BIOTECHNOLOGY

AND THE UNIVERSITY

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A surge of industrial and military interest in the university's bioscience community signalled the start of the new age of biotechnology.

In some ways this was familiar script. The university's partnership with industry and the military is well established in engineering and the physical sciences. President Eisenhower's recognition of the "military-industrial complex" could well have encompassed the university. The resources of academia have contributed indispensiblely to the waves of new technologies that fill life with miracles even as they have given humanity the capacity for self-extinction.

Yet biotechnology, born of revolutionary advances in university molecular biology laboratories, is not quite the story witnessed before -- neither for the university nor for society. At least some of the events and issues are distinct despite parallels in electronics and computer fields, and a history of academic involvements with agriculture, chemical and pharmaceutical industries.

We consider in this chapter the changes and challenges that the rise of biotechnology brings to the University, problems in the educational environment and the conduct of research, issues not only of internal regulation but of the university's relationship to social policy and to the public interest.

The role and problems of the university are central to the relationship between science and society and to the formulation of policies for science governance. That the university is the primary source of the golden egg need hardly be argued, but it is necessary (though often futile) to remind politicians, administrators, trustees and sundry others of the university's special vulnerability. In fact, the pressures generated by the technology boom make it appropriate for those of us who are scientists and educators to look hard at dilemmas that are integral to the university's place in society.
The university is required to provide a continuous flow of knowledge and new leadership needed to maintain prevailing social structures and institutions -- but new knowledge, fresh minds, innovative cultural expression and good science arise in an atmosphere of challenge and skepticism, unwillingness to be controlled by external pressures and interests. The social responsibility of the scientist and educator is indeed great, but it is not fulfilled as some suggest by availability on the market place or by conformity to the expectations of political or military agencies. These issues are strikingly presented by the transformations in biology whose import for science, society and the university is still emerging.

TURBULENT BEGINNINGS

What is special about the encounter between biotechnology and the university? Why did it initially attract so much attention and generate so much heat? Why did previous experience in other fields not suffice to cover matters of policy?

We can summarize some of the ways in which things are different, some of the features that require fuller consideration:

1) One factor is the suddenness and speed with which the new domain emerged. There has been an unprecedented rush of major, often unusual, financial arrangements with the rising biotechnology industry by individual faculty members as well as university and medical school administrations.

2) Adding to tension is the sharp before-and-after contrast in prevailing values among academics in biology, rapid adaptation to a market-oriented environment once regarded as alien by most of those committed to basic research in the life sciences.

3) Recombinant DNA techniques and the feasibility of genetic engineering inevitably brought forward new issues of morality, ethics, social priorities and public policy. Some heated debate took place among biologists at an early stage, but the areas of concern have been narrow. As for the general public, there has
been no significant involvement except as a target of sensational media treatment of the new biology.

4) There is a unique aspect to the long-term public investment in the university research that led to biotechnology. Alone among revolutionary technological advances of recent times, biotechnology is not a spin-off from research and development in weapons and space. Rather it resulted directly from decades of public funding of basic biomedical research predicated on an ultimate commitment to improved public health.

5) The university's interaction with biotechnology is taking shape in a social and political climate that differs significantly from that in which the foundations of the new biology were built. In the 1980s, the thrust is toward replacing government's social responsibility for education, health and welfare with free reign for the private sector. The only priority of federal government designated as sacrosanct by the present Administration is the expanding military budget.

BIOMEDICAL RESEARCH ON THE MARKETPLACE

Already in 1981, Barbara Culliton, News Editor of Science, described "a virtual explosion of 'technology transfer' as researchers and industrialists have moved with unprecedented speed and determination to exploit molecular biology in a search for useful and profitable products based on recombinant DNA and monoclonal antibodies -- technologies whose conceptual roots are in university-based science...." She commented: "Biomedical research itself has entered the marketplace; molecular biology has become big business. Concern increases that this development will result in fundamental changes in the way in which research is conducted, that new ties between the academy and industry will strain the fabric of the university, and that the public perception of science will be altered."1
The most publicized phenomenon in the commercialization of biology has been the emergence of the professor-entrepreneur, but university administrations have actively competed for contractual arrangements with biotechnology industries. The first of a series of such agreements was established between Harvard and the Monsanto Corporation in 1974. For $23.5 million Harvard sold Monsanto patent rights and access to an outstanding biomedical research group over a period of 12 years. Analyzing the contract, Wayne Riddle points out that Harvard changed its patent policy which simply had been: "No patents primarily concerned with therapeutics or public health may be taken out ... except for dedication to the public." "Apparently," Riddle says, "the Monsanto arrangement hinged on discarding this traditional guideline. And the standard practice of peer review through faculty committees and public comment was avoided during the year and a half of negotiations that preceded final agreement."

From 1980 on there has been a rush of such contracts, varying in form and amounts of money involved, but similar in character. The university gives the corporation privileged access to outstanding academic personnel, their laboratories and their students; it grants favored, sometimes exclusive, patent or licensing rights; it often agrees that the company is to review and approve research manuscripts before they can be submitted to journals.

A few of the universities entering such contracts are MIT (Exxon, W. R. Grace), Yale (Celanese, Bristol-Meyers), Cornell (General Foods, Union Carbide, Kodak), Illinois (Sohio), Rockefeller (Monsanto), and Columbia (Bristol-Meyers). Washington University at St. Louis has been one of the most enterprising, contracting with Monsanto for $23.5 million and with Mallinckrodt for $3.8 million, both grants for five years duration.

One of the largest such direct grants, for $70 million, binds Massachusetts General Hospital, Harvard's main teaching hospital, to the Hoechst firm of West Germany. The New York Times reported: "Under the terms of the 10-year contract,
Hoehchst is creating a new department of molecular biology at the hospital. In return, the company can capitalize on the department’s research findings before others learn of the results and obtain exclusive licenses to develop related commercial procedures ... The Hoehchst grant raises a new issue, since so large a grant forces an entire department to be financially dependent on one company.”

On the size of the grant, The Boston Globe commented⁶: “It surpasses the total endowments of either Boston University or Tufts University and the total endowment income of all U.S. medical schools in 1978-79.”

A different form of financial tie, but a far larger private investment, is represented by the Whitehead Institute established at MIT after some faculty controversy.⁷ Edwin Whitehead, founder of Technicon and presently the largest shareholder of Revlon, gives MIT $7.5 million for teaching and research in Institute-related academic departments, finances the building and equipping of a 130,000 square foot research facility, contributes $5 million annually until the year 2003 and a bequest of $100 million upon his death. The Institute, whose Board of Directors includes Whitehead’s three children, is to have up to twenty faculty members who also share appointments in regular MIT departments. It owns all inventions and other intellectual property created by personnel it funds.

Of course not many universities can attract deals of such magnitude regardless of the accommodations they may be prepared to make. The State University of New York and the University of Michigan have initiated more limited institutes or research centers supported by industrial consortia. Similarly, Stanford and the University of California, Berkeley, formed the Center for Biotechnology Research in conjunction with the establishment of a new company, Engenics, with six corporate sponsors.⁹

The university-industrial arrangements cited here are only a sampling. To picture how pervasive a transformation has occurred, one would have to consider
the multiplicity of commercial connections that now involve many faculty members in almost all departments with active research programs in molecular and cellular biology. A study now underway of "formal, long term ties between scientists and biotechnology firms"\textsuperscript{10} establishes the prevalence of dual academic-business affiliations among leading biologists -- those who are members of the National Academy of Sciences and/or serve on Study Panels of the National Institutes of Health and/or review grant applications for the National Science Foundation or the US Department of Agriculture.

NEW CRITERION OF ACADEMIC SUCCESS

Some culture shock was bound to accompany the link-up between academic bioscience and the new world of commercial biotechnology." The milieu in biology had been distinguished in some ways from that prevailing in other areas of science and engineering. The dominant culture among biologists was one of emphasis on basic rather than applied research and of hostility toward mercenary ambitions and patent seekers. Nevertheless, such ideological and psychological barriers seemed to collapse when opportunity's knock became persistent.

Competition between biotechnology firms for the vital resource of prestigious academic talent, along with fears that government support to basic biomedical research may be eroding, have generated a very powerful pressure on individual scientists and on the university itself. A new criterion of academic success in the life sciences has emerged, the ability to attract commercial offers, to swing deals and to make money.

As one writer comments\textsuperscript{11}: "Publish or perish was once the popular admonition to the young academic scientist. Now, with federal research funding dropping, scientists fear that while they publish they will also perish--unless they can find ways to patent through some industrial benfactor." Another article\textsuperscript{12} quotes Cesar Milstein, who has since been awarded the Nobel prize for co-discovery
of monoclonal antibodies: "In this society you're made to feel stupid if you can't make money." The writer notes that the inventors of monoclonal antibodies, true to the ethic of earlier days, sought no patent protection. He continues: "Plenty of researchers now are reeling from pressure, some of it applied by their immediate colleagues, to show that they can make money."

To ascribe the changed atmosphere and attitudes primarily to individuals who see a chance to become wealthy would be to overlook the main problems before the university. The university itself is a much bigger part of the problem than the temptations experienced by individual faculty. If Harvard contracts with Hoechst and MIT makes a deal with the Whitehead family, other universities must scramble for comparable coups -- at stake is the ability to compete, claims to academic status and ranking. Increasingly university deans and administrators are themselves the conveyors of the connection between progress in an academic career and skill at developing commercial ties.

CONFLICT OF INTEREST?

There is no shortage of advocates, enthusiasts in fact, for the new academic-industrial connection in biotechnology. Leaving aside the entrepreneurial motivations of some, the case for greater support by industry to the university and to research in biosciences is surely strong. Few if any who express concern about the way things are going would want the university not to encourage expanded interest from private as well as public sources.

Why then the concern?

At the most basic level there is the need to distinguish some of the essential drives, goals and values of the commercial boom in biology from those of academic research. Quite simply, the business of business is to make money, to beat the competition, and the mode is secrecy, a proprietary control of information and the fruits of research. Ideally, the motive force of the university is education and,
the pursuit of knowledge, and the mode is open exchange of ideas and unrestricted
publication of the results of research.

These very different missions call for a necessary separation between the
university and the marketplace. One may make a crude analogy to the relationship
between other elements in our society that have different missions, for example
religion and public education. Experience indicates that respect for the democratic
"separation" principle should apply if the mission of the university is not to be
diverted to the motivations and practices of the business world. Safeguards are
needed to keep research and education in biology from being submerged in the
entrepreneurial tide.

A conference on "Commercialism and University Research" was convened at Pajaro
Dunes, California in March 1982 by President Donald Kennedy of Stanford and co-
hosted by the presidents of Harvard, MIT, Cal Tech, and the University of California.
The list of those attending the meeting was both impressive and exclusive: in
addition to the university presidents, there were top executives (including six
presidents) of nine leading biotechnology corporations (Genentech, Dupont, Gillette,
Damon, Applied Biosystems, Cabot, Cetus, Syntex and Beckman); ten professors,
several of whom are founders and/or top executives of additional biotechnology
firms; eleven other top administrators and two General Counsels from the host
universities; and, completing the list, one Harvard Fellow and the President of
the Henry J. Kaiser Family Foundation, which funded the meeting with a $50,000
grant.15

Prior to the conference, President Kennedy had warned in testimony before a
Congressional committee that with "the introduction of strong commercial motivations
and conflicts of interest on the part of faculty members" ... "there is the prospect
of the significant contamination of the university's basic research enterprises."18
Following the conference, nothing noteworthy was claimed for its deliberations either by the conferees or in commentaries in the press and scientific journals (reporters were excluded from the sessions). Unfortunately the Pajaro Dunes meeting was more significant as evidence of the seriousness of the problems than as a contribution to their analysis or amelioration.

There is no reason to question the concern or the intentions of the convenor, yet the very structure of the meeting -- a restricted conclave of highest level executives of select universities and corporations -- blurred boundaries between commercial and academic interests. Symptomatic was the prevalence of dual affiliations not only among the faculty chosen to attend, but in each of the participating contingents. At least three of the university presidential hosts are on boards of directors or highly paid consultants of several corporations, including one (Cabot) represented at the meeting by its president; at least four of the chief executive officers who were the direct representatives of industry are trustees of Cal Tech, MIT, or MIT-sponsored enterprises.

Pajaro Dunes distilled to its essence the problem of conflict of interest: what is usually discussed as a matter of individual faculty behavior is shown to be first and foremost an institutional problem.

More indicative than who was at Pajaro Dunes is who was not. The challenges presented by the great revolution in biology -- the opportunities even much more than the difficulties -- are of profound general interest. The many dimensions of its potential significance for society, as well as its impact on education and research, certainly require new thinking and deliberation in all quarters. Yet there is no extraordinary initiative by the university in reaching out to stimulate minds and involve others beyond the business world. Nor is there much reaching inward to enlist student and faculty opinion on the changes wrought within the university or on the larger societal issues.
CAN BASIC RESEARCH BE DEPENDENT ON INDUSTRY FUNDING?

A condition for affording some protection to the integrity of the university's program for education and basic research in the biological sciences is to discount illusions that industry will take over major responsibility for its support.

Commenting on proposed federal cutbacks in biomedical research, a New York Times editorial pointed to "the rich flow of venture capital into biotechnology" and observed: "There are also times when a field of research no longer needs the Government as nursemaid..."17 However, the Prospectus circulated to the Pajaro Dunes invitees offered a different and more telling observation: "Ever since Herbert Hoover's energetic but frustrating effort to raise funds for 'pure science' from corporations in the mid-1920's universities and the government have sought to make the commercial sector a fuller partner in the basic research venture. It is still the case, however, that less than 4% of the support of all university research is derived from this source. And about two-thirds of all basic research is located in universities."18

It is true that a major consequence of the remarkable progress in biology is to bring basic and applied research into closer contact. Laboratories that investigate riddles of cell function and of development may now generate "practical" information and ideas leading to possible applications in medicine, agriculture, or manufacture. While this university resource is recognized and eagerly tapped by the biotechnology industry, the highly competitive character of the industry precludes far-sighted general funding of basic research and training. The several university-industrial contractual arrangements discussed earlier show a typically directed character, targeted to particular laboratories or departments and often to defined projects that offer hope of commercial returns. The latter feature may not always be quite so explicit as in Yale's contract with the Celanese Corporation, as reported by the New York Times: "Last week, Yale University and
Celanese Corporation, a chemical and fabric manufacturer, tied the knot.... Yale will conduct basic research for Celanese on enzymes, particularly enzymes useful to chemical and fabric production.\textsuperscript{19}

As a matter of fact, the scramble by commercial interests for favored status within the university distorts and weakens the commitment to basic research. It changes especially the circumstances in which a new generation of aspirants to creative careers in biology must approach its training and goals. Abuses of the faculty-student relationship have drawn attention at several universities: neglect of pre- and post-doctoral trainees by "two-hat" advisers busy with commercial involvements, increasing pressure for secrecy that inhibits communication and regards colleagues as competitors, fear that thesis and research ideas will be transferred to the commercial sector and exploited.\textsuperscript{20}

Yet there is a question more fundamental than any specific areas of abuse. Young investigators must now feel an almost irresistible pressure, indeed a logic, to go into so-called "hot" areas if they want to develop their careers. Whereas hot problems in biology have been those where a breakthrough in scientific understanding appeared possible, hot projects now may more often be those with an implied promise of marketable results. In this kind of process, a young scientist may pay a much bigger price than a more established scientist. That price may well be the sacrifice of independence and creativity because most researchers entering the new venture sphere will be operating with priorities set by others, generally on the basis of short-term considerations.

SAFEGUARDS

With the biology boom, many universities have felt compelled to review and revise guidelines on avoidance of conflicts of interest. Corrective action has been taken in isolated cases.\textsuperscript{21}
Although administrative safeguards are hardly an adequate solution to complex educational and social issues, it is worth projecting measures that might have some positive influence. It is also instructive to consider the difficulties in applying such regulation. Three recommendations discussed and generally favored at the conference of immunologists in 1982 may serve as reference points. The immunologists' proposals are clearly not exhaustive, but they relate problems within the university to issues of integrity in the conduct of research and in interaction with the public.

Proposition one states: "Faculty members who receive research support from any agency, public or private, should be willing to disclose the source and amount of personal income derived from private enterprises in areas related to their research."

Despite traditional resistance in the academic community to such disclosure, the matter is one of credibility. Once commercial attachments abound, a scientist cannot assume automatic public trust. Especially as scientists are called on for expert guidance to the public on the regulation of new technologies, on applications of genetic engineering and the sensitive areas of genetic screening and gene therapy, there should be no privileged immunity from questions about conflicting interests. There are already far too many cases where the expert status of scientists is compromised by commercial ties -- the list covers the gamut from chemical pollution to vaccines, to pesticides, to nutrition, to drug evaluation.

The second proposition presents serious difficulties even though it is based squarely on fairness and common sense: "Peer review processes of granting agencies and journals which require access to confidential grant applications or the refereeing of manuscripts should not involve the participation of individuals who have a financial or commercial interest in the research areas under review."

The principle here seems beyond challenge. The problem is that the invasion of biology by the business world has been so sweeping. If this proposition were
to be applied without reservation, it would probably knock out a heavy proportion of the experts from every important review body.

Nevertheless, it is important to consider the principle no matter how it might be interpreted ultimately in practical terms. As long as the fruition of all academic research achievements has remained publication, there has been a brake on the abuse of peer review. True, there has been no guarantee against plagiarism or taking advantage of confidential material. Yet there is a restraining influence on unethical practices when results and claims have to be presented in public before one's colleagues. In contrast, if the premium is on commercial development in one's day-to-day activity, secrecy must take over. There is no strong inhibition on cheating, deliberate or sub-conscious, where there is a rationale for not publishing so that you can beat your business competitor.

The third principle says: "Acceptance by the university of support from any source for a faculty member's research should always be contingent on assurance of adequate provisions for peer review and the absence of conflicts of interest that compromise educational standards and commitment. A standing faculty committee should verify that acceptable standards of review have been met and should, where there is doubt, initiate an appropriate ad hoc review procedure."

The intent of the latter proposition is that the quality of research and the nature of commitments involving graduate students and postdoctoral trainees would be evaluated whether the support money came through a deal negotiated on the market place or was awarded on the basis of established review procedures of non-profit granting agencies such as the National Institutes of Health, the National Science Foundation, or the American Cancer Society.

There are numerous other areas in which safeguards might curb inequity and restrain abuse. One critical need is for procedures that guarantee students and university employees effective means of registering and getting action on complaints
without fear of direct or indirect retribution. Outside the university, some journals have opposed the trend toward restricting scientific communication for proprietary reasons by refusing to publish manuscripts that withhold information or access to reagents needed for validating the reported research. The imposition of such a sanction by a few journals, while surely desirable, will hardly compensate for the depressing effect of patent wars that have become "biotech's battlefront" especially since the Supreme Court's decision that life forms can be patented.

THE MILITARY -- THE OTHER PARTNER IN BIOTECHNOLOGY

Biotechnology has not only created commercial interest in the bioscience resources of the university, it has brought on new military intervention as well. At the 1984 annual meeting of the American Association for the Advancement of Science (AAAS), it was reported that "...the Department of Defense (DOD) now sponsors more than 30 research projects involving recombinant-DNA techniques, including 11 at in-house laboratories and 25 major universities." On August 31, 1984, the AAAS journal, Science, carried three full page advertisements from the Fort Detrick headquarters of the U.S. Army Medical Research Aquisition Agency inviting proposals for research in "Bacterial Diseases of Military Importance", "Low Molecular Weight Toxins of Military Importance", and "Parasitic Diseases of Military Importance."

Three major features of policy of the Reagan Administration combine to force a serious distortion of academic research in the life sciences.

First, analysis of the proposed federal budget for fiscal year 1986 shows that military research and development "would climb by $7.2 billion, while total spending on all other R&D would drop by more than $500 million." In basic research, the military would receive an increase of 16%, while the life sciences would be reduced by 4.9%. 
Second, there is a dramatically increased investment in chemical and biological weapons research. In other words, while biologists seeking research support from the National Institutes of Health will have a harder time, there is a place to turn — the military is ready to fund appropriate projects involving the latest developments in genetic engineering and monoclonal antibodies.

Third, there is an unprecedented effort to increase federal intervention in the conduct of academic research, to impose restraints that, according to the recent document from Harvard University, threaten "to erode the American tradition of academic freedom". "The Harvard report," commented the New York Times account, "has appeared just as the Pentagon is making its most forceful push into university research since secret military work was all but banished from campuses in the Vietnam War."

As grants from the military attract a growing number of life science researchers, the issues indicated by the Harvard report — secrecy, security investigations, censorship, pressure to conform — will become more difficult to avoid even at universities that have rules against classified research. So will public suspicions about what may be going on in campus laboratories.

Acute contradictions are presented by the jointly sponsored university-military institutes for research and development, one of which is the Naval Biosciences Laboratory (NBL) affiliated with the School of Public Health at the University of California, Berkeley. Established in the latter 1940's as part of the University, "the NBL was discreetly camouflaged, but was in reality an agency of bacteriological warfare until 1969" when the Nixon Administration entered negotiations toward the Biological and Toxin Weapons Convention signed in 1972. The Laboratory continued under contracts requiring conformity to UC regulations prohibiting classified research on campus, but it fared poorly and its termination was being considered until a major revival occurred with the advent of biotechnology and the new attitudes of the Reagan Administration.
The ways in which NBL's fortunes have now changed are interesting. It has attracted some first class molecular biologists. From direct conversations which this author has had with faculty involved with NBL, the basis for the attraction is clear: equivalent facilities and support are not available elsewhere for their research, much of which relates to parasitic infections and potential vaccines that could be of particular value in the Third World. Some other faculty who are not a part of NBL, but who have access to it, are anxious to keep UC sponsorship of NBL because it has one of the best containment facilities for experiments with pathogenic organisms or forms of recombinant DNA. Most of these investigators would want nothing to do with a renewal of preparations for germ warfare and they rely on the effectiveness of UC's ban on secret research to prevent that from happening at NBL. Yet it wasn't until 1976, as a result of a law suit, that the public learned what NBL (then called the Naval Biological Laboratory) had been doing in the early 1950's when it conducted tests spreading a supposedly harmless microorganism over San Francisco and surrounding areas.31

In general, credibility is strained by arguments often heard among academics that sponsorship of a military research unit gives the university ultimate power of governance and, moreover, curbs the influence of the military establishment. That is the rationale that permits the Los Alamos and Lawrence Livermore Laboratories, which conduct almost all national research and development of nuclear weapons, to be designated affiliates of the University of California. The NBL is, of course, minuscule in comparison to the nuclear weapons laboratories and its contract does not now sanction classified research. Yet past experience and present directions in national policy present valid cause for concern.

What sponsorship of military research institutions gives to the university, omitting monetary considerations, is inevitable conflicts of interest. What it gives the military is greater academic access, respectability and influence.
Again there is the issue of contradictory missions that ought to be kept separate: military secrecy and authority are incompatible with the norms and values one should expect in the university.

THE PUBLIC — ON THE OUTSIDE

Probably no technological advance has as much long range potential for benefit to humankind as the revolution in biology. As with other technologies, society is challenged as to how priorities are formed, how hazards are limited, how moral issues are met. The challenge is all the more intense since biology is about the nature of life.

While the scientific and technical advances are awesome, little is inspiring in the way the university and the bioscience research community are relating to the new social issues, to matters of public interest, education and policy. The only excitement, other than in celebration of new discoveries and claims, seems to be to discount warnings from environmentalists and to counter any notion that biotechnology needs regulation.

Scientists, offended by perceived exaggerations of potential hazards, fear that misconceptions and anti-intellectual prejudices may interfere with their freedom of inquiry. The anomaly, however, is the low level of concern over the intrusions by commercial and military interests which actually are distorting research directions and values. More often than not, representatives of the university and of the biotechnology industry appear to be sending a common message to the public: stay out of the way, leave it to the experts, await the blessings of the new biology.

Concern about the growing involvement of the university bioscience community with commercial interests is sometimes dismissed by the observation that technology transfer can only be accomplished via the market place — that is "the American way" of making the benefits of science available to the public. This is, to say the
least, a most limited representation of the social and political context in which matters of public interest are to be considered and contested.

The potential impact of biology is not confined to matters of "technology transfer" from the university to the private sector. It is indeed a matter of public policy and social responsibility -- more emphatically now that the fruits of the heavy public investment in biomedical research are beginning to appear.

Just what and how much must be left to the market place? Our priorities as a society? Our values as educators? Do we really have no options other than to adjust, as if it were inevitable and eternal, to the current emphasis in Washington on deregulation, rolling back social benefits, and colossal military expenditure?

What we do with biology will be shaped by policy and goals in public health, education, nutrition, and agriculture; by attitudes toward the environment, relations with other nations and problems of the Third World. What biotechnology does for humankind will depend less on what can be done in the laboratory than on society's values -- and a most critical test will be whether we permit it to be developed for germ warfare. The need is for more public involvement not less, for hearings, discussion and research on how developments in the life sciences relate to broad areas of public policy.

Both the intellectual and social significance of the new biology should make it more, especially for the university, than another hot property to be offered on the market place.
NOTES TO CHAPTER


2. This subject is treated by Dennis Florig in Chapter "The Scientist Entrepreneur."


18. The *Conference Prospectus* was not a public document. It was made available by the National Resources Defense Council, Inc., San Francisco, California.

19. See Note 5.

20. See Note 12.

21. One of the more significant cases of corrective action is described in "The Evolution of Calgene, a Potential Conflict of Interest and its Resolution--From a Dean's Perspective," testimony presented by Charles E. Hess, Dean of the College of Agricultural and Environmental Sciences, University of California at Davis, to the Committee on Science and Technology of the U.S. House of Representatives at joint hearings of the Subcommittee on Investigations and Oversight and the Subcommittee on Science, Research and Technology, June 16, 1982. pp. 49-88 in *University/Industry Cooperation in Biotechnology*, U.S. Government Printing Office, Washington, D.C.

22. A session of the Midwinter Conference of Immunologists, Asilomar, California, on January 24, 1982 was devoted to discussion on commercialism in biology. The three recommendations quoted in the text were approved in a sense vote by the assemblage.
23. At Stanford, the Graduate Student Association addressed this problem in a letter to the Academic Council Committee on Research, April 8, 1982. In a campus announcement, Stanford students were invited to "contact the Ombudsman's Office" if they experienced "research directed toward capital gain rather than scientific advancement."


