie and Graham, *op. cit.,* p. 34.
5. *ibid.,* p. 138.
6. Australia, Parliament, *Science and Industry Research Act 1920-26.*
7. Currie and Graham, *op. cit.,* p. 138.
8. G. Lightfoot, *CSIR - 1945,* CSIR, Melbourne, 1945.
9. N.J. Vig, *Science and Technology in British Politics,* Pergamon, London, 1968, p. 13.
10. CSIRO and its predecessors will be treated as one organization in this paper.
11. L. Peres, 'Research organizations and control of incentives: the case of an Australian scientific organization', *Public Administration (Sydney),* 22, 1963, pp. 330-49.
12. *ibid.,* p. 347
13. R. Rivett, *David Rivett: Fighter for Australian Science,* Rivett, Melbourne, 1972, p. 188.
14. *ibid.,* p. 208, suggests he retired prematurely over the passage of the Act, but this is downplayed by F. White, 'CSIR to CSIRO: the events of 1948-49', *Public Administration (Sydney),* 34, 1975, pp. 281-93, who gives a detailed account of these events. Rivett did publicly threaten to resign.
15. Rivett, *op. cit.,* p. 206.

16. Australian National University, *Science in Australia,* Cheshire, Melbourne, 1951, p. 10.
17. F. White, 'Administrative problems in the development of science and research', *Public Administration (Sydney),* 27, 1968, pp. 113-40.
18. D.T.C. Gillespie, 'Research management in the CSIRO', *Public Administration (London),* 42, 1964, pp. 11-31.
19. CSIRO, *Annual Report 1963/64,* p. 1
20. These beliefs are still widely held, especially in older Divisions, despite a policy statement to the contrary by the Chairman in 1975. Members of the Science Communication Unit in CSIRO are currently conducting a campaign to encourage private expressions of opinion.
21. B.G. Johnston, 'Publish or perish: the financial rewards of publication for CSIRO scientists', *Search,* 12, 1981, pp. 404-8, has calculated a net present value of at least $1 000 in salary for each published paper.
22. 'Disciplinary' Divisions did, in fact, have missions: to investigate problems of national importance in the context of a particular discipline.
23. This description does not apply as strongly to CSIRO Divisions located on university campuses. These were more integated into the university community.
24. S. Macdonald, 'Faith, hope and disparity', *Search,* 13, 1982, pp. 290-9.
25. As shown by the survey in *CSIRO Officers' Association Bulletin,* No. 176, 1980.
26. White, *op. cit.;* E.G. Hallsworth 'The role and optimum structure of a national research organization: the potential for CSIRO', *Search,* 8, 1977, pp. 420-8.
27. CSIROOA, *op. cit.*
28. K. Mellanby, 'The disorganization of scientific research', *Minerva,* 12, 1974, pp. 67-82.
29. Rivett, *op. cit.,* p. 188.
30. *Science in Australia, op. cit.*
31. Office of the Minister of Science, *op. cit.,* p. 7. Unfortunately, the Australian Science and Technology Council (ASTEC), *Basic Research and National Objectives: A Report to the Prime Minister,* Australian Government Publishing Service (AGPS), 1981, calls mission-oriented reseach "strategic" research.
32. Peres, *op. cit.*
33. Mellanby, *op cit.* and others make this point. One of the internal investigating committees into manufacturing industry collaboration in the mid 1970s found that even in basic Divisions, such as the National Measurement Laboratories, staff were enthusiastic about the possibility of useful collaboration with industry, although older scientists were less sanguine.
34. Y. Esplin, 'TT takes two', paper presented to 52nd Australian and New Zealand Association for the Advancement of Science (ANZAAS) Congress, 1982, discusses these issues in more detail, and describes attempts to tackle the problem of technology transfer from CSIRO to manufacturing industry.
35. S.H. Bastow, 'Research in the manufacturing industry in Australia', *Journal of the Institute of Engineers, Australia,* 36, 1964, pp. N37-40.
36. CSIRO, *Annual Report 1965/66,* p. 7. While this statement appears to support strategic management, it cannot be taken entirely at its face value as it also includes an institutional demand for the management of science by scientists. The Organization has always been keen to maintain scrutiny over research programmes and individual activity, and sponsored research threatens this function.
37. The old low-profile sacred cow image may be fading. The recent successful High Court action by several apiarists to prevent CSIRO from releasing natural enemies of the weed Paterson's Curse, and the controvery over the Australian National Animal Health Laboratories, have been cited by the Chairman in the 1982/83 Annual Report as evidence of this.
38. British Labour Party, *Signposts for the Sixties,* London, 1961.
39. Committee of Enquiry into the Organization of Civil Science, *Report,* HMSO, London, Cmnd. 2171, 1963.

40. H. Brooks, 'Rothschild's recipe in the United States', *Nature,* 235, 1972, p. 301. P. Gummett, *Scientists in Whitehall,* Manchester University Press, 1980, says that the Rothschild reorganization had little effect on research programmes, apart from increasing the number of committees, and it would seem that scientists, after all, do have some idea of national research needs.
41. H. Brooks, 'The problems of research priorities', *Daedalus,* 107, 1978, pp. 171-90.
42. S.S. Blume, *Towards a Political Sociology of Science,* Macmillan, New York, 1974, p. 22.
43. L.G. Peres, 'The changing politics of Australian science' in A.T.D. Healy (ed.), *Science and Technology for what Purpose?,* Australian Academy of Science, Canberra, 1979, p. 57.
44. E.G. Whitlam, 'A national science policy', *Search,* 1, 1970, pp. 134-7.
45. B.S. Hetzel, 'Animal nutrition to human nutrition: achievements and prospects', *Nature,* 261, 1976, pp. 640-3. The Division was combined with Animal Health between 1944 and 1965.
46. CSIRO, *Annual Reports 1966/76, 1973/74.*
47. Peres, 1963, *op. cit.,* describes these responsibilities and the attitude of CSIRO and the Public Service Board in detail.
48. I.W. Wark, 'The Division of Industrial Chemistry', *Records of the Australian Academy of Science,* 4, 1979, pp. 7-41; G. Currie and J. Graham, 'G.A. Julius and research for secondary industry', *Records of the Australian Academy of Science,* 2, 1970, pp. 10-28.
49. *CSIROOA Bulletin No. 157,* 1975.
50. Science Task Force, *Towards Diversity and Adaptability. Report to the Royal Commission on Australian Government Administration,* AGPS, Canberra, 1975.
51. J.R. Philip, 'Towards diversity and adaptability: an Australian view of governmentally supported science', *Minerva,* 16, 1978, pp. 397-415.
52. Ronayne, *op. cit.*
53. P.F. Gross, 'Diversity and adaptabilty in science policy: a potential trade-off between autonomy and influence', *Search,* 7, 1976, pp. 89-92.
54. Rivett was also a member of committees that reported to Parliament in 1934, 1937 and 1939 on this topic.
55. Australia, Parliament, *Report by H.E. Wimperis on the Inauguration of Aeronautical Research in Australia,* December 1937. The Aeronautical Research Laboratories were transferred in 1949 to the Department of Defence, and are now run bureaucratically. Some informal social contacts with CSIRO staff remain.
56. Australia, Parliament, *Secondary Industries Testing and Research — Extension of Activities of Council for Scientific and Industrial Research,* February 1937.
57. Wark, *op. cit.*
58. *ibid.,* Preface.
59. *ibid.*
60. Some Chiefs were prepared to direct staff to work on particular projects of their own invention. D.E. Weiss of the Division of Chemical Technology initiated important projects such as water purification using ion-exchange and magnetic polymers, and other projects that were not as successful. Not all staff appreciated this style of management. Weiss now directs the Planning and Evaluation Advisory Unit in the Secretariat. The present Chairman, J.P. Wild, developed the INTERSCAN navigational landing system while Chief of the Division of Radiophysics. Centrally directed applied projects can be highly successful if a Divisional consensus is reached as to their relevance and worth.
61. CSIRO, *Annual Report 1967/68.*
62. CSIRO, *Annual Report 1969/70.*
63. Philip, *op. cit.* One scientist announced to a public meeting held in Melbourne by the Birch Committee in 1977, that when he joined CSIRO there were only two people between himself and the Executive, and after ten years of promotions there were four. This lengthening of chains of command has been quite general.

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68. P. Stubbs, *Technology and Australia's Future: Industry and International Competitiveness,* AIDA Research Centre, 1980.
69. A.M. Moyal, 'The effect of institutional evolution on science policy' in A.T.D. Healy (ed.), *Science and Technology For What Purpose?,* Australian Academy of Science, Canberra, 1979, pp. 67-83.
70. L.G. Peres, 'Science and technology' in R.K. Forward (ed.), *Public Policy in Australia,* Cheshire, Melbourne, 1974, pp. 214-48.
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72. CSIRO, *Annual Report 1981/82.*
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75. CSIRO, *Annual Report 1973/74.*
76. Whitlam, *op. cit.*
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81. Philip, *op. cit.*
82. L.T. Evans, 'The divorce of science', *Search,* 8, 1977, pp. 403-10.
83. CSIRO, *CSIRO-Australia,* Canberra, 1974, p. 43.
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87. Mintzberg, *op. cit.*
88. CSIRO Division of Building Research, *The Management of the Division of Building Research,* DBR, Highett, 1982.
89. P. Robinson, *Review of CSIRO's Commercial Activities,* September 1983.
90. CSIRO Division of Mathematics and Statistics, *Newsletter,* No. 85, April 1982.
91. Robinson, *op. cit.*
92. Healy, *op. cit.,* p. 18.
93. Organization for Economic Co-operation and Development, *Technology on Trial: Public Participation in Decision Making Related to Science and Technology,* OECD, Paris, 1979; and D. Nelkin, *Technological Decisions and Democracy,* Sage, London, 1977.
94. Rivett, *op. cit.,* p. 200.