BIOTECHNOLOGY: SUNRISE OR SUNSET?

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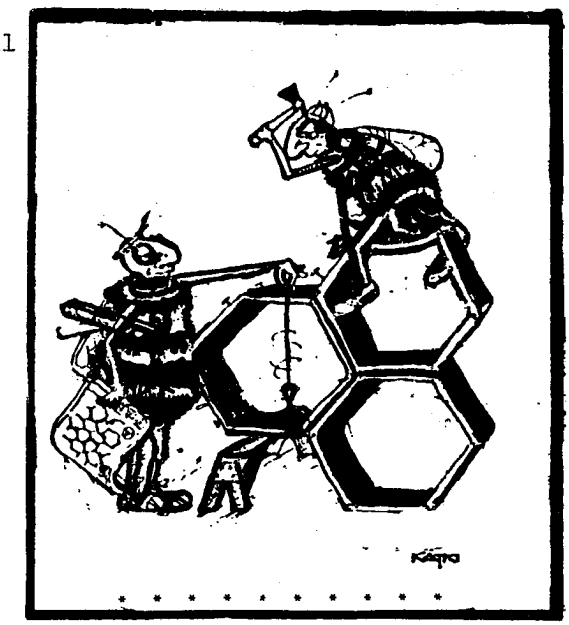
INTRODUCTION[1]

The current Minister for Science and Technology, Barry Jones, has described biotechnology as "the greatest industrial growth area of the 1980's"[2] and has set in motion a number of proposals aimed at stimulating investment in, and fostering commercial production of, the fruits of biotechnological research. Biotechnology is the manipulation of genetic material, the 'programming' of bacteria, plants and animals to exceed existing biological limits. In the field of microbiology, for example, bacteria have been genetically engineered to produce substances which can, normally only be extracted at high cost from animal sources. The proposed role of the state in such developments of biotechnology is, in the general terms proposed by Butler[3], a reflection of the needs of capital in exploiting them. More particularly it reflects the need for the privatisation of developments and the claim that insufficient private funds are available to finance biotechnological research. Instead of protecting and nurturing the exploitation of such research by private interests, though, a Labor government should surely be open to the establishment of more public enterprises in the field.

BIOTECHNOLOGY TODAY

Biotechnology is in its infancy in Australia. It was estimated in 1982 that less than $5 million is currently being spent on research annually by Australian industry.[4] Only one company, Biotechnology Australia, a Sydney-based subsidiary of C.R.A. conducts its own in-house research for the development of commercial products. At present it is limiting its operations to the conversion of low-cost organic matter to animal feed. There are, however, thirteen smaller companies, many utilizing the expertise and facilities of university and government departments, involved in monoclonal antibody production, biomedical and agricultural research, and in conversion of industrial wastes.[5] Fielder-Gillespie, the large food corporation, has recently expanded its operations into the area of high technology, establishing an IMTEC division for biotechnological research, and providing funds of $1 million over 5 years to the Queensland Institute of Technology for research on the commercial manufacture of diagnostic reagents. In what is becoming a standard model for biotechnological collaboration, Fielder-Gillespie provides the Institute with research money, determines research priorities, and has exclusive rights to products once they are developed. Other companies, including Austgen and B.H.P., are funding research in university laboratories under similar conditions. The companies provide a portion of the cost of research and the universities (via state funding) meet the cost of salaries and laboratory equipment. The research team is also able to apply for a Federal grant from the Australian Industrial Research and Development Incentives Board (AIRDIB).

It is the state, too, which allocates funds to the Commonwealth Scientific and Industrial Research Organisation (CSIRO), to the State Departments of Agriculture, and to various research institutes.



The CSIRO is the largest single institution involved in biotechnology in Australia. In its Industrial Microbiology Unit at Clayton, Victoria, scientists are investigating industrial applications of cloned and genetically manipulated micro-organisms; the Division of Plant Industry is involved in nitrogen-fixing research and is attempting to increase plant resistance to certain environmental agents; the Commonwealth Serum Laboratories in Melbourne is involved in antibody production; and monoclonal research is being conducted at the CSIRO's Molecular and Cellular Biology Unit in Sydney.[6] In the latter case, Bioclone Australia helps to fund the research, and is rewarded by having the rights to antibodies developed by the researchers.[7] As Dr. N. Broadman of the CSIRO executive argued at a Genetic Engineering Symposium held in Sydney in 1981, "collaboration between industry, CSIRO and universities will be essential"[8] for success in the industry. It would seem this view is shared by most of his scientific colleagues: Australian researchers have not only welcomed but have actively sought this type of collaboration. The most recent example is the establishment at the Australian National University of a Centre for recombinant DNA (r-DNA) research within the Research School of Biological Sciences. The Centre is comprised of the facilities of the Genetics Department and a number of updated laboratories. When it is fully established the Centre is to have about 25-30 research scientists at post-doctoral level, together with another 10-15 Ph.D. students.[9] About half the scientists will be on the staff of the University, the rest visiting researchers. The Centre will accept private funding for research projects which have prospects of commercial viability. In return, exclusive production rights will be granted to the funding organisation. The Centre is already in receipt of $2.25 M from a U.S. based company which has negotiated with the University to pursue research on its behalf.[10] Similar arrangements have been fostered at the state-funded Centre for Gene Technology at the University of Adelaide.

The funding of biotechnological research in Australia was a topic of some concern to participants at the aforementioned Genetic Engineering Symposium. Participants argued that Australia had a small "R" and "D" infrastructure, a small local market, offered few incentives to those companies wishing to enter biotechnology and could not provide enough venture capital to fund all the interested commercial firms.[11]

These themes were taken up by ASTEC in its 1982 submission to the Prime Minister on biotechnology. ASTEC recommended the establishment of a

National Biotechnology Scheme under which the Federal Government would provide financial support to research centres for specific research projects, especially those projects deemed to have possible commercial applications. Grants of money to the successful institutions would be made upon recommendation by an advisory committee set up by the Minister for Science and Technology and comprising academics, government officials, and business leaders.

The Fraser Government, which received the report, was unhappy initially about the proposed 'key industry' approach to research funding as it had traditionally funded industry through an 'across-the-board' system of grants. In a 1977 White Paper it had rejected the idea of stimulating 'selected' industries. The key industry approach was thought to be a form of favouritism - a form requiring unnecessary intervention.[12]

However, the 1982 ASTEC submission emphasised the important role to be played by government in facilitating new industrial development:

> "the process of bringing research results into commercial production is often a high cost activity...an important factor in inducing industries to enter the field will be the sharing of this risk by the Government. This will involve the promotion of in-house industrial research and development, and the provision of assistance in situations where firms do not choose to undertake the full costs of product development themselves."[13]

Prior to the 1983 election the Fraser Government accepted the ASTEC recommendations. The Government would distribute $2.5 M through AIRDIB to fund groups undertaking biotechnological research in 1983-4, and this funding would reach a level of $5 M in 1984-5. Furthermore, the Government would establish a National Biotechnology Scheme under which funds of $1.5 M would be available in 1983-4, $3 M in 1984-5, and $5 M per year thereafter.[14]

When Labor came to office it gave further support to the idea of government stimulation of selective industries and to the formation of a "National Biotechnology Program." The March 1983 elections pre-empted any action by the Fraser government but the new ALP government, and its science minister Barry Jones, strongly supported the proposal and the 1983/4 budget included a total of $12.2 million for biotechnology research. The figure of $12.2 million was arrived at by specially earmarking $7.8 million of CSIRO's recurrent funds for research in specific biotechnology programs, and included $1.5 million for the first year of the National Biotechnology Scheme, $2.5 million for distribution through AIROIB, and $400,000 for the Howard Honey Institute in Melbourne.

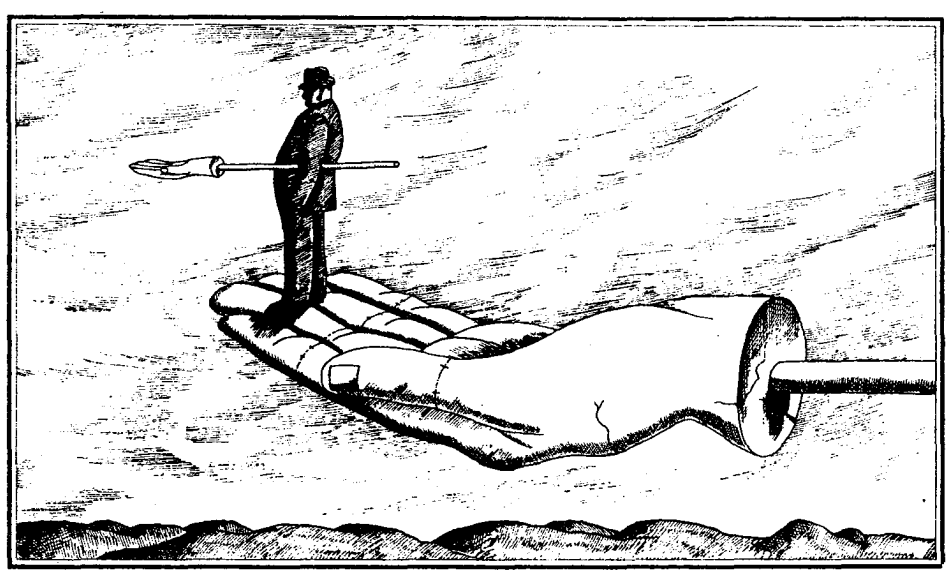
Biotechnology was also one of the ALP's 'sunrise' industries and became thus an eligible area of investment in the government's venture capital tax scheme. Under this scheme the government issued management and investment company (MIC) licences to seven venture capital firms established to exploit developments in high technology. Shareholders in MIC's can claim full deduction on invested capital so long as it is used for the development of "innovative technology". The scheme is to cost the Australian public about $20 million per annum.[16] The Labor Government has also established

SIROTECH - an independent, non-profit company with a Board whose membership spans industry, science and finance. The company, with an overall aim of facilitating technology transfer between the CSIRO and private industry, has been formed to give the CSIRO business strengths it is perceived to lack.[17] In simple terms, SIROTECH will contract the development of the products of CSIRO research to private capital. This parallels moves within the CSIRO to remove the barriers to private involvement in state-funded biotechnological research.

ORGANISATION AND OWNERSHIP

The cosy relationship being fostered between government, industry and the universities is open to a number of criticisms. Public funds are to provide the research laboratories, salaries of academics, the purchase of new and expensive equipment, and a large slice of the costs required to bring a new substance or organism into commercial production. Knowledge and facilities built up over many decades at universities and government-funded research institutions and paid for out of the public purse will now be harnessed for the benefit of private companies. The risk is underwritten by the state, and the firms fortunate enough to be involved in this 'joint' research receive the windfall gains arising from commercial application of new inventions. As Thompson has argued

> "the loss of control over technology is basically the transformation of accumulated social knowledge into private property in order to serve the interests of capital accumulation."[18]

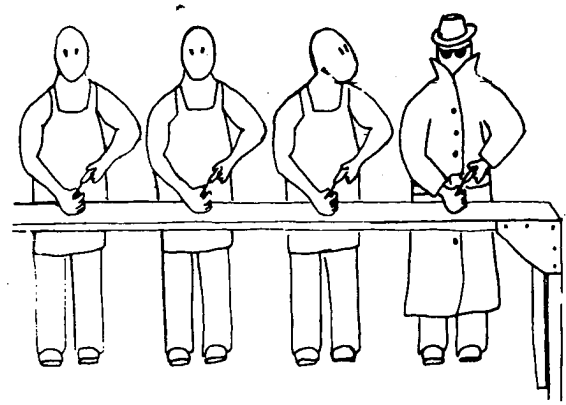


The Minister for Science and Technology has sought to justify this privatisation of social knowledge where the privatisation is by Australian firms.[19] The Secretary of the Minister's Department has argued that the Government must "provide a range of incentives to encourage industry to make

full use of (the state's)...research and manpower base". At the same time, he suggested, the CSIRO would need to reorganise its activities towards 'key technology' areas, thereby fitting publicly-funded research more closely to the profit-making desires of private companies. Presumably, it was Australian firms which the secretary hoped would be able to establish "market niches" on the basis of the privatised social knowledge. It is a major problem, however, that "high technology" in Australia is already dominated by overseas firms.

Given this dominance, it is particularly difficult to sustain the argument that the government must provide industry with financial support and incentives. The overseas firms have access to a worldwide capital market;[20] and, if they cannot raise the necessary venture capital, it is arguably unlikely that the prospective new products will be successful. Funds provided under the National Biotechnology Program are likely to go to the larger pharmaceutical and agricultural corporations and their affiliates or subsidiaries. In its review of government expenditure on R & D in Australia, the Myer Committee established that grants had been directed to large firms with "massive" financial resources.[21]

The size and market power of the recipient corporations poses yet another problem. As against the claim that by developing new products they are improving human welfare, Australian users may be paying twice for the new products. Given the elementary profit motivation of the corporations concerned, the user is likely to provide monopoly profits after having initially funded the development of the new products.



Other "distortions" occur. When university researchers have commercial links with firms providing research funding potential conflicts of interest may arise. Is the researcher responsible to the university, the company, or both? Evidence from the United States suggests that some of the more 'entrepreneurial' researchers exploit their positions to pursue economic ambitions and achieve personal aggrandizement.[22] Some have unashamedly appropriated student research findings; others have selected the best and most promising students for industry positions, undermining government research programmes and disrupting post-graduate studies.[23]

Finally, the privatisation of biological knowledge may prejudice the progress of science. The ideology of science emphasises dissemination of research findings, replication of studies, testing of theories, and formal and informal discussions between scientists. How will state-based science develop under the direct (and indirect) influence of corporations? First, it is unlikely that the scientists in the public institutions which accept industry grants will be allowed autonomy in the determination of research priorities. Barry Jones has stressed the need for CSIRO scientists to undertake more 'relevant' research,[24] and has come into direct conflict with the head of the CSIRO over issues of funding and research. Second, it has been shown that where corporations have engaged in joint ventures with

the state they have demanded secrecy in research and have acted to restrict access of outsiders to information deemed to be corporate property. Recent research would seem to corroborate this.[25] It would be ironic indeed if the very conditions which are being sought to 'liberate' biotechnological research in Australia stifled the flow of scientific knowledge, undermined public confidence in state research and acted as a fetter on future genetic experimentation.

How straightforward is the privatisation of advances in biotechnology? As the ASTEC submission candidly asserted:

> "A company is likely to invest in an activity if it anticipates that the developments of that activity will accrue primarily to itself. In this way it is able to establish an early lead over potential rivals and achieve market dominance. A problem facing (biotechnology) firms is the degree to which property rights on modified organisms, processes and assests can be clearly defined and protected."[26]

In Australia under present laws there are only limited provisions for exclusive rights over the manufacture of biological organisms, particularly where those organisms are capable of self-reproduction. Most of the privately-funded research in Australia has been in the textile, food, agricultural chemical, agricultural engineering, pharmaceutical and veterinary sectors. It is no coincidence that in these fields patent legislation has allowed new products to become private property and hence commercially exploited by the inventors.[27]

While the Australian Patents Office allows biological processes to be patented (on the grounds that they are similar to chemical reactions), the position is less clear in relation to the patenting of forms of life. The Office has reiterated its intention of registering living material under the 1952 Patents Act but, as one of its own officers has stated "...the question of actually patenting living material has never been considered by an Australian court...and there is no guarantee as to which way a court would go in Australia."[28] However, as Christopher Arup has revealed in one of the only critical examinations of the patents system as it applies to genetically engineered organisms, the trend is for the courts to accommodate the demands of business for proprietary rights.[29]

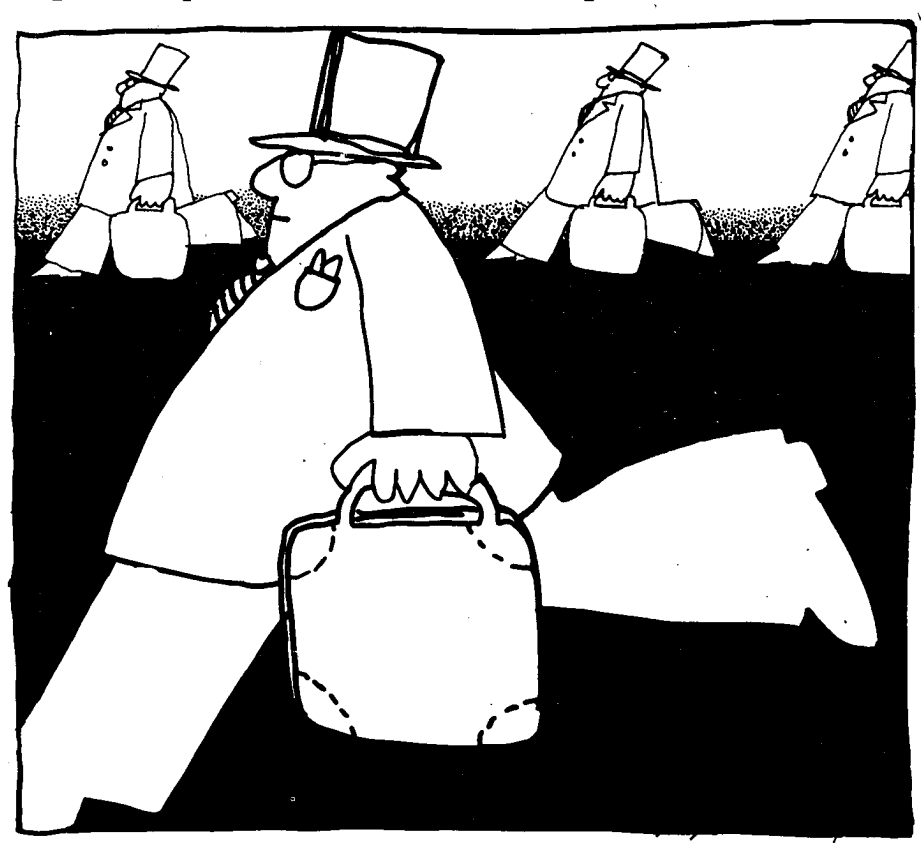
A number of problems are likely to arise from the extension of patents to cover the new life forms created by molecular biologists and geneticists. Patents may foster research with an immediate, profit-generating potential to the detriment of so-called 'basic' research which may be of greater long term importance.[30] It may result, in some cases, in superficial genetic manipulation. Such 'cosmetic surgery' may allow a corporation to claim a new patent but do little to improve the biological or commercial potential of an organism.[31] Biotechnology companies, following a long capitalist tradition of differentiating and advertising what are basically similar products, will spend money promoting their "new" products or organisms. This money, which may have been better spent on research, will be built into the final cost of products on the market, and so be passed on to consumers. Under the new demands of corporate bosses, researchers may find themselves spending as much time with venture capitalists, patent lawyers and advertising executives as with their electron microscopes.

A further problem which emerges concerns safety and surveillance. While it is recognised that certain forms of r-DNA research once considered dangerous can now be handled in conventional microbiology laboratories, this is no guarantee that future experimentation will not produce dangers to the community. With the rush to gain market control harmful substances may be unintentionally released into the environment. As it stands Australian safety guidelines are voluntary, not mandatory. The same situation exists in the U.S. where biotechnology firms have found ways of by-passing high-cost safety measures. It is not particularly gratifying to learn that these firms are owned by the same chemical companies responsible for toxic chemical pollution throughout the U.S.[32]

In Australia, the industry has insisted on the implementation of voluntary guidelines - it has not been kindly disposed to what it perceives as attempts to limit its operations. Some industry officials remain convinced that information leaks will occur if scientists are closely monitored or are required to report to a regulatory body.[33] Patents, profits and privatisation are uppermost in the minds of the new elite in biotechnology.

BIOTECHNOLOGY AND THE STATE IN LATE CAPITALISM

Perhaps the most important function of the capitalist state is to guarantee the perpetuation of private property rights and to facilitate the extension of these rights into new areas of economic profitability for capitalists. Biotechnology, as an area of enormous potential profit for private firms, is being fashioned in a way which will leave development costs with the state but which will allow profits from new inventions to be appropriated privately. The close relationship between the state and



industry embraces a shift in the state's role from one of support for new industries to one of direction. The state is anxious to establish conditions for new private capital accumulation and to rationalise its own expenditure by identifying and promoting 'key' technologies.

Newly-emergent state/corporate linkages can be identified in joint decisions about profitable investment areas, the re-direction of state research, and state-initiated control of the investment process. Most apparent is the state's preparedness to intervene in the economy to enhance industry's profit structure. It is accomplished through what we might call the 'collaborative planning process'. In this way the state encourages growth of dynamic sections of industry at the same time as it withdraws support from areas of reduced economic viability. In doing so it is better able to integrate public research and to direct funds of the state into areas which stimulate monopoly capitalist production. Barry Jones has criticised the previous Government's lack of direction in the area of technology. That government believed, he said, "that new technologies ought to be left to the market...their view was leave it alone, the market will look after it."[34] He stressed that his government's policies would be more actively interventionist and announced, with the allocation of $0.4M for a study into world application of Australian high technology, "this is a departure from previous approaches. We are deliberately seeking out technology growth areas and we intend to take positive action to make sure conditions are right for their development".[35]

Two further changes have accompanied the Labor Government's plans to stimulate high technology. The first concerns the new directions for the funding of research at universities. Senator Ryan has foreshadowed major changes including the requirement that university researchers engage in direct collaboration with industry. Suggesting that past research has been uncoordinated and lacking in direction, the Minister stressed that greater public accountability "would be achieved by the forging of links between industry and university research workers."[36] The second change relates to the functions of, and within, the C.S.I.R.O. The aim is to loosen the existing structures so as to ensure maximum opportunity for commercial application of research. This requires a changed view of proprietary rights. How is this to be achieved? During the late '70's C.S.I.R.O. policy aimed at making research findings available to as wide an audience as possible. Proprietary rights were <u>not</u> seen by C.S.I.R.O. in the late '70's to be consistent with community interest. The argument was that "maximum of royalty returns usually requires maximum of privilege, secrecy and pre-licencing development; it is seldom consistent with maximum utilization".[37] By 1982, however, it was considered that monopoly rights "confer a commercial advantage on the company, and this, in turn, provides a prime incentive to maximise utilization of the project results"![38]

A second change of direction concerns staff promotion. A committee established to review activities of the C.S.I.R.O. argued that staff promotion was biased toward the "academic" criterion of research publications. It recommended that "due recognition in promotion should be given to achievement in the development of industry contacts, technology transfer, consulting, and development activities".[39]

The third mechanism for loosening the structure of the C.S.I.R.O. was the announcement that SIROTECH would be established to encourage commercialisation of C.S.I.R.O. research. The C.S.I.R.O. is to contract the development of its products to outside agencies. As it stands the C.S.I.R.O. grants exclusivity in cases where work is jointly funded, and as Arup has concluded "it is unlikely that the Federal Government will reserve any rights when it affords the 100% tax relief to high technology investments by licensed venture capital companies".[40] At present the Government does not even demand a licence or royalty for inventions under the AIRDIB scheme. One of the stated aims of the C.S.I.R.O. is to maximise economic returns to the Australian community from the application of C.S.I.R.O. research.[41] Public interest is seen to directly coincide with private profit - a fundamental belief, it seems, in the Hawke consensus model.

A notable characteristic of the move to more collaborative research is an increase in obfuscation. For one thing, there is the development of para-state or 'intermediary' organisations which are less publicly accountable and which are less directly political than traditional government-funded administrations. The formation of 'centres of excellence' within universities provides an ideal cover for the collaborative research of the state and industry. The status of universities adds support to the perceived neutrality of scientific investigations. Universities are nominally part of the apparatus of the state but are not subject to direct and immediate public scrutiny. There is in effect a "confusion" of public and private. The state manages to disguise the degree to which it is underwriting private profit, at the same time as it bypasses the traditional, but less flexible, administrative structures in sectors of the CSIRO and in the State Departments of Agriculture.[42] Should public concern be raised over the new links, 'misconceptions' could always be corrected by a public education and public relations campaign - as was suggested by one industry leader.[43] Meanwhile the slick publicity emanating from the Department of Science and Technology includes key words such as 'cooperation', 'collaboration', 'selectivity' and 'planning', as part of a technocratic vocabulary designed to legitimise current forms of intervention.[44]

It would be wrong, of course, to think that the developments in Australia are somehow isolated from world trends. Britain and the U.S. have both experienced encroachment by private companies on public research resources.[45] One writer has observed that biotechnology is the fastest growing field for academic-industrial collaboration in Britain - "with a government keen to promote industrial ventures, a strong national academic base, and innovative companies seeking partnerships just when higher education (has) started to feel the public expenditure pinch, the area has proved irresistible to universities and polytechnics."[46]

AN ALTERNATIVE ROLE FOR THE STATE

There is an alternative Australian route for the development of biotechnology. Australia has had a long history of state ownership of productive enterprises, particularly in the field of agriculture. Since government is the biggest spender in the area of biological research it is important to ask why it is not prepared to continue with traditional funding arrangements. If the state does not yet have the facility to exploit

commerically the products of biological research, perhaps it could consider the establishment of a public corporation to manufacture the products itself. This possibility does not appear to have been contemplated by the present Government, yet it represents an acceptable means for the state to recoup the costs of publicly-funded research - at the same time as it controls the development of potentially useful products. Given that discoveries from collaborative research may be treated secretively, joint funding arrangements make it impossible for outsiders to determine whether research is in the public interest. This problem could be reduced if government-funded research were to meet strict guidelines of public accountability, or better still, if public research institutions were given sufficient funds to manufacture products without the need for commercial interference. SIROTECH would seem to be a less than satisfactory public commitment to this goal.

To date the CSIRO and the State Departments have been the main motors of scientific discovery in Australian agriculture. It would seem to be a desirable and uncomplicated step for a Labor Government to establish a state-run enterprise to market products developed in state-funded research establishments. Since the bulk of molecular biology and microbial genetics is funded by the state, the Australian Government has an opportunity to strengthen public ownership and control in an important field of technology. There is no guarantee that business, whether or not it is provided with taxation concessions and venture capital, will be capable of developing products of benefit to Australia. It appears that under current Labor Party policy intervention cannot proceed to its logical limit - state ownership and control of products generated through state funded research. Yet in terms of public accountability, and more particularly in terms of the dissemination of products, the surveillance of genetic engineering, the return to public investment, and the free-flow of scientific knowledge, public ownership would have distinct advantages. The 'key industry' approach developed by Labor guarantees instead the redirection of Federal funds in a manner designed to enhance returns to private industry.

CONCLUSIONS

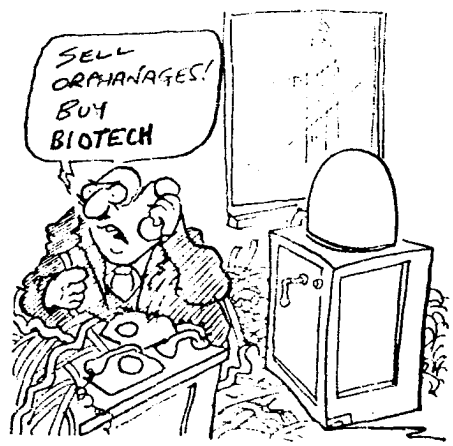
Biotechnology will be a major contributor to economic growth during this decade. There are few who doubt that great potential benefits lie in the areas of recombinant-DNA research, fermentation and enzyme synthesis, cell fusion, and other applications of molecular biology and microbial genetic research. It is how these developments are to proceed and precisely who will benefit which are questions which have been ignored by social commentators.

Studies have shown that in the traditional areas of biological research Australia has been well served by public agencies. What is occurring today in a period of fiscal austerity is that the state is attempting to reorganise public research so as to tailor research projects more closely to the profit-making aims of private enterprise. One force behind this is industry. Where industry can tap into public resources that have been built up over many decades it is able to reduce or even eliminate its expenditure on costly in-house research laboratories and on the salaries of research scientists. By contributing a token amount of capital to a university or other state-funded research establishment, private enterprise is able to claim rights to products which arise from the 'joint' research.

A second force is the academic staff at universities and the research staff at government research institutions. Aware of cuts in Federal funding, many scientists have warmly welcomed collaborative research as a means of securing their futures in genetic engineering. Under patent legislation proposed for biotechnology many individual researchers can expect to make a great deal of money from manipulating forms of life. But more than this, biotechnology is novel and exciting. Australian scientists have evinced deep interest in the new techniques and have actively sought research arrangements which might enhance their national and international scientific standing.

The third force is that of the state. The traditional role of public research institutions has been to solve problems which have been ignored by private enterprise. Left to market forces much of Australia's biological research would not have taken place. It has been difficult, and in many cases impossible, for private enterprise to exploit biology for commercial purposes since biological organisms have been capable of self propagation, and there has been some debate as to whether the legal apparatus would recognise new life as private property. This has changed as industry has recognised the commercial applications which can result from genetic manipulation. The state is attempting to meet the needs of industry by fostering collaborative research, reviewing patent laws, underwriting commercial investment in biotechnology and redirecting public research toward the commercial desires of private companies.

These combined forces will bring about the development of new administrative arrangements, the continued scaling down of activities in existing areasof state-funded biological research and will result in a skewed pattern of development in the biological sciences. In becoming a tool of private enterprise, publicly-funded research may come into direct conflict with public interest. Products will be developed only where they can guarantee maximum gain to industry. At the same time as the sun rises on the new profit-making activities of corporations it will set on the more traditional areas of biological research in Australia.[47] Under the arrangements being fostered by the state, corporations will enter the new areas of biological research at the very time when public ownership and control of biotechnology might have allowed for the profitable expansion of state activities and a high return on public funding.



FOOTNOTES

The author wishes to thank Stewart Carter, Richard Dunford and David Rowe for their assistance in the prepration of this paper.

1. Australian Science and Technology Council, Biotechnology in Australia, Australian Government Publishing Service, Canberra, 1982, p.1.

2. Ford, J., "Waking in time for the genetic engineering industry's sunrise", The Weekend Australian, August 13-14, 1983.

3. Butler, G., "The State and the Disposition of the Social Surplus", Journal of Australian Political Economy, No. 9 November, 1980 and "The Limits to De-Regulation", Journal of Australian Political Economy, No. 11 January, 1982.

4. Australian Science and Technology Council (ASTEC), op.cit., p. 16.

5. see National Times, February 13-19, 1983, and The Weekend Australian, August 13-14, 1983.

6. ASTEC, op.cit., p. 9.

7. see National Times, op.cit.

8. Broadman, N., "Genetic Engineering - The Australian Scene", in Department of Science and Technology, Genetic Engineering, Australian Government Publishing Service, Canberra, 1982, p. 45.

9. Pateman, J., "Industry-University Interactions: Centre for Recombinant DNA Research", in Department of Science and Technology, Genetic Engineering, op.cit., p. 308.

10. ASTEC, op.cit., p. 11.

11. See Hurst, W., "The Role of Government in Australia", Pateman, op.cit., Abbott, C., & Tregear, G., "An Industry for Australia - Constraints and Solutions", and Jones, S., "The Relationship between Government, Business and the University to Further Research" in Department of Science and Technology, Genetic Engineering, op.cit.

12. see The Australian, Thursday, February 10, 1983, and White Paper on Manufacturing Industry, Australian Government Publishing Service, Canberra, 1977.

13. ASTEC, op.cit., p. 12.

14. ibid., p. 1 and p. 17.

15. Jones, B., "New Directions in Science and Technology Policy", ASCENT, Vol. 1, No. 1, May 1983, p. 7.

16. CSIRO, Industrial Research News, CSIRO, Canberra, September 1983, p. 1.

17. CSIRO News Release, N.R. No. 21, 26.9, 1983.

18. Thompson, H., "The Social Significance of Technical Change", Journal of Australian Political Economy, No. 8, July 1980, p. 64.

19. Jones, op.cit., p. 7.

20. Gannicott, K., "Research and Development Incentives", in Report of the Committee of Inquiry into Technological Change in Australia, Technological Change in Australia, Vol. 4., Australian Government Publishing Service, Canberra, 1980. Gannicott notes that there "is now considerable evidence from both Europe and the United States, that private capital markets and firms are quite capable of raising large sums of money for risky and long term ventures, and that if commercial money is not available for development, it is because entrepreneurs do not consider the market prospects strong enough to produce an adequate return." ibid., p. 303.

21. see Report of the Committee of Inquiry into Technological Change in Australia, Vol. 4, op.cit., p. 324.

22. see Kenney, M., Buttel, F., Cowan, J. & Kloppenburg, J., "Genetic Engineering and Agriculture: Exploring the Impacts of Biotechnology on Industrial Structure, Industry-University Relationships, and the Social Organisation of U.S. Agriculture", Cornell University Rural Sociology Bulletin Series, No. 125, July 1982.

23. see Harsanyi, Z., "Issues in Industry - Research Interaction and Equity Considerations", in Department of Science and Technology, Genetic Engineering, op.cit., p. 313.

24. see Ford, J., "Wild About Jones", The Australian, Wednesday, September 28, 1983, p. 13.

25. As part of my research I sent questionnaires to over 25 private and public research establishments requesting information on the links being established between universities, government departments and private enterprises; the types of products which were being developed; the type of government funding for collaborative research; and the safety measures adopted in research. While I received informative responses from the government sector, replies from industry were of the sort from Austgen-Biojet "Unfortunately the nature of our business and the questions you put to us are of a confidential nature". One wonders whether the public will ever know how its money is being used in collaborative research given the secretive attitudes of industry. See Kenney, (et.al.), op.cit., p. 40 for a discussion of secrecy in research.

26. ASTEC, op.cit., p. 15.

27. Jarrett, F. & Lindner, R., "Rural Research in Australia", and Jessup, J. & Dun, R., "Organisation and Administration", in Williams, D., (ed.), Agriculture in the Australian Economy, Second Edition, Sydney University Press, Sydney, 1982.

28. Quotation from Mr. Philip Thomas in Department of Science and Technology, Genetic Engineering, op.cit., p. 289.

29. Arup, C., "Genetic Engineering", Legal Service Bulletin, Vol. 7, No. 1, February 1982, p. 9.

30. see Yoxen, E., The Gene Business, Crucible, London, 1983, p. 99, and Arup, C., "Intellectual Property Rights in the Context of Public and Private Institutional Collaboration", Paper presented at 54th ANZAAS Conference, A.N.U., May, 1984.

31. Gladstones, op.cit., see Arup, C., "Intellectual Property Rights..." op.cit., p. 8.

32. Kenney, (et.al.), op.cit., p. 59.

33. Beaumont, O., "Biotechnology and Patents", in Department of Science and Technology, Genetic Engineering, op.cit., p. 198.

34. Jones, B., op.cit., p. 5.

35. see The Weekend Australian, July 9-10, 1983.

36. see The Australian, Wednesday, May 9, 1984.

37. see Report of Review Committee and Statement of Executive Decisions, Review of CSIRO's Commercial Activities, CSIRO, September, 1983, p. 30.

38. ibid.

39. ibid., p. 14.

40. Arup, C., "Intellectual Property Rights..." op.cit., p. 15.

41. see Report of Review Committee, op.cit., p. 26.

42. The Balderstone Committee, reporting to the Minister for Primary Industry in 1982, recognised the importance of this:

> "There is a need for more joint public-private research undertakings, and the administrative machinery allocating research funds should give this more recognition. Increased private sector involvement would be facilitated by giving private researchers greater access to publicly-sourced funds."

see Working Group Report to the Minister for Primary Industry, Agricultural Policy Issues and Options for the 1980's, Australian Government Publishing Service, Canberra, 1982, p. 121.

43. Lester, A., "The Role of Government" in Department of Science and Technology, Genetic Engineering, op.cit.

44. see Department of Science and Technology, ASCENT, op.cit.

45. see Yoxen, op.cit., and Kenney, op.cit.

46. Turney, J., "The Fast Breeder", The Times Higher Education Supplement, June 10, 1983, p. 9.

47. Some of these areas might include plant breeding, agronomy and entymology. It is well understood that public research priorities in agriculture have begun to change and that funding for research has been reduced. See Jarrett and Lindner, op.cit.