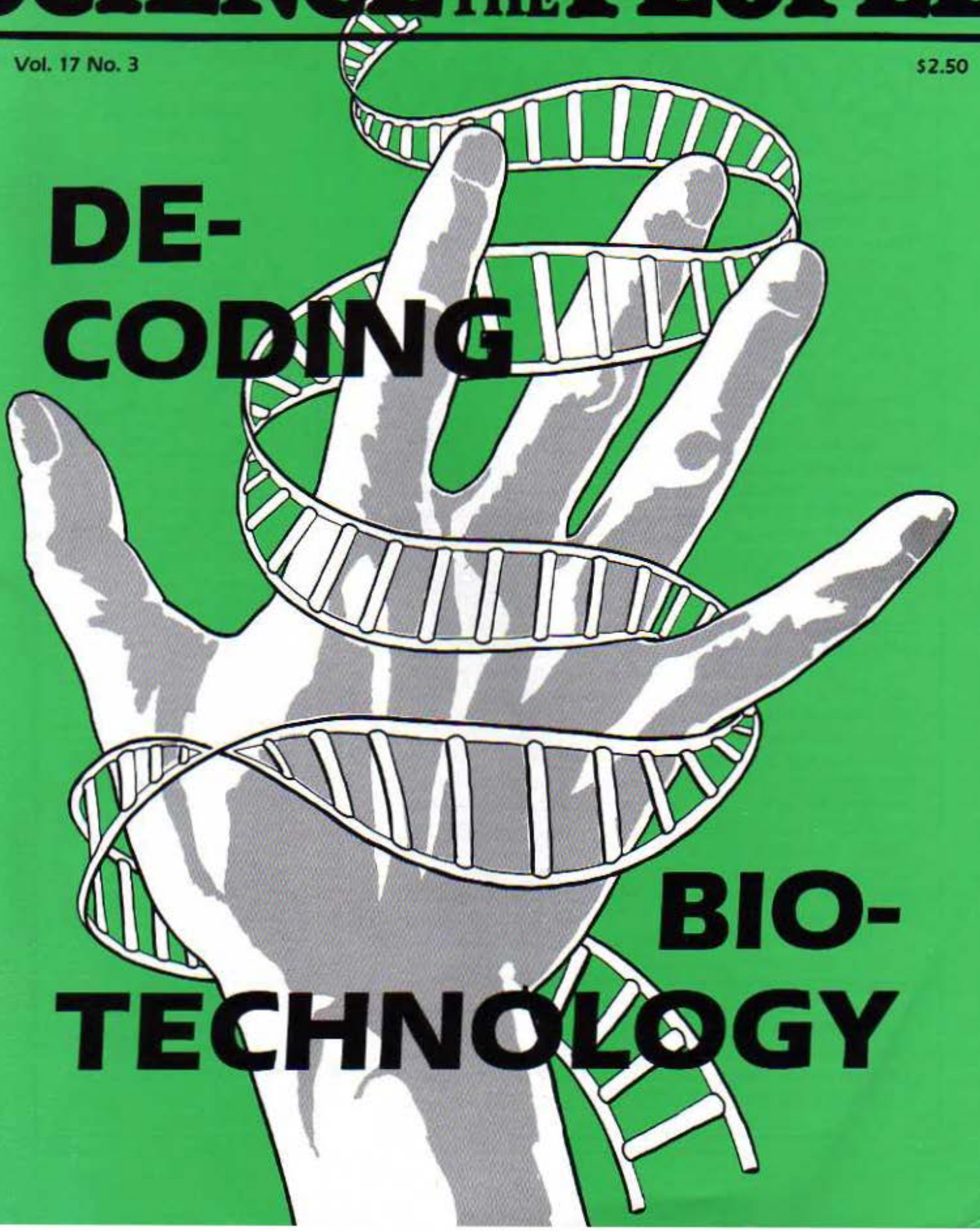
SCIENCE FOR THE PEOPLE

Vol. 17 No. 3

$2.50



DE-CODING BIO-TECHNOLOGY

Preview

Before us lies the vast field of biotechnology, based on a set of technological capabilities which promise to open up new horizons in many of the biggest industries: agribusiness, pharmaceutical, and chemical. With implications for our treatment of disease, for our control of the human gene pool, and for use in a whole new breed of weapons.

Rarely do we stand with so lucid a picture of the emerging technology at our doorstep, and rarely do we have the power to influence and control the destiny of that technology as we do now in the case of biotechnology.

In this sense, this collection of articles could not be more timely. Much of the course and direction of these capabilities may already be set, but the social and political control of the implications of this new technology has just begun. This is why we tried to put together as complete a picture as possible of the latest developments in biotechnology, and this is why, with the help of the generous support of the C.S. Fund, we are sending this issue to thousands of educators and legislators in addition to our normal subscribers.

Because of the breadth and length of articles we are featuring, we also decided to present them in a revised format, foregoing some of the columns and sections we usually run. We hope our readers will be pleased with the results.

The compilation of this large an edition and the undertaking to get it out to as wide an audience as possible has stretched our resources to the limit. The long and dedicated work of an overextended staff was supplemented by the dedication of a special committee who saw the project through from beginning to end. Not adequately represented in the credits to the right, special thanks go out to these concerned and knowledgable members: Kostia Bergman, Ross Feldberg, Sheldon Krimsky, and Gerry Waneck. Thanks also to Terri Goldberg, Director of the Committee for Responsible Genetics, and former SftP staffer, for a variety of information and help along the way.

We hope this collection will be used as a resource to help us educate ourselves on the choices and problems that lie ahead in this area. But more than that, we hope that it can serve as a catalyst to encourage a more active public role in current efforts to shape and monitor this unfolding technology. Only in this way do we have a chance to assert control over these choices to make them work for the benefit of all, and not simply for the profit of a few.

SCIENCE FOR THE PEOPLE

Editorial Coordinator
Seth Shulman

Magazine Coordinator
Leslie Fraser

Business Manager
Gary Keenan

Art & Photos
Andrew Joslin, Mara Loft, Anthony Russo, Ellen Shub

Production
Richard Aichelmann, Audrey Borus, Leslie Fraser, Howard Gale, Jess Gugino, Gary Keenan, Laura Reed, Joseph Regna, Sholeh Regna, Nancy Shulman, Seth Shulman, Dale Sylvain, Cathy Wenthe

Circulation
Richard Aichelmann

Material Requests
Jim Barton

Typesetting
Platform Studio, 636 Beacon St., Boston, MA 02215

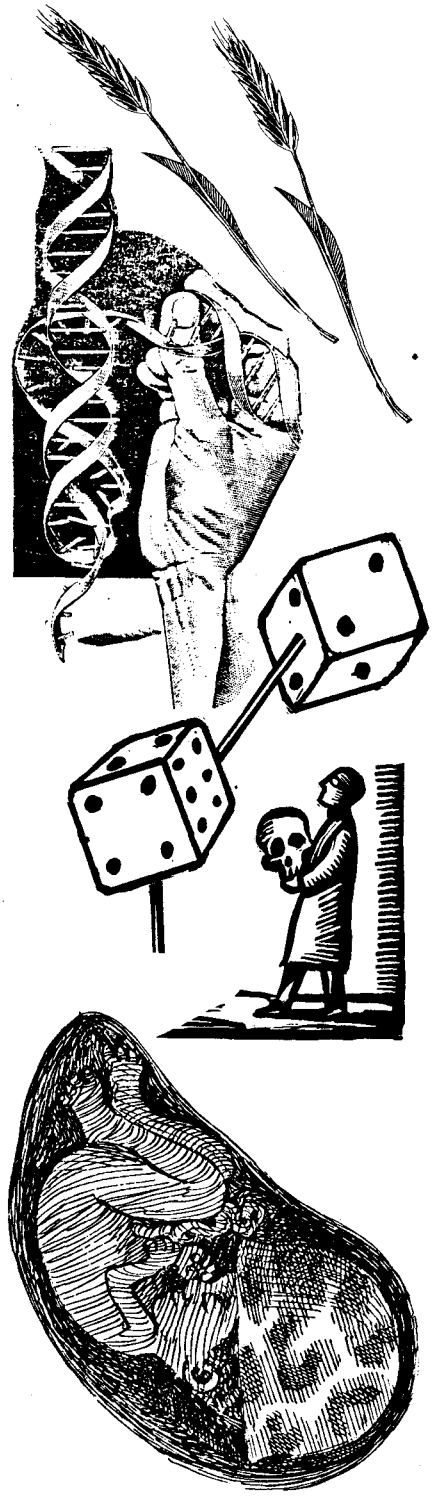
Printing
Charles River Publishing
45 Landsdowne St., Cambridge, MA 02139

SUBSCRIPTIONS: U.S. one year/six issues: $15. Foreign suface mail: $20. Air mail to Canada: $20.50. Air mail to Latin America: $24.50. Air mail to Europe: $28. Air mail to Asia and Africa: $31.50. Institutional/library rate: $24. Member subscriptions (includes the magazine, our newsletter and other internal communications): $25. Foreign subscribers must remit in U.S. currency, with either an International Money Order or a check drawn on a U.S. bank.

SCIENCE FOR THE PEOPLE is available to bookstores on consignment from the publisher or through Carrier Pigeon Distributors, P.O. Box 2783, Boston, MA 02208. The magazine is available on microfilm from Xerox Microfilms, 300 North Zeeb Rd., Ann Arbor, MI 48109. Science for the People is indexed in Alternative Press Index, P.O. Box 7229, Baltimore, MD 21218.

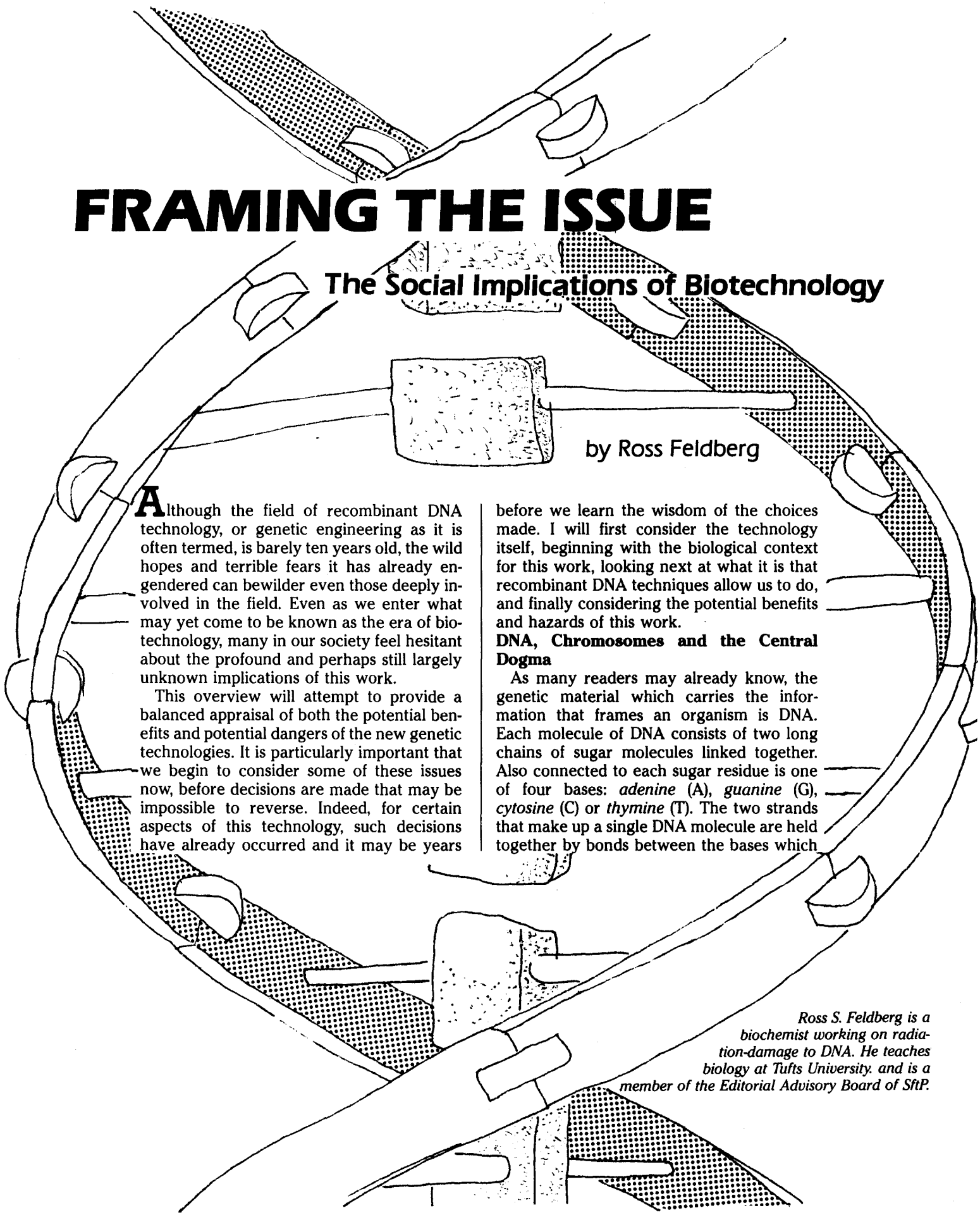
SCIENCE FOR THE PEOPLE

May/June 1985
Volume 17, No. 3



Decoding Biotechnology

SCIENCE FOR THE PEOPLE (ISSN 0048-9662) is published bimonthly by the Science Resource Center, Inc., a nonprofit corporation, at 897 Main St., Cambridge, MA 02139, telephone (617) 547-0370. Edited and produced by the national organization of Science for the People. We offer a progressive view of science and technology. Articles, letters, books reviews, newsnotes, photos and artwork are welcome. Please send three copies of double spaced, typed manuscripts.



FRAMING THE ISSUE

The Social Implications of Biotechnology

by Ross Feldberg

Although the field of recombinant DNA technology, or genetic engineering as it is often termed, is barely ten years old, the wild hopes and terrible fears it has already engendered can bewilder even those deeply involved in the field. Even as we enter what may yet come to be known as the era of biotechnology, many in our society feel hesitant about the profound and perhaps still largely unknown implications of this work.

This overview will attempt to provide a balanced appraisal of both the potential benefits and potential dangers of the new genetic technologies. It is particularly important that we begin to consider some of these issues now, before decisions are made that may be impossible to reverse. Indeed, for certain aspects of this technology, such decisions have already occurred and it may be years before we learn the wisdom of the choices made. I will first consider the technology itself, beginning with the biological context for this work, looking next at what it is that recombinant DNA techniques allow us to do, and finally considering the potential benefits and hazards of this work.

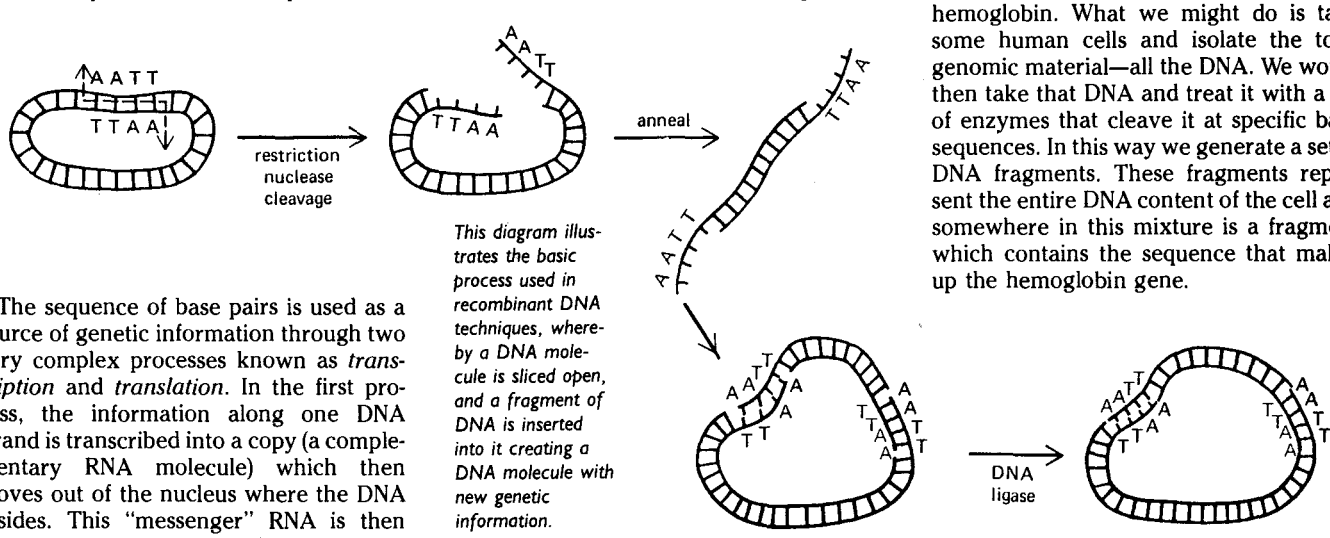
DNA, Chromosomes and the Central Dogma

As many readers may already know, the genetic material which carries the information that frames an organism is DNA. Each molecule of DNA consists of two long chains of sugar molecules linked together. Also connected to each sugar residue is one of four bases: *adenine* (A), *guanine* (G), *cytosine* (C) or *thymine* (T). The two strands that make up a single DNA molecule are held together by bonds between the bases which

Ross S. Feldberg is a biochemist working on radiation-damage to DNA. He teaches biology at Tufts University. and is a member of the Editorial Advisory Board of SftP.

pair an A with a T and a G with a C. In this way, the two strands are complementary. The information on one strand thus deermines the information on the other. The sequence of these four bases along the DNA chain is the information that codes for the structural and functional features of any living cell.

The amount of DNA within each human cell is enormous. To fit this material into this tiny space, the DNA is packaged together along with proteins to make up the distinct structures known as chromosomes. Each of our cells contains 46 chromosomes. Chromosomes differ in size, but if we could imagine for a moment an "average" chromosome, we would find that each of the 46 chromosomes contained approximately *150 million* base pairs.



This diagram illustrates the basic process used in recombinant DNA techniques, whereby a DNA molecule is sliced open, and a fragment of DNA is inserted into it creating a DNA molecule with new genetic information.

The sequence of base pairs is used as a source of genetic information through two very complex processes known as *transcription* and *translation*. In the first process, the information along one DNA strand is transcribed into a copy (a complementary RNA molecule) which then moves out of the nucleus where the DNA resides. This "messenger" RNA is then translated into a series of amino acids joined together to form a protein. There are 20 different amino acids commonly found in proteins and a protein may contain anywhere from 50 to 1000 of them. It is the exact sequence of amino acids in this chain that determines the properties and functions of the protein. Proteins can play a variety of roles, from hormonal functions such as insulin to structural roles such as collagen, to catalytic functions of the enzymes which catalyze all the chemical reactions in the living cell.

The region along the DNA which codes for a specific protein is known as a gene. If a typical protein contains anywhere from 50-1000 amino acids, and there are three bases that code for each amino acid, then the size of a gene could be anywhere from 150-3000 bases long. If a single chromosome contains 150 million bases on average, it is clear that a single chromosome could contain at least 50,000 genes. As it turns out, only a tiny fraction of the DNA is actually involved in coding for proteins and one of the great unresolved mysteries of the cell is why we have so much "extra" DNA in our cells. We can perhaps visualize a gene better if we consider a specific example. The DNA sequence or gene that codes for the β-chain of hemoglobin resides on the short arm of chromosome 11. Hemoglobin is the protein that carries oxygen from the lungs through the blood and to the cells of our body, and it is made up of two chains.

What is it We Wish to Know?

Having located this gene, there are many questions we would like to ask about it. For instance, the genetic material in all our cells is the same, yet hemoglobin is produced by only a few specialized cell types. The gene must be active in these cells and inactive in all other cell types. How does the cell control the expression of particular genes? In certain individuals, for example, a change of a single base in this gene results in a hemoglobin molecule which forms aggregates within the red blood cells. As a consequence, the red blood cells show abnormal shapes, tend to not flow normally through the capillaries, and result in a condition known as sickle-cell anemia. How do such changes arise in the DNA?

The problem we face is "How does one study a single gene in the presence of tens of thousands of other genes?" How do you pick it up in such an enormous background? The answer to this problem lies in the techniques of recombinant DNA research, and we thus begin our story with a brief overview of this technique.

Recombinant DNA Techniques

Essentially, recombinant DNA research is the set of techniques that allows us to pull out a single gene from among the millions of DNA sequences in the cell and to transfer that gene into a bacterial cell which we can then grow in culture so as to obtain millions of copies of the specific DNA sequence. The techniques of recombinant DNA research are truly elegant to perform. But even more remarkable is the fact that these techniques are also quite simple—within the reach of even a modest laboratory. Indeed, they are so simple that at most good universities they are taught to undergraduates as part of one of the advanced biology laboratory courses. Although the detailed methodology is not important to a discussion of the social impacts of this technology, let me briefly outline just one of the various procedures that one might use in this field.

Let us take a hypothetical example and suppose that we were interested in the specific gene which coded for the protein hemoglobin. What we might do is take some human cells and isolate the total genomic material—all the DNA. We would then take that DNA and treat it with a set of enzymes that cleave it at specific base sequences. In this way we generate a set of DNA fragments. These fragments represent the entire DNA content of the cell and somewhere in this mixture is a fragment which contains the sequence that makes up the hemoglobin gene.

To obtain this sequence, we make use of what is known as a plasmid—a small circular DNA molecule which can enter a bacterial cell and be replicated along with the cell, but remain independent of the bacterial genome. In a way, a plasmid is similar to a primitive, incomplete virus. Like a virus, plasmids can infect cells, but unlike viruses, plasmids don't generally take over the cell. The plasmid is used as a vector to carry the mammalian DNA fragments and to allow them to be reproduced in bacterial cells. This is done by treating the plasmid as well with the enzyme that breaks the DNA. If you now incubate the broken plasmid molecules together with the DNA fragments from the mammalian cell and an enzyme that can rejoin broken DNA molecules, you can obtain a large number of plasmid molecules that now contain in addition to their own DNA, a fragment of the mammalian DNA. Such molecules are termed "recombinant DNA molecules." You next take these plasmids and use them to infect a growing culture of bacteria. When the cells divide, each daughter cell

receives one copy of the plasmid along with its own DNA. You still have a major problem, however.

Out of the millions of cells growing in culture, only one or two contain a plasmid which has on it the hemoglobin gene. How do you isolate that cell? The details of how you accomplish this make up the most difficult aspect of genetic engineering. If the gene is actually expressed in the bacteria, you could simply screen for the one cell in the culture which contains hemoglobin, a protein not found in bacteria. If the gene is not expressed into protein, then you need a probe for the gene itself. For instance, hemoglobin messenger RNA isolated from red blood cells can be used to screen the bacterial cells for the ones containing hemoglobin DNA. However you do it, if DNA, you begin with an enriched subset of only expressed genes. What you might do with this material brings us to the next topic I would like to cover, the current commercial applications of genetic engineering.

What is it that gene-splicing allows us to do that more traditional genetic analysis does not? The ability to select out a single gene or a limited portion of the genome and to selectively place that DNA into a bacterial cell where we can duplicate it many millions of times allows us to study single genes in ways we could not before. We can now determine the base sequence of genes and we can begin to study how gene expression is controlled by altering the DNA sequence and looking for what effect that alteration has on the gene.

Ellen Shub

you can identify the cells which contain the DNA fragment you are interested in, you can isolate them and grow them up in pure culture. You can take the few cells and grow them up in a test tube of culture medium and then take those cells and transfer them to a flask of medium and then let them divide some more and you can keep doing that until, if you are interested in commercial applications, you can obtain a culture of 250 or 500 liters of the bacteria containing the mammalian gene. In practice, the above procedure is often modified since mammalian genes are generally not expressed in bacteria. Instead, what is often done is to take RNA from a cell which is synthesizing the protein in which you are interested and copy this RNA back into a DNA copy. This cDNA, as it is called, is then cloned as described above. The advantage to this is that instead of dealing with the entire genomic

Benefits of Recombinant DNA Research

Basic Research: In cancer biology, recombinant DNA techniques have led in the past year or so to a unified theory of oncogenesis. Using the above procedures, it has become clear that tumor viruses carry a gene very similar to one found in normal cells. This gene codes for a protein which acts to place a phosphate group on an amino acid residue in other proteins. Normally, a protein like this plays an important role in the regulation of cellular growth and division. However, when picked up by the virus, the activity of this enzyme is increased many fold, and growth imbalances occur which seem to lead to neoplastic growth. These normal genes can also be activated by other processes, such as damaging the cell's DNA by radiation or chemicals. The areas of basic research which these new techniques have opened up to study are truly enormous and impact on every facet of cell biology, theories of evolution, and now even animal behavior. Rather than run through a compilation of these, however, let me turn to consider a rather new phenomenon, the application of these techniques to industrial problems.

Pharmaceuticals: The pharmaceutical industry has turned to genetic engineering as a way of obtaining potentially useful drugs which are present in normal tissue at levels too small to be commercially extracted and which can not be easily synthesized. Human growth hormone, human insulin, interferon, interleukin-2, tissue plasminogen activator and Factor VIII are all compounds normally found in the body in tiny amounts but which perhaps can be obtained in large scale by recombinant techniques. Some of these are actually being produced at present; others will be available in the next few years. Potentially, these represent new modes of therapy for a variety of diseases, but the potential for abuse also exists, as I shall discuss below.

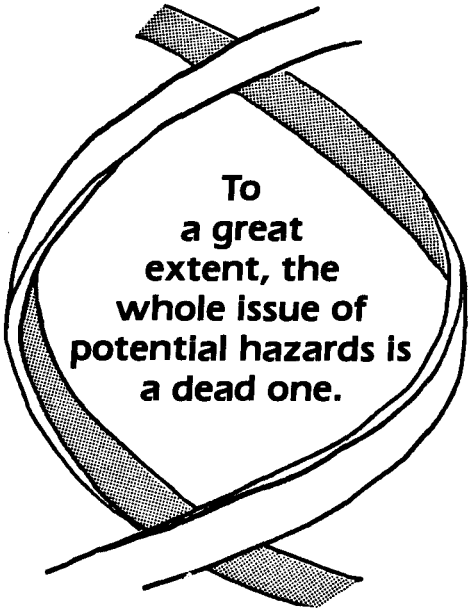
Agricultural Products: The other race for profits from recombinant DNA techniques lies in agricultural products. Recombinant DNA techniques can allow for the production of new vaccines which are safer and cheaper than old traditional vaccines. Such vaccines are first appearing in the animal care field, since federal approval is much more rapid in this area. A vaccine to prevent "scours," a deadly form of diarrhea in newborn calves is soon to be introduced to the market. Bovine growth hormone to increase weight gain in cows may soon be introduced as well, along with a number of other products.

Plant-related products are also being developed. Genetically engineered bacteria to reduce the danger of frost damage to crops are being tested, crop varieties with higher protein contents are being developed, and even attempts to widen the number of species that can fix atmospheric nitrogen are underway. Some of these plant products raise broader questions about the wisdom of creating lifeforms whose eventual distribution in nature it is impossible to predict.

Diagnostic Testing: Although still being worked out, the use of recombinant techniques to design new diagnostic tests for genetic disorders is another broad application of this technology. It is perhaps ironic that this work is developing at the same time that forces in our society are working to severely limit the availability of therapeutic abortions.

General Commercial Applications: With all the above almost-science-fiction developments, it is easy to lose sight of the fact that recombinant techniques are also being applied to the production of a variety of chemicals. Aspartame, marketed under the brand name NutraSweet, for example, is one of the biggest product developments being brought to market.

With all of the above benefits, is it possible to raise any questions about the beneficial applications of recombinant DNA research? I think the answer is a resounding yes. I would like to examine several aspects of genetic engineering that society must deal with if it is not to be once again overtaken by events.

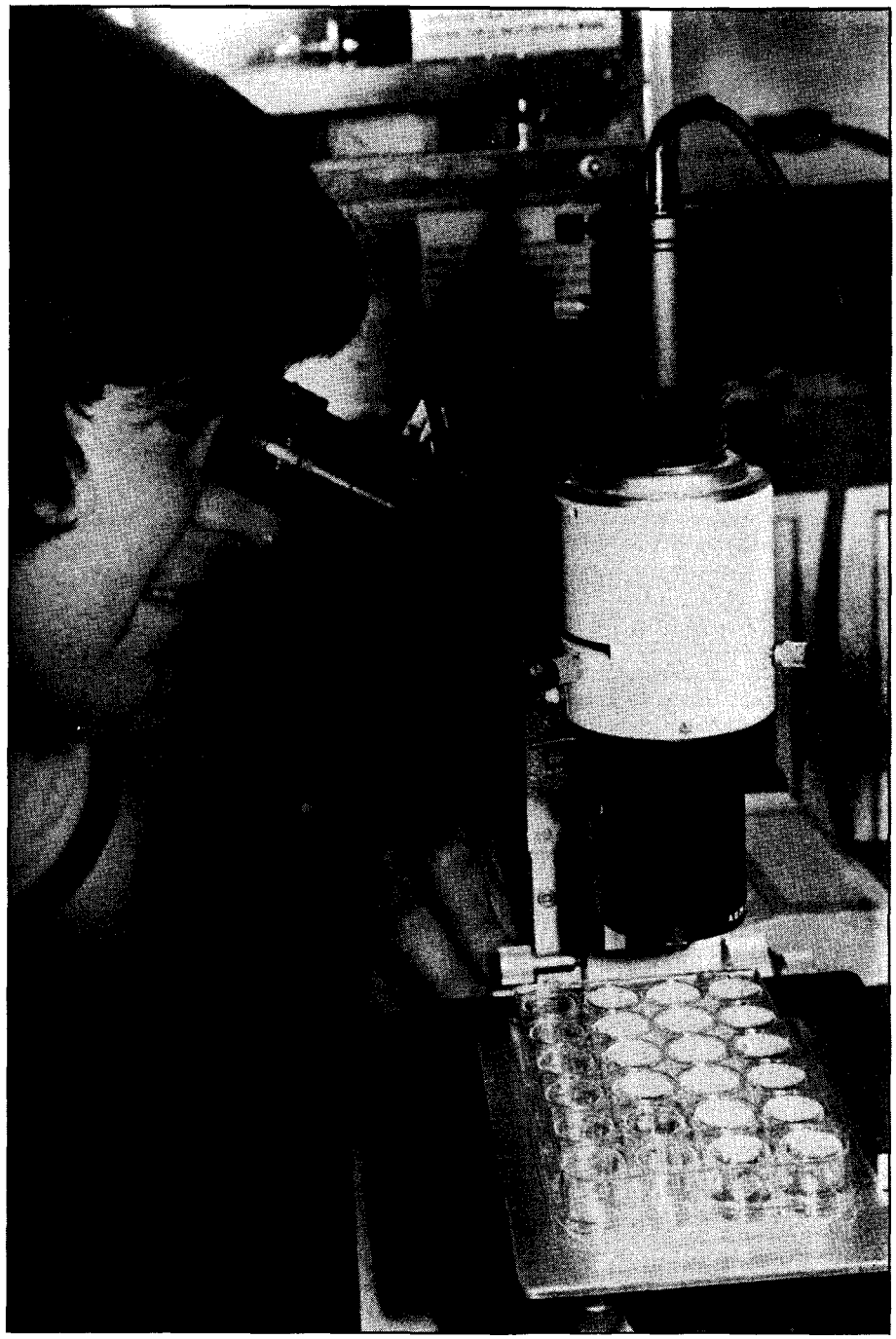


The Tensions of Genetic Engineering

Biotechnology per se is nothing new. We have long exploited living organisms for a variety of ends. What is new, however, is the sophistication of techniques for manipulating genetic material directly rather than indirectly, that is, the ability to place genetic material directly into bacteria to produce biochemicals that were previously available only from less convenient or limited sources. This new ability does have a profound impact.

Occupational and Public Safety

Although this is certainly an important topic and one that I could spend many hours discussing, I hesitate to spend much time on it, because it is officially a "dead" topic. Yet, an examination of its history is fascinating for what it reveals about the attitudes of scientists when confronted



Ellen Shub

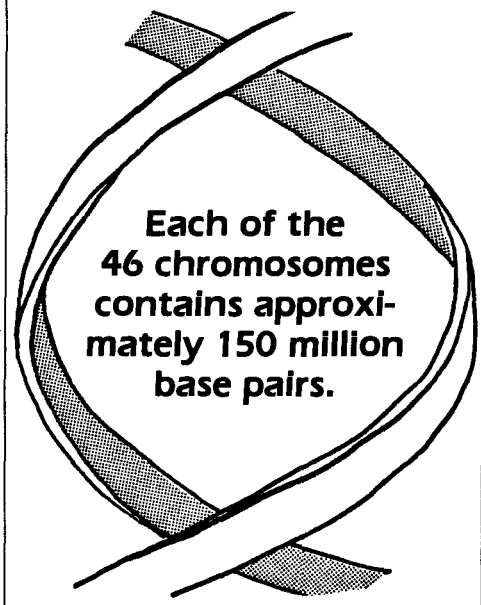
with the possibility of external controls over their activities.

Initial concern around genetic engineering began before the very first experiments had even begun. Back in 1970, the Stanford biochemist Paul Berg was beginning to study tumor viruses and realized that he could use certain enzymes to make a hybrid of the SV40 tumor virus and part of the genetic material of a bacterial virus. One goal of the research was to determine if the bacterial virus genes could be expressed in animal cells and a second goal was to determine if genes of the tumor virus could be reproduced in bacterial cells. Normally, one can only obtain limited amounts of tumor viruses because of the difficulty and expense of working with animal cells in culture. But, if the viral genes could be propagated in bacterial cells, large amounts of virus DNA could be produced and this might perhaps even be safer than working with the complete virus. However, as other scientists heard about this work, a number of them began to express serious doubts about the wisdom of carrying out such an experiment. Might the bacteria carrying the virus pose a potential danger for the laboratory workers? Or might there even be a possibility of a worst-case scenario in which the bacteria escape into the general environment causing an epidemic of virus-induced cancers? These concerns resulted in an immediate moratorium on such experiments until a larger meeting of scientists could be convened to explore the potential dangers.

At an initial meeting in 1975, known as the Asilomar conference, a set of precautions and controls were agreed to by the participants, and experiments utilizing tumor viruses were banned outright until more data on the potential hazards could be collected. However, as the immense power of recombinant DNA techniques became apparent, there was increasing pressure within the scientific community to discard most of the controls. In addition, the scientists were alarmed by the growing interest of those outside the scientific community in playing a role in the decisions being made. In this context, the scientists were eager to backtrack. A few studies (very few) evaluating the potential dangers were carried out and provided reassuring results. With these in hand, by 1979 there was a general relaxation in the guidelines and work on tumor viruses was allowed.

To a great extent, the whole issue of potential hazards of recombinant DNA research is a dead one. No disasters have occurred. Initial fears, although not groundless, were probably overemphasized, and today any scientist who still insists on raising this issue—no matter how cautiously—risks severely damaging their scientific career. Yet, a careful reading of the history of this debate is a valuable experience. The best treatment of this topic is that of Dr. Sheldon Krimsky of Tufts University in his book *Genetic Alchemy*, published by the MIT Press. If I had to summarize the lessons we learned from this initial controversy, it would be that the guidelines were lifted not due to any clear proof of safety, but rather because of the desire to maintain the competitive edge in basic research over European and Japanese scientists, because it was easier to evaluate the benefits than the risks, and because of the fear of opening the issue of control over science and technology to a broader audience.

Although nonscientists were eventually



invited to participate in the NIH committee used to evaluate experiments, their task was to carry out policies and not to formulate them. The regulations were formulated and imposed at the federal level in a purely administrative context and were relaxed in the same way. Yet, this episode is notable in being the only example that I know of where scientists themselves gathered to consider some of the broader implications of the work they themselves were eager to do.

The health hazards of recombinant technologies are still unclear. If history is any guide, it may take decades or even generations before any deleterious effects of the widespread applications of recombinant DNA research show up. But the first casualty, the notion that society as a whole should have some control over those whom it supports, has already occurred.

Environmental Impacts

Currently, the most controversial aspects of recombinant DNA research concern its application to the engineering of crop species or the manipulation of microorganisms which interact with crop plants. If we reflect on the initial debate about the potential biohazards of genetic engineering, one of the key arguments made for the safety of the work was that the bacterial vectors employed in the research were weakened, laboratory strains which could never establish themselves in the natural competitive ecosystem outside of the laboratory. Yet, without major comment or new debate, we now see the commercial exploitation of genetic engineering posited on the notion that the organisms created will not only survive, but will indeed flourish and replace the natural species.

The recent and well publicized example of this work is that of Drs. Steven Lindow and Nicholas Panopoulos of the UC, Berkeley on the ice-nucleation bacteria. In order for ice to form, there have to be nucleation sites around which the water molecules can form the regular ice structure. In the ecosphere, specialized bacteria perform this role. These bacteria contain a specific protein which acts as the nucleation center for the growth of ice crystals. These bacteria colonize plants as epiphytes (plants that grow on other plants, e.g., spanish moss) and induce ice formation and thus frost damage as the temperature drops to the freezing point.

What Lindow and Panopoulos apparently have done is to construct a new strain of bacteria in which the nucleation protein is absent or altered so that the bacteria can no longer play the role of nucleation centers. What these researchers would like to do next is to field test this new organism to see if it will outcompete the normal strains and if it will thus protect against frost damage. On the face of it, it sounds wonderful: no more ice-damaged citrus crops, millions of dollars in lost crops saved, etc. The problem is that we know virtually nothing about the normal role these bacteria play in the ecosphere. They are apparently quite ubiquitious, and some have even suggested that they may play a role in the moisture nucleation in clouds and consequent rain or snow fall. What if these new strains really were effective? What if they did compete for the same ecological niche as the natural strains? What if they allowed clouds to hold much more moisture before precipitation occurred?

Although these experiments have been enjoined in a suit filed by Jeremy Rifkin's Foundation on Economic Trends along with Environmental Action and the Envir-

onmental Task Force, until an environmental impact assessment has been prepared by the EPA, I think it is likely that the economic and scientific pressures will build as more and more companies develop similar or analogous products designed specifically for widespread release.

Another development which indicates some of the broader issues that can be raised by the application of genetic engineering techniques to agriculture relates to creation of herbicide resistant plants. Scientists at Calgene, Inc. have isolated the gene responsible for providing glyphosate resistance in *Salmonella typhimurium*, have cloned the gene in *E. coli*, and have successfully transferred it into plant cells.

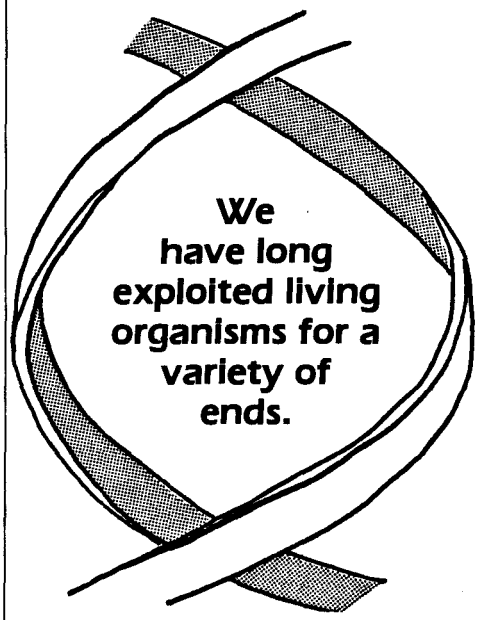
The idea is that herbicide resistant strains of crops will allow farmers to employ much higher levels of herbicide than can presently be used to control weeds. Herbicides in too high a dose will kill non-weeds as well as weeds, and must thus be used with some care and together with mechanical methods of weed control. By increasing the differential response of crops and weeds to herbicides, one could apply the herbicides more often and in higher dose to control weeds. I find it both ironic and disturbing that at a time when we are becoming increasingly concerned about dangerous chemical residues in foodstuffs, recombinant DNA technology should be used to effect the increased chemical treatment of food crops.

In this field more than anywhere else, the question of who decides which technologies are appropriate must be addressed. Who decides which considerations receive priority? Does society have the right to evaluate the impact of significant new technologies? If the answer to that is affirmative, then who in society should carry out that evaluation? How do we balance the right of companies to protect their investments and the right of society to have the necessary information to carry out an informed evaluation?

The Medicalization of Social Problems

Another issue that arises in a consideration of the impacts of the new genetic technologies is the tendency they will have to further impose medical models on social problems. I should start by emphasizing that this problem is not at all unique to this field, and has long been emphasized by groups such as Science for the People. What I mean by imposing medical models is the treatment of social problems as though they were medical problems. An example of this appeared in the Oct. 27, 1983 issue of the New England Journal of Medicine in an article which described the use of human growth hormone to treat very short but otherwise healthy children. These children, although they fell far below the mean heights for their ages, showed no deficiency in growth hormone or in growth hormone receptors. Indeed, the youngest child treated was less than five years old, hardly old enough to allow one to come to reliable conclusions about his eventual height.

So, what we have is a case of apparently healthy children being treated with a powerful hormone in an attempt to push them toward the average height. Is shortness *per se* a sickness? Shortness can indeed be a social problem. Short individuals do suffer a variety of forms of discrimination. But is the appropriate response to that to make those individuals change or to make society change? Medicalizing this



"problem" transfers the responsibility for the discrimination away from those doing the discrimination and to the victims. Are we to deal with discrimination by making short people taller or black people whiter? It would be laughable if it weren't so frightening. Getting back to our discussion of genetic technologies, it is interesting that one of the justifications presented in the paper for the above experiment was that with new recombinant DNA technologies, human growth hormone would soon be commercially available in large quantities at low cost! Or, to quote the authors, "The identification of short, otherwise healthy children who may benefit from growth hormone therapy has now become clinically important, since there is no theoretical limit to the amount of biosynthetic human growth hormone that can be produced." I believe that we are now seeing the beginning of a new wave of the application of pharmaceuticals to social problems. The enormous investments made in this area will provide a very strong driving force in this direction, and it will be more important than ever that groups sensitive to this issue be prepared to deal with it.

Genetic Screening

Genetic screening is another topic that is not unique to recombinant DNA technologies, but again it is an area that we can safely predict will be greatly broadened by the application of these technologies. Although most people think of genetic screening in the context of fetal assessment via amniocentesis, there are other less familiar applications of this work. One such application is the screening of potential workers in industries with high exposure to noxious agents for abnormally high susceptibility to those agents. The idea is that individual genetic differences make some people more sensitive than others to the deleterious effects of various chemicals. If hypersusceptible individuals could be identified and prevented from taking employment in these industries, then the incidence of occupational disease might be reduced.

Although this sounds not at all unreasonable, it does raise some complex questions. First, because some of the genetic traits screened for have a higher incidence among people in certain racial and ethnic groups, employment based on genetic screening can increase racial and ethnic discrimination in employment. In addition, such screening could be used as an alternative to cleaning up the workplace environment. In an excess labor market, it is cheaper to select out only those who show maximal resistance to the agents which contaminate the work environment. In a recent report of the Congressional Office of Technology Assessment, 17 companies reported using genetic screening in the last 12 years and another 59 companies stated that they planned to initiate some form of genetic screening over the next five years. The introduction of recombinant DNA methods for screening for genotypes will only increase this technology. Interestingly, there is yet no conclusive evidence that any of the five genetic traits presently screened for actually does result in higher susceptibility to any industrial disease. Genetic screening rests on the assumption that it is genes that cause health problems. An alternative assumption is that the workplace can cause health problems and it is the workplace that must be changed to eliminate these problems.

continued on page 53

BIOLOGICAL WARFARE AND THE NEW GENETIC TECHNOLOGIES

by Charles Piller

When the U.S. army moved last fall to build a $1.4 million laboratory to conduct secret research on "substantial volumes of toxic biological agents," it sparked concern among scientists around the country. They fear the Department of Defense (DOD) is on the path to violating the 1972 convention which bans biological weapons (BW), which may result in the initiation of a new BW race. The DOD contends any tests would be purely defensive and conducted under conditions of utmost safety, but acknowledges it intends to use the lab for secret work. Secrecy, however, is considered the litmus test of offensive goals by many scientists.

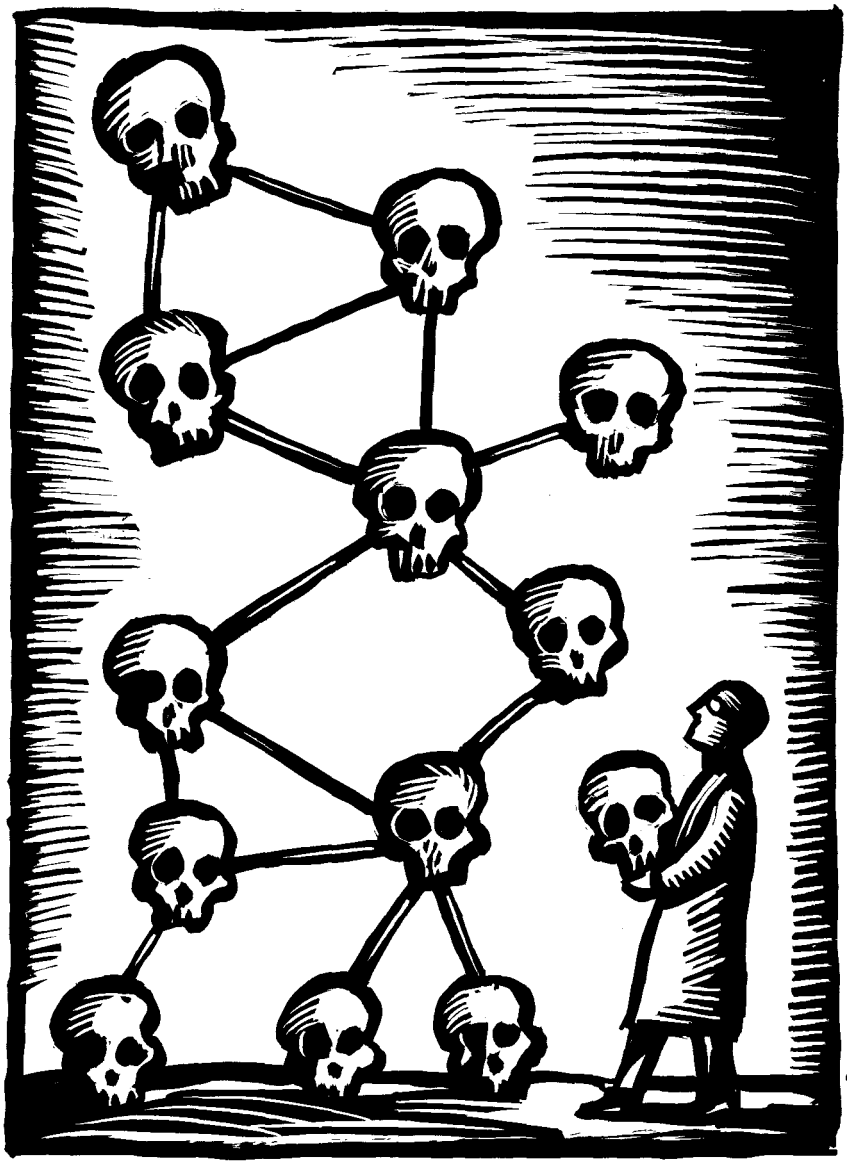
The lab's construction was temporarily stalled in late February when a lawsuit filed by the Washington, D.C.-based Foundation on Economic Trends, a private watchdog on genetic engineering, compelled the DOD to produce an environmental impact report. If built, the lab would be the centerpiece of a $250 million modernization and expansion of chemical and biological weapons (CBW) research facilities at Dugway Proving Ground, located 87 miles from Salt Lake City. According to the Army, Dugway's workload is expected to double by 1988, adding 309 jobs to its payroll.[1]

The Army lab proposal is part of a worrisome trend. During the Carter years, the BW defense research budget hovered around $15 million. Under Reagan, it has tripled to approximately $50 million in fiscal year 1985—largely for advanced biotechnology research. When related biological research is counted, some analysts place the spending figure at over $120 million.[2]

The Pentagon's BW researchers are using recombinant DNA ("gene-splicing") technology, whereby segments of DNA, the basic genetic blueprint, are removed from the cell of one species and attached to that of another, creating a "new" organism. A related development is hybridoma technology, by which different kinds of cells are fused, creating "immortal" cell lines that do not die off after a few generations, as do normal cells.

For the moment, the thrust of the research appears to be for the development of vaccines to protect U.S. or allied troops and populations against biological agents that might be used by the "enemy" or by U.S.

Charles Piller is an Oakland, California-based journalist. He has written on chemical and biological weapons issues for The Nation, *the* Philadelphia Inquirer, *and other publications.*



Anthony Russo

forces. DOD-financed scientists are seeking vaccines for some of the world's deadliest and most infectious diseases, such as Rift Valley Fever, dengue-2 ("breakbone fever"), anthrax and rickettsia ("Q-fever"). But Pentagon researchers could use the same techniques to create "super germs," or to enhance the virulence and antibiotic resistance of existing BW agents, or even to make harmless bugs lethal—all possible applications.

The proposed lab—which the Army acknowledged might be used to conduct recombinant DNA work—would dramatically increase the offensive potential of such tests. It would provide the highest level of physical containment possible. The lab is needed, according to the Army's request for funds, "to evaluate biological defense readiness" and test protective and detection gear "by employing toxic microorganisms and toxins requiring a level of containment and safety not now available within the Department of Defense."[3]

Many analysts are concerned about the lab's capability for conducting aerosol tests—in which biological agents or toxins are suspended in air. "Aerosols are the most dangerous vehicle for dissemination," says David Novick, a molecular biologist and former member of the federal committee which oversees recombinant DNA work. Novick said that federal guidelines "are focused on the absolute avoidance of aerosols."[4] The February lawsuit which stalled the lab focused on this kind of threat to public safety.

Such a lab normally requires congressional debate. Instead, the Army attached it to a "routine" reprogramming request to use unspent funds from other projects. Sen. Jim Sasser (D-Tenn.), who sits on the Senate subcommittee which approved the lab funds, concluded that the Army used reprogramming to avoid the regular congressional authorization and appropriation process.

Even the military acknowledges that differences between prohibited "offensive" research, and "defensive" BW research, which the 1972 convention allows, emerge only in application. But leading scientists—including 200 who signed a petition distributed by the Committee for Responsible Genetics objecting to the lab (see box)—question the need to test BW agents for purely defensive purposes. Critics include biophysicist and University of California at Santa Cruz Chancellor Robert Sinsheimer, and molecular biologist and Nobel laureate David Baltimore, scientists who are generally found in disagreement on issues of science and technology regulation.

Harvard University biochemist Matthew Meselson, considered the most authoritative scientific voice on CBW issues, also questions the proposal. He suggests that using simulants—innocuous organisms which mimic the behavior of disease agents—would be safer and more effective for work that is truly defensive. Simulants can be made hardier and more persistent than the diseases themselves, thus yielding more useful information without the risks of actual BW agents.

Historical Reasons for Biowar

The significance of the new BW research lies, in part, in the way scientific developments and international affairs have influenced each other. The heyday of modern BW work, the late 1930s through the 1960s, was a period when most major powers had some kind of research program, and many stockpiled BW agents and developed sophisticated delivery systems. Vast operations were maintained by the Soviet Union, the United States, and Britain, as well as Japan before and during World War II. Only Japan, during its occupation of China, is known to have used BW militarily during the war, and even that was on a relatively limited basis.

Moral repugnance towards BW and international pressure for an effective treaty pushed President Nixon to renounce all possession and use of BW in 1969. Shortly thereafter, Nixon added weapons made from toxins to his order.

His move anticipated the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction signed by nearly all world powers in 1972. The U.S. Senate ratified the convention in 1975. It was widely believed that this would end the threat of biological warfare.

Nixon's apparent move to the moral high ground obscured the more likely reason for both his action and the convention: at that time BW were not considered militarily useful. This was due to several factors. Although no international agreements prohibited possession of BW in 1969, their use was already a violation of international law—the 1925 Geneva Protocol on chemical and biological arms. Within a decade of 1925, all major powers had signed the protocol (although the U.S. Senate did not ratify it until 1975) and therefore, to use these weapons would have risked causing serious international sanctions.

Furthermore, any nation contemplating the use of BW faced the very serious risk of retaliation, threatening both military and civilian populations. Finally, spread of disease was considered difficult, if not impossible, to accurately predict. Thus, a potential aggressor using BW agents would have encountered the danger of self-infection, or infection of allied troops or populations. Similarly, because of the inherent hazards and uncertainty of testing disease agents in the environment, meaningful field tests to track the spread and characteristics of BW agents generally were viewed as unfeasible.

But advancements in biotechnology during the past decade and new revelations of Army research have rendered this logic, and hence the 1972 convention, obsolete. Part of the problem lies in gaping loopholes in the agreement itself. For example, the convention contains no mechanism for verifying compliance, and there are no U.S. laws prohibiting the development of new or "improved" weapons by industry or academia. Historically, major CBW developments, including nerve and mustard gases, have been the direct result of research from those two quarters.

Convention definitions are extremely hazy. Stockpiling of BW agents is forbidden, even for deterrence. Signatories are permitted to maintain agents for "prophylactic" or "protective" purposes, but the convention leaves to each nation the task of deciding how large a stock it needs. Because the same agents can often be used defensively, for creation of vaccines and equipment vulnerability research, as well as for offensive purposes, it is sometimes hard to distinguish the intended use of agent stocks. Even a minute amount stored for prophylactic purposes could pose a significant offensive threat. In some cases, as few as ten organisms can cause an infection, and a single drop of virus may contain a trillion live organisms. The Army maintains a variety of toxins and other agents for research purposes. Among these, it holds 100 crude grams and one pure gram of botulism toxin—enough to kill millions of people if properly disseminated.

Although actual BW agents and missiles are not being mass-produced, Army reports indicate extensive research on all as-

TO PREVENT A BIOLOGICAL ARMS RACE

The Committee for Responsible Genetics has been circulating two petitions opposing the military use of biological research. One, which has to date garnered over 200 signatures of prominent scientists, opposes the construction of the Aerosol Test Facility discussed in this article, as well as "any other action which might threaten to provoke a biological arms race."

A more general version, which has been circulating among scientists, medical professionals, peace, environmental, religious and other organizations, "as a first step in creating awareness of this situation," has been signed by over 1600 people to date. The petitions are to be delivered to key Congressional representatives and promoted as widely as possible by the Committee for Responsible Genetics to, in their words, "begin to work with other groups toward the specific demands in the petition."

In an effort to help further promote this effort we are reproducing the text of the more general petition below. For more information, readers are urged to contact the Committee for Responsible Genetics, 5 Doane St., 4th Floor, Boston MA 02109.

Petition Text:

We, the undersigned, oppose the use of biology for military purposes. At this time, we are particularly concerned that new biotechnologies, such as recombinant DNA and hybridoma technologies, may be used to generate new biological and chemical weapons systems. Therefore, we call on scientists and all people throughout the world to voice their opposition to the development of such weapons now, before nations begin to make major military investments in the new biotechnologies. It is essential that we affirm our commitment to the existing chemical and biological warfare treaties and work to strengthen them.

We urge that all nations:

1. Sign the Biological Weapons Convention and incorporate its provisions into their domestic law.
2. Seek to extend the Biological Weapons Convention to prohibit biological research aimed at weapons and to include provisions for verification of compliance.
3. Prohibit all military biological research conducted in secret.
4. Adopt the Geneva Protocol of 1925, which would prohibit the use of biological and chemical weapons.
5. Seek to develop an international treaty to prohibit research that can be used for development, production, and stockpiling of chemical weapons.

We wish to voice our strong opposition to the uses of the sciences of life, which hold so much promise for humanity, for the production of death. We therefore call on scientists throughout the world not to participate in research associated with the development and production of biological and chemical weapons.

pects of biological warfare, from lethality of various germs to efficacy of different delivery systems. If built, the Dugway lab would greatly enhance what is already a very sophisticated program. Still, much of the DOD's efforts are vaccine-oriented, arguably a laudable, defensive goal. But almost any vaccine research, however humanitarian its objectives, produces knowledge that can be used in offensive ways—including the development of new agents.

The Significance of Vaccines

The advent of recombinant DNA revolutionized the potential of both offensive and defensive BW research. Nowhere is this more evident than in vaccine development and its impact on the fear of retaliation. According to the Stockholm International Peace Research Institute's (SIPRI) definitive CBW study:

> "The typical vaccine plant is inadequate for the production of a fully military capability, [but] it would be adequate for the production of quantities [of BW agents] required for a sabotage attack . . . Some common forms of vaccine production are very close technically to production of CBW agents and so offer easy opportunities for conversion."[5]

Harvard Medical School Professor Richard Goldstein maintains, "The key is vaccination . . . [With recombinant DNA technology] you can make a vaccine against anything, and if you have a vaccine, it makes use of these weapons more feasible."[6]

After recombinant DNA technology has created a new or better vaccine, hybridoma technology can purify the vaccine faster and more efficiently than ever before. The vaccine can then be mass-produced. At the point of mass-innoculation, a problem arises. U.S. troops are routinely innoculated for a wide variety of diseases, and even large-scale civilian vaccination is nothing new. However, mass-vaccination for rare or exotic diseases would touch off a public furor, so the Army apparently has another idea. It is studying the effectiveness of aerosol immunization, in which the vaccine, against such potential BW agents as anthrax and tularemia, is inhaled rather than swallowed or injected. The Army describes its aerosol-vaccination research as routine. According to a 1980 report, studies are targeted toward "stimulating protective immunity on mucosal surfaces throughout the respiratory tract."[7]

The Army is studying the effectiveness of aerosol immunization, in which the vaccine against potential biological warfare is inhaled rather than swallowed or injected.

Although aerosol vaccines have produced immunity, they are much more dangerous and less effective than standard methods. Disease is more likely to spread —the result of releasing germs into the air. Then why is the DOD even considering aerosols? The answer may be they could be used clandestinely. Theoretically, an entire civilian population could be covertly innoculated against BW agents by spraying a vaccine over wide areas.

In the 1950s, the Army secretly disseminated "simulants"—supposedly innocuous germs—over the San Francisco Bay Area, in New York's subways and elsewhere, to test this technique's feasibility in biological warfare. Revelations of the experiments did not surface until the late 1970s, after millions of unwitting civilians had been exposed.[8] Many scientists believe these tests caused many illnesses and at least one death.

Although the idea of covert mass-vaccination may seem farfetched, the stuff of science fiction, the Army disagrees. As early as 1963, an article in the Army's *Military Medicine* noted that "a plan for large-scale immunoprophylaxis of the civilian population should be prepared. This would include standby legislation for compulsory immunization if required."[9] A separate article cites aerosol vaccination as a means to accomplish that goal. Documents released under the Freedom of Information Act indicate the Defense Intelligence Agency believes the Soviet Union is also exploring aerosol immunization.[10]

Of even greater immediate concern is research on toxins, defined in the convention as inert poisions produced by living organisms. Recombinant DNA technology has rendered this definition ambiguous because it is now possible to synthesize toxins. Genes regulating the enzymes essential to produce toxins can be cloned within a prolific bacterial strain. The cells can then be broken open and the enzymes extracted, using a biochemical purification process. The raw materials from which toxins derive can then be combined with the enzymes, creating toxins without a living organism.

Toxins might also be created in the laboratory using new chemical building block techniques. Substances are "built" by attaching appropriate amino acids—the substances which form all proteins—in the proper sequence. Although toxins are made up of highly complex molecules, their synthesis is possible. An unclassified portion of a 1981 report prepared at Dugway reads, "A more reliable use of DNA than the creation of new pathogens is the cheap manufacture of toxins . . . by newly created bacterial strains under controlled laboratory conditions." Thus, not only are synthetic toxins overlooked by the the convention, they are cheap to produce.

Historically, the development of new technologies for CBW has encouraged the use of the weapons even as much as international law has discouraged it. For example, in 1936, in direct violation of the Geneva Protocol, the Italians used mustard gas during their invasion of Ethiopia. The gas caused 15,000 casualties among the primitively equipped and trained soldiers. New methods of disseminating the gas, unavailable when Italy ratified the Geneva accord in 1928, provided an irresistable incentive.

Similarly, the application of gene-splicing and hybridoma technologies to this kind of warfare was not known until years after the 1972 treaty was signed. According to SIPRI's 1973 analysis:

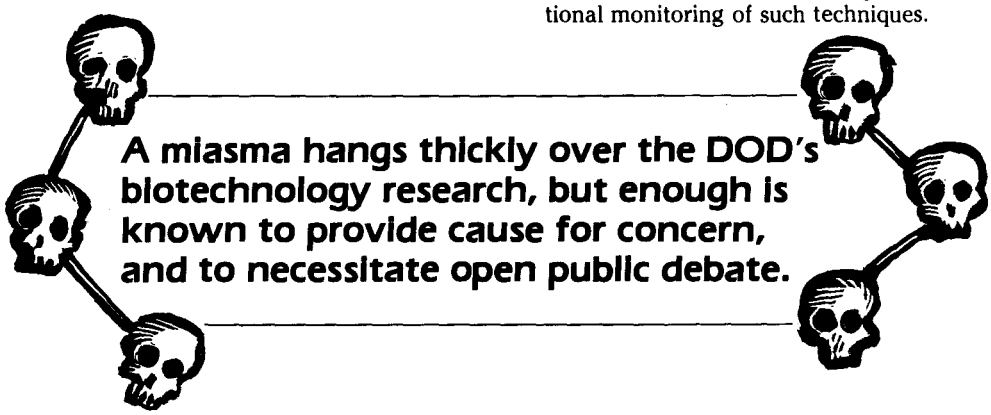
> "If . . . 1990s-type biological weapons already existed in 1972, the BW convention would surely not have been signed then; and just as there might have been strong military pressure in 1972 against accepting biological disarmament under such circumstances, so may there be strong military pressure in the 1990s to abrogate the 1972 convention."[11]

The Final Step — Tracking

Using new biotechnologies to exploit treaty loopholes, even when combined with delivery systems research, leaves unsolved the thorny problem of field testing and tracking the agents as weapons. There is now evidence to indicate that these issues are far from being overlooked by military planners. In the 1960s, and probably for many years before, the University of Utah conducted secret experiments for the Army at Dugway, which involved large scale, open-field testing of some of the most infectious and toxic known BW

The University of Utah conducted secret experiments for the Army which involved large scale, open-field testing of some of the most infectious and toxic known BW agents.

agents, including Rocky Mountain Spotted Fever, Plague, and Q-Fever.[12] The tests were designed to track the spread of these diseases over wide areas, and involved infecting thousands of wild animals using insects and aerosol chambers.



A miasma hangs thickly over the DOD's biotechnology research, but enough is known to provide cause for concern, and to necessitate open public debate.

The results of the tests—the only publicly-known example of BW agent field experiments near populted areas—have never been released, but the experimental protocols strongly imply open-air spraying of BW agents. The research contracts refer to "primary areas of biological agent release," and animal testing "at appropriate distances downwind from such areas."[13] The tests were conducted with the explicit assumption that disease may spread beyond test zones to populated areas, according to the contracts. The only other known incidents of open field tests by a Western power were on deserted islands or at sea.[14]

"It's clearly not responsible," said Sinsheimer, regarding the Utah experiments. To infect animals and risk infecting humans is "a very unwise policy . . . I don't know of any other instance of this kind of experiment," in the military or academia.[15] The justification for allowing the tests, according to a University of Utah memo, was that the diseases studied were already endemic to Utah or nearby states.[16] Sinsheimer disagrees: "If it's endemic and a problem, you don't want to increase the problem."

After decades of secrecy, the simulant spraying of the 1950s came to light in a piecemeal fashion over a period of years. In question is what other secret open-field testing with actual BW agents has taken place, and to what effect. The Army's stated defensive intentions and concern for public safety in BW research beg a general reassessment in light of the Utah tests.

The remaining gap in BW planning is large scale tracking of disease. Enter Leonid A. Rvachev, chief of the Laboratory of Epidemiological Cybernetics at Moscow's Gamaleya Research Institute of Epidemiology and Microbiology. According to a detailed report in *Environmental Action* magazine, Rvachev has developed a mathematical model which can project the worldwide spread of disease.[17] The model was intended for peaceful purposes, but he fears it could be used militarily. Rvachev sent a description of his model to Western scientists, to encourage international monitoring of such techniques.

Although the model is unproven, the article indicates that it may be a "recipe" for plugging in data on disease agents, populations, transportation routes, and other factors, and coming up with an accurate projection of disease spread. Whether or not Rvachev's particular model is reliable, its implications are clear: The final technical requirement for BW is within reach.

Oversight Problems

Clearly, international law is inadequate to curb biological warfare in general, and the use of gene-splicing to that end in particular. What about U.S. law? Recombinant DNA work in this country is regulated by the National Institutes of Health's Office of Recombinant DNA Activities (ORDA); compliance with its guidelines is mandatory for the projects it funds, but voluntary for the military and private industry.

The degree of protection the guidelines afford depends on the effectiveness of the oversight. The vast majority of recombinant DNA experiments are supervised by local institutional biosafety committees, one for each research facility registered with ORDA. A Recombinant DNA Advisory Committee (RAC) of scientists and laypeople evaluates the most potentially dangerous or novel ideas. But neither ORDA nor RAC is required to review decisions of the local committees.

The DOD says its policy is to comply fully with the NIH guidelines, but that is open to question. According to Army records, the Illinois Institute of Technology conducted gene-splicing research on nerve gas antidotes throughout 1982 without registering a local committee with ORDA until October, 1983.[18] If it were to use recombinant DNA techniques, the proposed Dugway lab could also be in violation of the guidelines.

In July, 1982, a heated debate broke out within RAC. Committee members Goldstein and Novick sought an amendment to the guidelines, prohibiting "the construction of biological weapons by molecular cloning."[19] The proposal was rejected by the rest of the committee on the grounds that the 1972 convention was already sufficiently broad to cover that activity. William Gartland, director of ORDA, stated in 1983 that his agency has never provided RAC with the DOD's annual CBW reports —the public record of military activities in the field. To Goldstein, who left RAC in 1982, this is a serious sin of omission. "How can they (RAC) make an intelligent decision," he asks, "if they don't know what's going on?"[20]

In October 1982, RAC approved Harvard University's proposal to clone the diphtherial toxin gene. Goldstein's concerns seem to gain credence upon reading the minutes of that meeting. The committee dealt exclusively with the question of whether such an experiment could be conducted safely, ignoring diphtheria toxin's potential use in biological warfare and the implications of the experiment on the BW convention.

In February 1984, RAC approved a DOD proposal to clone the gene for Shiga toxin, which causes a form of dysentery. The purpose of the experiment, said the military, was to create a vaccine. In its approval, the committee overrode protests from Paul Warnke, former Arms Control and Disarmament Agency head, among others, who pointed out that the experiment could result in a biological weapon and disrupt the BW convention. Although ORDA ultimately rejected RAC's approval due to several dissenting votes on the committee, it is further evidence of RAC's inability to provide effective military oversight.

MIT biologist Jonathan King told the *San Jose Mercury News*, "I don't think you can ask a committee that's constituted on narrow technical grounds around safety to deal with questions of policy . . . [RAC] is trying to help the technology along. They don't want questions raised in public. They don't want people to say, 'Gee, this technology could be used for war.'"[21]

What is U.S. Policy?

Given substantial deterioration of the historic deterrents to germ warfare and the DOD's prodigious research efforts detailed above, offensive intentions are clearly possible. But without meaningful oversight on BW issues, there is no tangible evidence one way or the other, and the public is left to speculate about the meaning of military actions and policy initiatives.

A key to evaluating the honesty of U.S. claims that all BW research is defensive may lie in overall Reagan administration treaty policy and attitudes toward the Soviets on weapons issues. Following a well-established pattern set in other military areas, Soviet intentions and strength have been greatly exaggerated in a relentless drumbeat, while the potency of U.S. systems are minimized. As McGeorge Bundy, national security advisor to presidents Kennedy and Johnson, described the policy, "we must have a counter for every capability of every 8-foot Russian that fear can find."[22] Given current international tensions, it is virtually certain that BW research will continue to grow rapidly.

With repetition, the "certainty" of U.S. inferiority takes hold in the minds of the public and of Congress despite a paucity of meaningful evidence. The method has worked well with nuclear weapons. Using it, the administration has in each of the past three years, nearly succeeded in getting Congress to renew manufacture of nerve gas for the first time since 1969. This is in the face of a report by the federal General Accounting Office that little is known about the nature of the Soviet arsenal or the condition of its U.S. equivalent.

Last year, amid much fanfare, the United States delivered a draft treaty to the Soviets which sought to ban chemical weapons. "Even the allies of the United States feel that it is written such that no treaty would be signed," according to Jorma Miettenen, an internationally-known arms control expert and advisor to the government of Finland.[23] Miettenen explained that the proposal was disingenuous in its requirements for almost unlimited on-site verification, something neither superpower would be willing to do. On-site verification has always been a source of contention in arms negotiations with the Soviets.

Now the administration's sights are set on BW. "Yellow rain," allegedly a toxin weapon used by the Soviets in Afghanistan or by their allies in Indochina, is a case in point. Despite strong contrary evidence backed by leading experts, the State Department says with absolute certainty that the Soviets produce and use these yellow rain mycotoxins.

When yellow rain receded from the headlines, the administration found a new enemy: Soviet genetic engineering. On at least a dozen separate occasions during 1984, a year when U.S. military biotechnology research mushroomed, the DOD and CIA issued or leaked statements flatly accusing the Soviets of using gene-splicing to create new BW agents.

When pressed, DOD spokespersons admit their evidence falls far short of proof. And the most convincing data—used to justify new weapons or new research—is always classified, making corroboration or independent analysis impossible. Yet, the strategy was successful enough in the yellow rain case to elicit a unanimous voice vote in the Senate condemning the Soviets for using toxin weapons.

More important than the veracity of U.S. claims is their relationship to repeated allegations—in defense of the new Dugway proposal and on many previous occasions—of Soviet BW convention violations. Administration charges were publicly disputed by Paul Warnke, Gerard Smith and Herbert Scoville, Jr., former top arms control aids to four presidents.[24] Even if true, they argued, allegations should be made privately bo the Soviets before they become a public issue. Talk of any arms treaty violations without demonstrable proof leaves the administration's true intentions—to bolster or deter arms control—in doubt.

Speaking on yellow rain on public television's *Nova*, Meselson said U.S. accusations could make verifiable agreements impossible, "either because of a poisoning of the negotiating atmosphere," or because enough U.S. senators will be persuaded to scuttle ratification. "Treaties should be based ... on verifiable provisions," he said, "but these allegations have muddied the waters and hang as a miasma over the negotiation process."

The same miasma hangs thickly over the DOD's biotechnology research. But, in spite of the secrecy which surrounds projects, enough is known to provide cause for concern, and to necessitate open public debate. ✱

REFERENCES

1. U.S. Army. Information Paper, Subject: Modernization of Dugway Proving Ground, DAMA-PPM-T, November 8, 1984, p. 1.

2. R. Jeffrey Smith, "The Dark Side of Biotechnology." *Science*, Vol. 224, June 15, 1984, p. 1215-1216.

3. Military construction, Army. Reprogramming Request, Project 0817200 p. 1. (Undated. Request delivered in August, 1984.)

4. Richard Novick, declaration in Civil Action No. 84-3542, U.S. District Court For The District of Columbia, Foundation on Economic Trends, et al., v. Caspar W. Weinber, et al.

5. Stockholm International Peace Research Institute, *The Problem of Chemical and Biological Warfare, Vol. V: The Prevention of Chemical and Biological Warfare.* New York: Humanities Press, 1973, p. 155.

6. Interview by telephone, March 31, 1983.

7. Department of the Army. *Obligation Report on Biological Research Program*, for the Annual Period 1 October 1979 to 30 September 1980. RCS DD-DR&E (SA) 1065, p. 9. See also, same report, for the Period 1 October 1983 through 30 September 1984, RCS: DD-USDRE (A) 1065, p. 47.

8. Robert Harris and Jeremy Paxman, *A Higher Form of Killing.* New York: Hill and Wang, 1982, p. 255.

9. Thomas J. Hartford, "Medical Defense Against Biological Weapons," *Military Medicine*, February, 1963, p. 146.

10. Defense Intelligence Agency, *Defense Technical Intelligence Report: Soviet Genetic Engineering — Research and Development*, 31 March 1980, p. 12.

11. Stockholm International Peace Research Institute, op. cit. *Vol. II: CB Weapons Today*, p. 327-328.

12. W.S. Partridge, Internal memorandum, Office of Research Administration, University of Utah, December 4, 1967, p. 2.

13. University of Utah-U.S. Army. Contract for Experimental Research in Arbovirus Epidemiology, #242-510386, DAAD09-67-C-0006(R). Principal investigator, Douglas Hill, 1968.

14. Robert Harris and Jeremy Paxman, *Higher Form of Killing*, p. 171. A review of the five major works written on biological warfare in the past 15 years, as well as an extensive search of both academic and popular periodicals indicates no tests similar to the Utah experiments.

15. Interview by telephone, January 19, 1985.

16. W.S. Partridge, Internal memorandum, p. 2

17. Richard Asinof, "Averting Genetic Warfare," *Environmental Action*, June 1984, p. 16-22.

18. Interview with ORDA spokesperson Stanley Barban by telephone, October 24, 1983.

19. National Institutes of Health, Recombinant DNA Advisory Committee, Minutes of Meeting, June 28, 1982.

20. Interview by telephone, March 31, 1983.

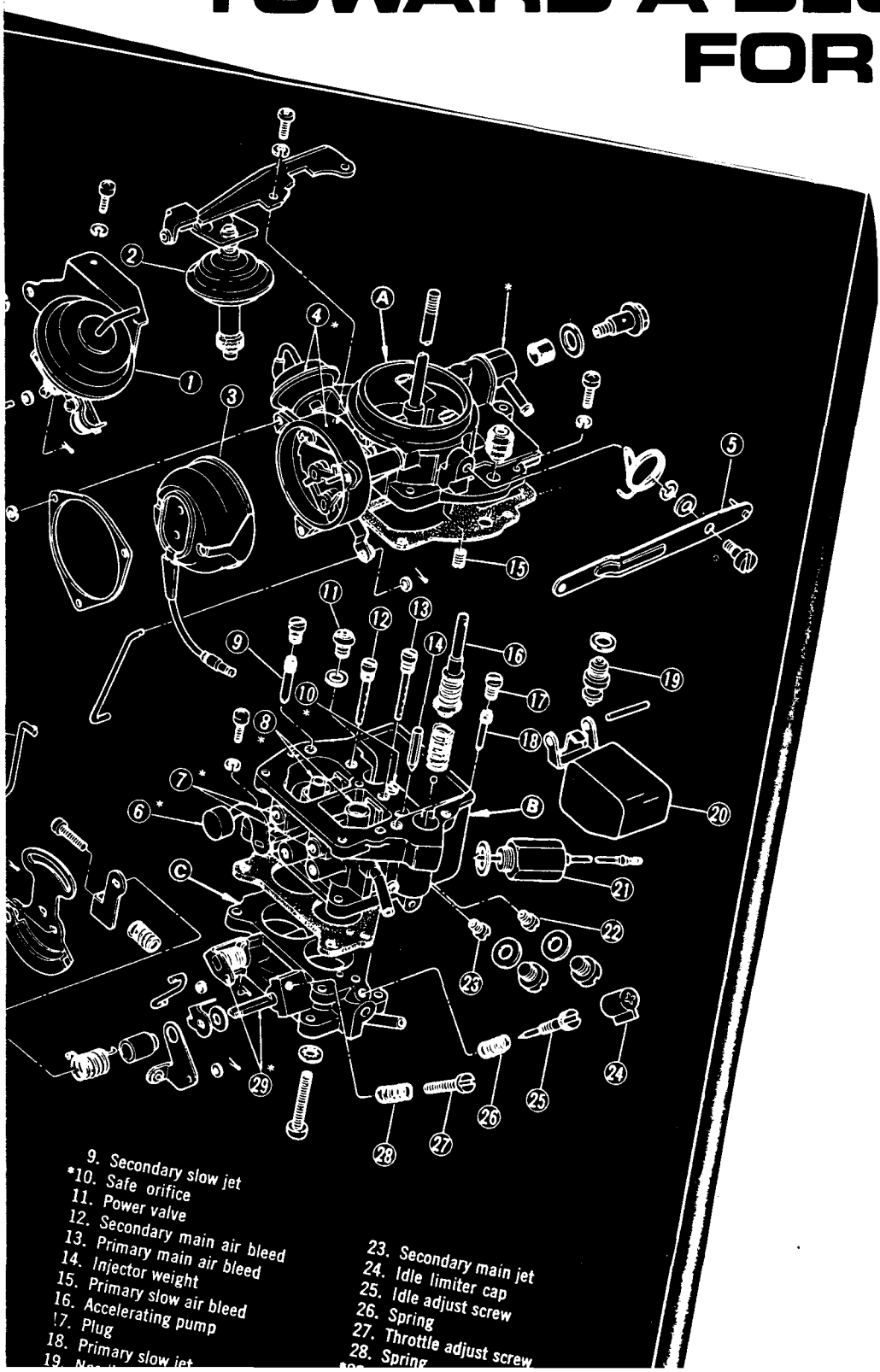
21. John Hubner, "The Hidden Arms Race," *San Jose Mercury News, West* magazine, April 15, 1984, p. 35.

22. McGeorge Bundy, "Deception, Self-Deception and Nuclear Arms," *New York Times Book Review*, March 11, 1984, p. 15.

23. Public lecture at University of California at San Francisco, Institute for Health Policy Studies, February 21, 1985.

24. *Los Angeles Times*, January 19, 1984. Comments came at a news conference in response to a speech by President Reagan in which the Soviets were accused of violating a number of arms control treaties, including the 1972 biological weapons convention.

EMERGING TECHNOLOGIES: TOWARD A BLUEPRINT FOR ACTION



by Seth Shulman

Caught up as we all are in technology's "march of progress," it is easy to feel that we are merely helpless observers. Because of its seemingly unstoppable nature, some writers have called the progression of technology "autonomous,"[1] as though it proceeded somehow with a life of its own outside of our control, and in many ways this depiction seems accurate. Even looking hard for historical analogies, one can find only a small handful of cases where a capability came along—a new technology emerged—and people had the good sense, after assessing its benefits and risks, to refrain from exploiting it.

Unfortunately, a review of the history of emerging technologies shows plainly that all too often we have failed to effectively guide the development and use of our own technological tools, failed to ask the right questions, or to ask them early enough. This collective inability to control our technologies is exhibited in some of the major environmental and social problems of our time such as rampant toxic waste, or vast arsenals of nuclear weapons. Jacques Ellul has stated: "There can be no human autonomy in the face of technical autonomy."[2] As we stand at the threshold of some of the most powerful technological capabilities to date, history seems certainly to have borne out Ellul's warning.

Seth Shulman is the Editorial Coordinator for SftP, and a freelance writer on science issues.

To insure our collective freedom, even our survival, we need to find ways to assert our human autonomy, our control over our own capabilities.

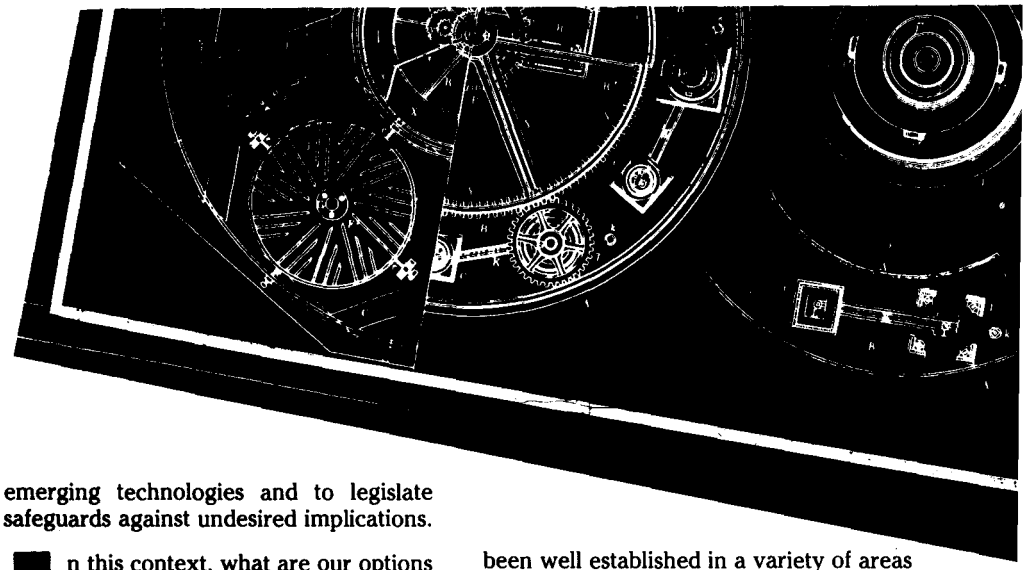
The emergence over the past decade of new gene-splicing techniques—genetic engineering—may well be the latest "autonomous" technological revolution. And yet, since their development, these genetic engineering techniques have already caused considerable debate. Initial questions about potential biohazards among a small coterie of scientists led to a two-year, worldwide moratorium on certain types of genetic experiments. This two-year halt allowed some time for people to assess risks and implications and was a rare and important case of people exerting direct control over the development of a new technology. The arrival of this new technology also has caused serious concern among members of the broader community, and sparked debate on the need for mechanisms to monitor and regulate its appropriate growth and development. The public concerns are as real as the technological implications are vast.

As the field of genetic engineering has quickly spawned a burgeoning biotechnology industry, so have its direct social and political implications been thrust upon a largely unwitting society. Many of these processes are well underway. Established multinational firms representing most major industries are already actively pursuing genetically engineered products including everything from less-watery tomatoes for use in ketchup to vaccines for herpes and other diseases. According to one estimate, genetically spliced drugs alone will reap an annual $15 billion for the pharmaceutical industry by the year 2000.[3] But this is just part of a bigger picture which involves a dramatic array of products and processes on corporate agendas for agribusiness, the food and fragrance industry, chemical manufacturing, the medical establishment, and the military.

Questions of Control

Throughout the development of biotechnology the key questions have been political questions of control: who will make the decisions about how this technology is used, what mechanisms will be established to oversee it, and what provisions within this system will protect the interest of the general public against dangerous or untoward implications.

While the issue of biotechnology is unique in many respects, these questions are not. They apply when virtually any new technology comes along. The answers that we can find to these questions of regulation and control should and inevitably will draw upon previous examples of attempts to channel the direction of emerging technologies and to legislate safeguards against undesired implications.



In this context, what are our options for regulation and control? What are the possibilities for involvement by concerned individuals outside of the scientific community? And what kinds of historical analogies can we draw in this specific case? These are all questions that need attention.

Participatory Technology

In 1971, James Carroll wrote, in his article "Participatory Technology":

> To an indeterminate extent, technological processes in contemporary society have become the equivalent of a form of law—that is, an authoritative or binding expression of social norms and values from which the individual or group may have no immediate recourse. What is at issue in the case of the computer and privacy, the supersonic transport and noise levels, highway development and the city, the antiballistic missile and national security, and the car and pollution is the authoritative allocation of social values and benefits in technological form.[4]

The issue Carroll addressed was certainly not new, but the way he couched it was. Carroll maintained that important choices were being made—essentially passed into law— often with little or no public debate of their implications, because the established systems treated them *de facto* as "technical" rather than social and political issues. One clear problem he identified is that, for a variety of reasons, the public has lacked adequate access to the decisionmaking processes involved in regulating new technologies. What Carroll was reminding us is that this needn't be the case; the public could have a significant say in such matters.

There is little doubt that the seemingly irreversible nature of technology—the "technological imperative," as some have termed it—is closely linked to the vested political and economic interests that help to propel it along. These connections have been well established in a variety of areas by many authors in the pages of *Science for the People* and elsewhere over the years.[5] One need look only at the growth of the transportation or communication networks in the U.S., not to mention the military industrial complex for clear examples. Nonetheless, financial backing and political expediencies aside, there is a force to the advance of a technology that seems in some ways so fundamental as to merit close scrutiny itself. Ultimately, the following examples will attempt to selectively glean what we may have learned about public involvement in the broad area of technological decisionmaking. But first, it is important to look more closely at how technologies actually evolve.

Indelible Markings

The modern typewriter was born in 1873 according to history books, when Christopher Latham Sholes made a contract with the gun manufacturing firm E. Remington and Sons to produce his design.[6] The machine was revolutionary in so many respects that it is easy to understand why relatively little thought was given to the arrangement of letters on the keyboard; at the time the keyboard didn't seem to be of much consequence. Ironically, over a century later, Sholes' keyboard is literally the only aspect of his design to remain unchanged. Perhaps he would have given it more thought had he realized its lasting impact.

Standards are almost always fixed and key relationships established at the emergence of a new technology. And often these early markings prove indelible. As hard as we might try after the fact to reshape or redirect a new technology, we find certain features to be irrevocably "locked in." Over the past one hundred years since the advent of the typewriter, for example, several designers have introduced new keyboard designs in which letters are placed

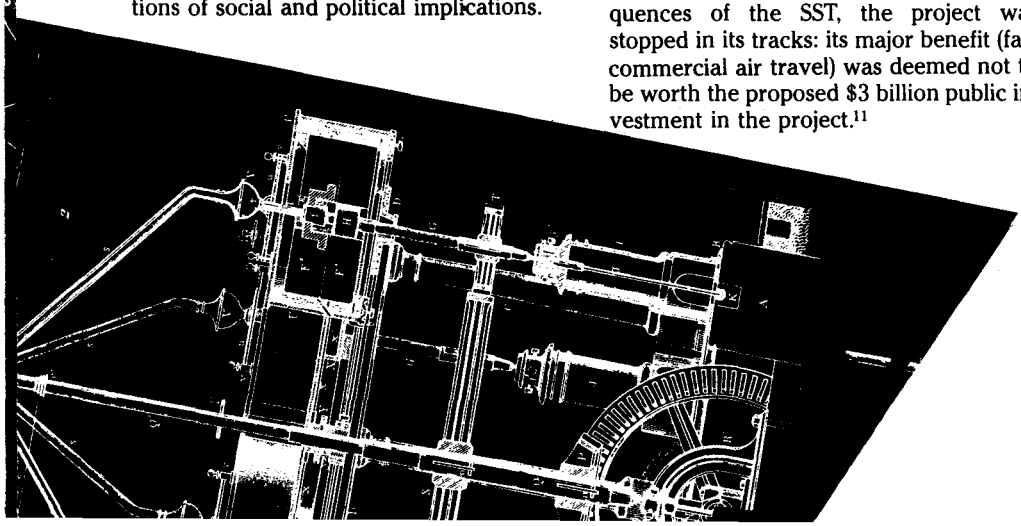
to more closely conform to established facts about the frequency of their use. Try as they might, however, these designers' efforts have little or no chance of achieving widespread acceptance. The standard was fixed at the emergence of the technology. No one wants to learn how to type all over again even if they could ultimately type faster or more accurately. The example may be trivial, but the lesson is not. In fact, if the history of technology has taught us anything at all it is the importance of this feature of technological development.

Encouraging Debate Early

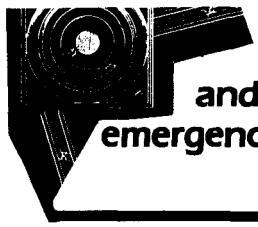
The fixed nature of established technologies speaks to the vital necessity for input when it can make a difference: during the formative stages of a technology's development. While features often do become "locked in," it is important to note that technologies do not actually evolve that way. In the case of the typewriter, for example, for approximately forty years prior to the first Remington, there were dozens of prototypes of typewriter machines, each with wildly varied characteristics and keyboards. The state of affairs is not uncommon, but rather is the norm as a technology emerges. As Edward Yoxen has noted in his book *The Gene Business*, new technologies,

> arise through endless rounds of conjecture, experiment, persuasion, appraisal and promotion. They emerge from chains of activity, in which at many points their form and existence is in jeopardy. There is no unstoppable process that brings inventions to the market.[7]

Again, however, while the lesson is clear, its implications are fraught with difficulty. Often the public is not informed about the advent of a new technology until it is already established. In such cases, public input is forced into a reactive role, and debate is often polarized. Clearly, to have effective input during the formative stages of an emerging technology requires an informed, participatory public. In addition, however, it may also necessitate governmental or independent bodies that can monitor technical fields and raise questions of social and political implications.



Many authors have stressed the importance of viewing technologies themselves as social systems rather than simply artifacts.[8] When seen in this light, it becomes clearer what types of social arrangements a technology implies. This perspective can be important in predicting a technology's development early on, and can also help to frame the social and political questions effectively. While scientists and technical professionals often can best understand the technical aspects of a developing technology, the public invariably serves as the catalyst for open dialogue and debate of the questions raised by a new technology. In addition, even on the most technical of issues, it has been shown repeatedly that input from the public can be informed, and innovative. From a political perspective it is vital to involve as diverse a group as possible in the decisionmaking process, especially those most immediately at risk.[9] Some interesting lessons in this area were learned in the case of the development of the Supersonic Transport commercial aircraft (SST).



Standards are almost always fixed and key relationships established at the emergence of a new technology. Often these early markings prove indelible.

Involving Diverse Constituencies

> For it must be obvious to anyone with any sense of history and any awareness of human nature that there will be SST's. And Super SST's. And Super-Super SST's. Mankind [sic] is simply not going to sit back with the Boeing 747 and say 'This is as far as we go."[10] —Spiro Agnew

The SST is an important example to review because it is one of the only cases in modern history when, despite Spiro Agnew's sentiments, the technological fish was thrown back into the pond. Due in large part to diverse input concerning the perceived adverse environmental consequences of the SST, the project was stopped in its tracks: its major benefit (fast commercial air travel) was deemed not to be worth the proposed $3 billion public investment in the project.[11]

In case you have forgotten this chapter of our recent history, in the late 1960s, with pressure from Britain and France's newly formed cooperative development of the Concorde supersonic jet, a "technological imperative" reared its head. To maintain the U.S.'s virtual monopoly on sales of commercial aircraft, Boeing, with the help of billions of dollars of governmental aid, was to develop the SST. Early on in its development, the Nixon administration funneled funds for its testing through general Department of Transportation appropriations for roads, railways and airports. Because of such tactics, little significant debate occurred initially, at least until public awareness of the issue developed.

Between 1968 and 1970 when the SST was killed by a narrow margin in the Senate, a pivotal role was played by the public whose support was mobilized around the fear of environmental threats posed by the SST. Issues of the sonic boom, the hazards to the ozone layer, pollution in the ionosphere—all extremely technical in nature —were coupled with arguments of the dire economics involved, to mobilize a vocal constituency against the aircraft's development.

The struggle over the SST posed problems that routinely occur in the development of an emerging technology. First, the risks weren't clearly known. Often only a select group of technical professionals understands the technical issues involved, and their "expert" testimony about potential risks may differ widely. This was true in the case of the environmental implications of the SST. Some scientists projected a dramatic greenhouse effect from the destruction of the ozone layer, and others maintained that the effect would be minimal. Some claimed the sonic boom would cause millions of dollars of damage to buildings and take a huge toll in human health costs, while others said that the noise factor was relatively inconsequential.[11]

Secondly, in the course of the history of the SST, as is often the case with an emerging technology, there was considerable confusion over exactly who should handle the issue. In his capacity as vice chairman of Congress' Joint Economic Committee, Senator William Proxmire called special hearings to debate the SST which received much media coverage and turned out to be quite influential. Importantly, however,

these hearings were not an institutionalized function, but were called due to the specific interest of one senator, in turn the outgrowth of public concern. The citizens groups such as Citizen's League against the Sonic Boom, and Coalition against the SST, which formed to try to influence the evolution of the technology, proved an effective and needed voice.

The SST is an important case study both for the public mobilization and for the role of technical information. And yet, as an analogy to biotechnology it falls down in several key respects. The major one of these is that, as has been evidenced by the recent success of so many of the special, single-issue groups that have formed in the political arena, it is much easier to deal with and counter a specific, narrow project such as the SST than to mount a campaign to deal with the implications of something more expansive and amorphous like the emergence of computer technology, or biotechnology. To capture this aspect of the current burgeoning state of biotechnology, perhaps the best analogy can be found in the emergence of the synthetic chemical industry in the 1940s.

A Fantastic Dream

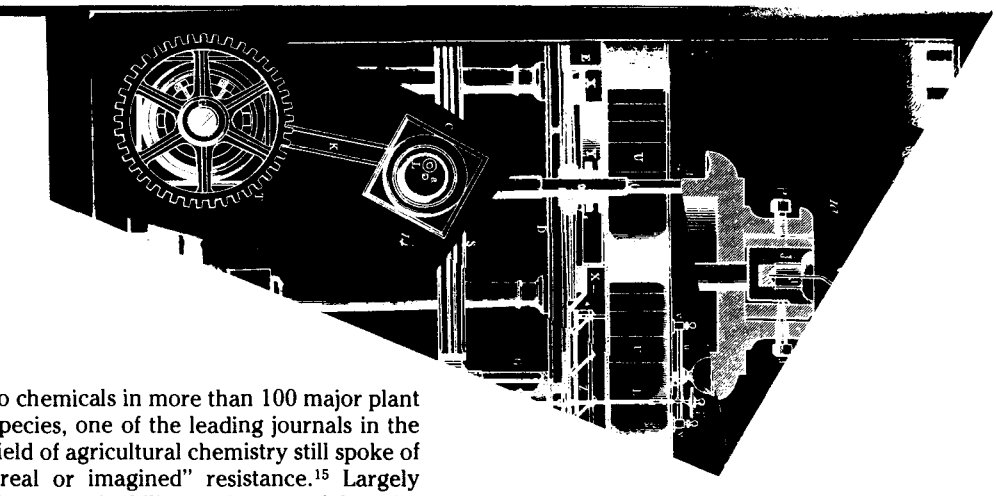
The chemical industry was changed forever when the insecticide DDT was introduced during World War II to protect U.S. soldiers against insect-borne diseases. As DDT production exceeded military requirements, the War Production Board allowed for civilian experiments with the surplus of the chemical and, shortly after, released DDT for general public use in August 1945.[13] As is so often the case in the infancy of a new technology, the expectations were unbounded. Many scientists at the time thought that the new synthetic chemicals could rid the earth of entire insect species. Take, for instance, this statement in 1947 from Clay Lyle, president of the American Association of Economic Entomologists:

> The time has now arrived for the eradication of the house fly and with it the horn fly. . . .This is not a fantastic dream but something almost certain to happen."[14]

During the growth of this technology, those with vested interests were so convinced of the many benefits the new technology could bring that they steadfastly ignored and diminished the possibility of serious risks. For example, this lopsided view of the technology's benefits caused a major blindness on the part of many in industry and academia to the growing realization that insects were becoming resistant to pesticides.

Even as late as 1959, by which time scientists had documented definite resistance to chemicals in more than 100 major plant species, one of the leading journals in the field of agricultural chemistry still spoke of "real or imagined" resistance.[15] Largely due to the inability on the part of those involved to confront these potential risks, we find ourselves today in the almost unfathomable situation of undertaking recombinant DNA research to engineer herbicide resistance into plants so we can use even more herbicide without killing the crops themselves, all despite the well-documented residues on our produce and the tremendous chemicalization of our environment.

It wasn't until an outsider to the industry, Rachel Carson, gathered information from publically available documents in her book *Silent Spring* that environmental concerns about synthetic chemicals were effectively brought to light. As many people well know, Carson's book concluded that these new synthetic chemicals such as DDT represented a severe health and environmental risk. What people may not know, however, is the astounding extent of resistance Carson encountered to her findings.



> sinister influences, whose attacks on the chemical industry have a dual purpose: 1) to create the false impression that all business is grasping and immoral, and 2) to reduce the use of agricultural chemicals in this country and in the countries of western Europe so that our supply of food will be reduced to east-curtain parity.

Rachel Carson's campaign required an extreme perseverance in the face of charges of treason, and highly personal attacks before her case was even tried on its own merits. As clearly as any, this struggle has taught us the lesson that industry cannot be left to regulate itself. And while this situation was highly polarized, it showed the possibility for asserting our human autonomy by raising important issues about the implications of a new technology even in the face of formidable obstacles.

The fixed nature of established technologies speaks to the vital necessity for input when it can make a difference: during the formative stages of a technology's development.

Outraged not only by her findings, but by her very input into the debate, academics postured on their right to set policy in this area. The entire department of Entomology at the University of Wisconsin, for example, signed a document declaring that the subject of pesticide use "should be put back into the hands of the professionals . . . We agricultural scientists have been given the responsibility for making pest control recommendations."[16]

One company, the Velsicol Chemical Corporation, afraid of the adverse effect it might have on sales of two of their products, went so far as to try to halt publication of *Silent Spring*. In their correspondence with Houghton Mifflin, Inc., Velsicol officials stated that Carson's book was an element of a plot on the part of

Public Input

We can't claim to have taken control of synthetic chemical technology. We are still denying serious potential risks, and have become frighteningly dependent upon increasing levels of chemicals in our entire agricultural process and in almost every major industrial process we use. We are also stuck with the consequences. For example, conservative estimates place U.S. industries' yearly production of hazardous waste at a total of almost 60 million tons—*500-600 pounds per person.*[16] Hopefully, though, we can at least claim, in light of these brief case studies, to have learned a few things from the past which we can apply to biotechnology and all future emerging technologies. Perhaps we may

be in a better position to demand some of the following next time around. In fact, we might even apply them to some well-established and out-of-control technologies.

Encourage Debate Early: To be effective we must try to encourage debate during the formative stages of an emerging technology. Unfortunately, although there has been a good deal of debate, some of it public, on the issue of recombinant DNA technology to date, the formative stages of this technology may have already passed to a good degree. Many of the issues raised are clearly not settled, however, and people should do everything they can to inform themselves about the implications for human gene manipulation, for biological warfare, for agriculture and livestock, for pharmaceuticals, etc.

Involve Diverse Groups: A central tenet of democracy is that parties involved should have a say in decisionmaking. In the case of emerging technologies, it is vital to involve as diverse a group as possible in the decisionmaking process, especially those most immediately effected and those at risk. The Cambridge Experimental Review Board in the early debate on the safety of recombinant DNA techniques established to many the public's ability to have important, informed say on these issues. This group, made up entirely of laypeople, was effective in setting landmark policy in this area.[17]

Avoid Self Regulation: The economic demise of nuclear power exhibited in the WPPSS (Washington Public Power Supply System) loan default in Washington, or the chemical industry's fiascos such as Hooker Chemical's Love Canal or Union Carbide's Bhopal, India have for many effectively illustrated the lesson of industry's dismal failure at self regulation. Nonetheless, setting up regulatory bodies that can effectively serve as watchdogs is not always easy. Academic scientists are very often tied to industry concerns. (See Sheldon Krimsky's article in this issue for more details in the area of biotechnology.) Clearly public input is crucial in this area as well, and much more needs to be learned about the establishment of appropriate mechanisms for setting national priorities. In biotechnology the time is now to establish such watchdog, regulatory bodies, and debate on this topic is well underway.

Monitor Potential Hazards: Another clear lesson from past emerging technologies is the importance of requiring the ongoing monitoring of potential health and environmental hazards. Early on in the debate on recombinant DNA, members of Science for the People called for the establishment of an independent tumor registry for workers in rDNA labs, including janitorial, and other effected groups. Such a registry has not been established, but historical precedent points evermore clearly to its need. The recent disclosure of Department of Energy findings of significantly higher cancer rates for workers in U.S. nuclear facilities is only the latest example of the importance of staying on top of such demographic data. In the case of biotechnology, such a registry would require minimal costs, and could help to flag potential hazards early. Requiring industry to foot the bill for such a plan seems to be an effective and reasonable way to cover the costs.

Our collective blueprint for action is to call for assessments of the implications of new, emerging technologies before they become fixed, irrevocable parts of our lives.

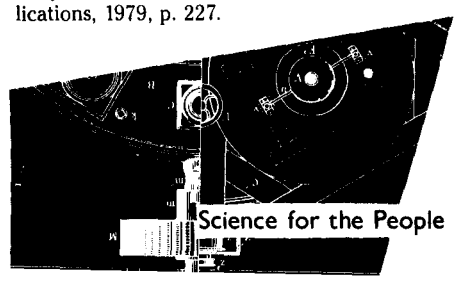
Initial Guidelines Aren't Final: Too often, we consider serious questions about a new technology settled after only the initial round of dialogue and testing. The need to establish regular, and ongoing public forums for the reexamination of initial guidelines is clear. This type of reexamination can take place at public hearings, at sessions of scientific meetings, or in independent, activist gatherings. In the current state of genetic engineering, we are witnessing a tremendous pace of technological change.

Because of this, regulations need to be continually reassessed. (As Gerry Wanecks article in this issue discusses, this is particularly true of health hazards in this area.)

Require Social and Environmental Impact Statements: When planners undertake a new project, blueprints of every system involved, and environmental impact statements are required before ground is broken. Increasingly many involved in the growth and development of new technologies are seeing the need to institute similar requirements. Indeed, the current court battle requiring an environmental impact statement from the National Institutes of Health (NIH) before field testing of recombinant DNA research is undertaken is a case in point. It is clear that we are moving in this direction, but there is much further to go. A major part of our collective blueprint for action is to call for such assessments of the implications of new, emerging technologies before they become fixed, irrevocable parts of our lives. ★

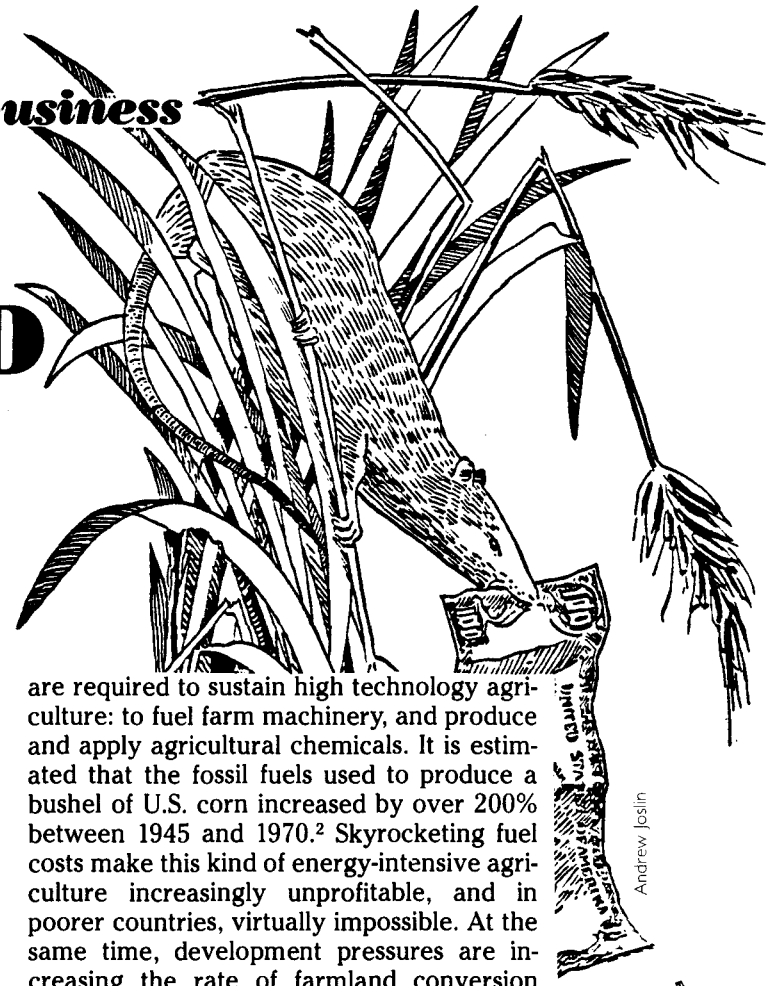
REFERENCES

1. Langdon Winner, *Autonomous Technology*, MIT Press, 1977.
2. Jacques Ellul, *The Technological Society*, Alfred A. Knopf, 1964, p. 38.
3. *Office of Technology Assessment, Commercial Biotechnology: An International Analysis*, 1984.
4. James Carroll, "Participatory Technology," *Science*, 171, Feb. 19, 1971, pp. 648-9.
5. See for example, David Noble "Academia Incorporated," *Science for the People*, Vol. 15, No. 1; Jack Manno, "The Military History of the U.S. Space Shuttle, *SftP* Vol. 15, No. 5; and Philip L. Bereano, ed., *Technology as a Social and Political Phenomenon*, John Wiley and Sons, 1976.
6. *Encyclopedia Brittanica*, 1970 ed. Vol. 22, p. 444.
7. Edward Yoxen, *The Gene Business*, Harper and Row, 1983, p. 27.
8. See, for example, David Dickson, *The Politics of Alternative Technology*, New York, Universe Books, 1974; David Noble, *Forces of Production*, Alfred A. Knopf, 1984; Philip Bereano, "Technology and Human Freedom," *Science for the People*, Vol. 16, No. 6.
9. Sheldon Krimsky, "Beyond Technocracy: New Routes for Citizen Involvement in Social Risk Assessment," in James C. Peterson, ed., *Citizen Participation in Science Policy*, The Univ. of Massachusetts Press, 1984, p. 55.
10. Spiro Agnew, quoted in Langdon Winner, *Autonomous Technology*, p. 315.
11. John Costello and Terry Hughes, *The Concorde Conspiracy*, Charles Scribner's Sons, 1976, chap. 16.
12. William A. Shurcliff, *S.S.T. and Sonic Boom Handbook*, Ballantine Books, 1970.
13. Thomas R. Dunlap, *DDT: Scientists, Citizens and Public Policy*, Princeton University Press, 1981, p. 63.
14. *Ibid.* p. 37.
15. Rachel Carson, *Silent Spring*, Fawcett Crest, 1962.
16. Thomas R. Dunlap, *DDT: Scientists, Citizens and Public Policy*, p. 111.
17. Lewis Regenstein, *America the Poisoned*, Acropolis Books, Ltd., 1982, p. 17.
18. *Ibid.* p. 365.
19. Cambridge Experimentation Review Board, "Guidelines for the Use of Recombinant DNA Molecule Technology in the City of Cambridge," December 21, 1976. For more on the Cambridge Experimentation Review Board, see Sheldon Krimsky, "Regulating Recombinant DNA research," in Dorothy Nelkin, *Controversy: Politics of Technical Decisions*, Sage Publications, 1979, p. 227.



Biotechnology Meets Agribusiness

ICE MINUS AND BEYOND



Andrew Joslin

by Constance Matthiessen and Howard Kohn

The creation of the "sunbean" in 1981 signaled a bright future for plant biotechnology. The sunbean was born when USDA scientists moved a gene from a french bean seed into a sunflower: it was the first time a transfer between two species had ever taken place. Agriculture Secretary John Block heralded the event as a "breakthrough achievement" that would open "a whole new era in plant genetics." Said Block, "It is the first step toward the day when scientists will be able to increase the nutritive value of plants, to make plants resistant to disease and environmental stresses, and to make them capable of fixing nitrogen from the air."[1]

Those were heady days for biotechnology, and if some initial promises were grandiose—there was wild talk of everything from trees bearing pork chops to plants that would substitute for oil—four years later hopes are still high. Though no headline miracles have yet been achieved, it is still contended that biotechnology will lift U.S. agriculture to new heights of abundance and usher in a second Green Revolution.

Promises for biotechnology come at a time when the dramatic crop yields of the first Green Revolution are beginning to slow. At the height of the first Green Revolution—which was underwritten by chemical pesticides and fertilizers, hybrid seeds, and large farm machinery—annual yields of most crops increased by an average of two bushels an acre. Today that increase has dropped to a half bushel, and has even leveled off in some areas. Experts cite a number of causes for this lag. One is cost. Huge infusions of energy are required to sustain high technology agriculture: to fuel farm machinery, and produce and apply agricultural chemicals. It is estimated that the fossil fuels used to produce a bushel of U.S. corn increased by over 200% between 1945 and 1970.[2] Skyrocketing fuel costs make this kind of energy-intensive agriculture increasingly unprofitable, and in poorer countries, virtually impossible. At the same time, development pressures are increasing the rate of farmland conversion throughout the world, thus limiting the amount of land available for agricultural use. And environmental degradation in the form of soil and water contamination, drought, and soil erosion, all exacerbated by large-tract, large-machine farming methods, inhibit agricultural productivity. For all these reasons, the first Green Revolution seems to have reached the point of diminishing returns.

Despite current overproduction problems in this country, it is nevertheless true that the world is hungry and will grow hungrier in the future. The United Nations Food and Agriculture Organization estimates that food production must be nearly doubled by the year 2000 to feed the ever-expanding world population.[3] Casting about for the next agricultural shot in the arm, many have hooked onto biotechnology.

But there is increasing evidence that the second Green Revolution, like its predecessor, may be little more than a technological fix that will ease production and enhance yields in the short-term, but over the long run could create health and environmental hazards and undermine agricultural prosperity. Because of this potential for widespread health and environmental disruption, it is important that the direction and control of the new technology be carefully examined from the outset.

Connie Matthiessen and Howard Kohn are Washington correspondents for the Center for Investigative Reporting.

To date, a large majority of funding for agricultural biotechnology has come from agribusiness industries. Although an advisory committee to the U.S. Department of Agriculture (USDA) concluded in 1983 that bioengineering deserves to be made a high priority in agricultural research, biotech is still only a small fraction of the already small USDA research budget. Agribusiness firms, on the other hand, gave universities an estimated $40 million for bioengineering research in the 1983-84 school year; this amount is expected to increase dramatically in the future. And companies like ARCO, Allied Corporation, Dow, Ciba-Geigy, and Continental Grain, Eli Lilly, Stauffer Chemical, are all funneling dollars into in-house biotech research. Du Pont, for example, tripled its investment in bioengineering between 1980 and 1983. Even more striking than the dollar amounts, however, is the fact that industry priorities have so thoroughly shaped the direction of the research in this area.

Many of these companies have also acquired seed companies, which will even further increase their influence on the direction of agricultural biotech developments. According to a report by an international agricultural consulting firm, L. William Teweles & Co., "The significant sales and profit potential to be derived from seed crops improved through new plant genetics has led to the acquisition of more than 80 seed and plant science companies during the past 10 years. Through acquisition, multinational companies, such as Monsanto, Ciba-Geigy, and ARCO, now participate in what, until a few years ago, was an industry largely made up of family-owned businesses."[4]

From the beginning, trends in plant biotechnology have been oriented more with an eye to the market than the public welfare. Given the tremendous profits at stake, it looks like this trend will continue. The Policy Research Corporation of Chicago has predicted that sales from bioengineered farm products will reach $50 to 100 billion by the end of the century.[5]

Herbicide Resistance

> "Environmentally, it is desirable to develop pest-resistant plants, because such plants would reduce the need for spraying crops with pesticide chemicals, and disease control would be more effective. It should be kept in mind, however, that much of the agricultural research effort is being made by the agricultural chemical industry, and this industry may see the early opportunity of developing pesticide-resistant plants rather than undertaking the longer term effort of developing pest-resistant plants."[6]
>
> —From: 1984 Office of Technology Assessment Report on Biotechnology

Indeed, a number of major companies are funding research to develop plants with resistance to their brand of herbicide. Herbicide resistance will increase the market for chemicals currently limited in use because they are as deadly to crop plants as they are to weeds.

The tradeoff for herbicide resistant crops could end up being a worsening condition in human and environmental health, as chemicals are woven even more tightly into our agricultural system. Casting about for the next agricultural shot in the arm, many have hooked onto biotechnology.

Ciba-Geigy, for example, is funding research to develop soybeans with resistance to the herbicide atrazine. Atrazine, sold by Ciba-Geigy under the trade name AAtrex, is widely used on corn. Corn contains enzymes that detoxify the chemical, but soybeans do not. If farmers rotate soybeans on land previously sprayed with atrazine, the bean crop will be damaged.

By examining weeds that have developed resistance to atrazine, scientists at Michigan State, their work funded by Ciba-Geigy, discovered that the immunity develops as a result of a mutation in the weed's DNA. Researchers, who have managed to isolate and clone the atrazine resistant gene, are attempting to transfer the gene to soybeans and other crop plants.

Annual sales of AAtrex amount to about $250 million, but the price has fallen since the herbicide came off patent. Teweles consultant George Kidd believes that with the development of soybeans resistant to atrazine, two to three times more atrazine would be used each year, boosting Ciba-Geigy's sales by $120 million.[7]

Researchers at Du Pont have already developed tobacco strains with resistance to two Du Pont herbicides, "Glean" (chlorosulfuron) and "Oust" (sulfometuron/methyl). Through chemical and random mutation, Du Pont scientists developed bacteria strains that are resistant to chlorosulfuron. The resistant gene was then transferred to a tobacco plant. Glean is a highly effective, low-dosage herbicide but its use has been restricted to cereals since it is deadly to most other crop plants. Oust has mainly been used for industrial purposes. If resistance can be conferred to other crop plants, the market value of the two herbicides will dramatically increase.

At Calgene, a biotechnology firm in Davis, California, researchers are experimenting with the herbicide glyphosate. Glyphosate, the main ingredient in the widely used herbicide, "Round-up," marketed by Monsanto, is lethal to most herbacious plants, and so cannot be applied directly to crops. Using a breeding method later used in the Du Pont experiments, Calgene scientists developed a bacteria gene that was resistant to glyphosate, and transferred the gene to tobacco. Calgene officials hope to field test tobacco and tomato plants with glyphosate resistance by 1985 or 1986.

Calgene is also working with Nestle to develop a glyphosate resistant strain of soybeans. And Calgene officials predict that if the same can be done with corn, the chemical could corner a share of the market now dominated by atrazine.

Agricultural chemicals are a big business. According to the International Trade Commission, the value of pesticide sales increased 144% from 1973 through 1982 to reach $4.43 billion.[8] Clearly the development of plants with herbicide resistance will markedly increase herbicide sales, which will be a boon for major chemical companies, many of which depend on agricultural chemicals for a major share of their profits.

Agricultural chemical sales, after a lag in 1983, shot up again in 1984, and herbicide resistant crops are expected to ensure future markets. For corporations that own seed subsidiaries the payback will be even greater. According to the Teweles report, "Herbicide resistance developed from the new plant genetics is expected to add $3.1 billion to crop value shortly after the year 2000 . . . We expect the annual value of seed incorporating herbicide resistance will be about $2.1 billion by the year 2000, and it will increase to $3.5 billion just after 2000."[9]

But the tradeoff for herbicide resistant crops could end up being a worsening condition in human and environmental health as chemicals are woven even more tightly into our agricultural system. Farm chemicals are suspected of causing birth defects, genetic damage and cancer, but as of 1984 the Environmental Protection Agency (EPA) had completed reregistration of less than 1% of all pesticides requiring review to ensure compliance with current safety standards. Overwork and understaffing has bogged down the review process, and in the meantime the agency must rely on corporations to conduct their own tests for product safety.

A report by the Office of Technology Assessment found that 5% of all pesticides end up in the nation's surface water. All over the country, wells have been shut down because of farm chemical contamination. There is also growing evidence that the groundwater in many areas is contaminated with pesticides.

Experts are suspicious that the high rate of cancer among farmers in the midwest can be attributed to farm chemicals. Iowa professor Leon Burmeister has observed, "The association of corn production with leukemia mortality in both Iowa and Nebraska indicates that modern farming practices may be a cause of the higher leukemia mortality rates in farmers."[10] Pesticides are the most frequently cited factor, but to date evidence has been inconclusive.

The longterm effects of chemicals on the soil is still under study, but there is circumstantial evidence that herbicides disrupt microscopic organisms that allow air and water to move freely through soil. And there are signs that over the long term, chemical pesticides simply aggravate the problems they are intended to control. Farmers in Minnesota report that wild oats has become a profligate weed despite widespread use of herbicides. A recent study by the World Resources Institute indicates that many strains of insect and plant pests have spontaneously developed resistance to agricultural chemicals. According to the study, more than 150 kinds of fungus and bacteria are resistant to pesticides, up from 20 in 1960. Over the 25 years that atrazine has been used, about 30 types of weeds have developed resistance to the herbicide. Research conducted by Dr. David Pimentel of Cornell's College of Agriculture indicates that herbicides actually make plants more susceptible to attack by insects and plant diseases.[11] Farmers often then apply even more toxic chemicals in what becomes an apparently endless cycle.

Tufts scientist Dr. Ross Feldberg also points out that herbicide resistance may be transferred to surrounding weeds. "Just as indiscriminate use of insecticides leads to resistant strains of insects, it may be the case that the use of genetically engineered crop strains together with increased applications of herbicides will set up the very conditions that will lead to gene transfer between plant species and perhaps the accelerated appearance of herbicide-resistant weeds. In the long run, such a result could make us worse off than we are now," Feldberg observes.

Those were heady days for biotechnology. . . . There was wild talk of everything from trees bearing porkchops to plants that would substitute for oil.

Andrew Joslin

ICE-MINUS

> "It is thus my view that alien organisms that are inadvertently or deliberately introduced into natural environments may survive, they may grow, they may find a susceptible host or other environment, and they may do harm. I believe that the probability of all these events occurring is small, but I feel that it is likely that the consequences of this low-probability event may be enormous."[12]
>
> —From testimony by Dr. Martin Alexander, EPA consultant and Professor of Agronomy at Cornell

A primary goal of plant biotechnologists is to use genetic engineering techniques to make plants more adaptable to the environment and thus improve agricultural efficiency and productivity. But initial research has raised questions about the possible effects of genetically altered organisms on the surrounding environment.

The most celebrated case concerns bacteria that would inhibit frost damage to crops, and thus allow crops to survive in lower temperatures. University of California scientist Steven Lindow discovered that a specific protein produced by a bacterium named *Pseudomonas syringae* triggers the formation of ice crystals on plants at temperatures between 0 and –7 C. If the bacteria are not present on a plant, ice crystals do not form until temperatures drop below –7 C. Using recombinant DNA techniques, Lindow eliminated the *P. syringae* gene that codes for the ice nucleating protein.[13] By spraying the plant with the "ice-minus" bacteria before it is colonized by the "ice-positive" strain, the plant will be protected from frost damage at far lower temperatures.

A research team at the University of California, led by Lindow and Nickolas Panpoulos and funded by Advanced Genetic Sciences, planned to introduce the bacteria into the open environment on a

potato crop. The team was granted permission for the field test by the Recombinant DNA Advisory Committee (RAC), a team of scientists established by the National Institutes of Health (NIH) to oversee basic genetic engineering research and enforce specific research guidelines. But the test was abruptly halted when a coalition of environmentalists and scientists took the NIH to court to prevent the release of the bacteria.

The main plaintiff in the case, author Jeremy Rifkin, director of the Foundation on Economic Trends, argued that the impact of the open air test had not been given a comprehensive evaluation. "The NIH has not developed the procedures and protocols to judge risk," Rifkin told *Genetic Engineering News*. "They don't have the appropriate scientific expertise to judge risk, and they have not complied with the National Environmental Policy Act, which requires an environmental impact statement for the whole [NIH deliberate release] program, as well as the individual experiments."[14] (In December, 1984, the National Institutes of Health agreed to conduct an environmental assessment of the ice-minus experiment, but is appealing the challenge to its overall deliberate release impact program.)

The ice-minus incident sparked controversy because it was the first attempt to introduce a genetically altered organism into the environment. The controversy revealed very real gaps in scientific capacity to determine environmental effects of such a release. At a 1983 Congressional hearing, the Environmental Protection Agency's Don Clay, of the Office of Pesticides and Toxic Substances, conceded that, "There are almost no accepted methodologies for evaluating the safety of genetically engineered products. The risk assessment tools and data we have used for inanimate chemical substances will not apply in the case of organisms."

Dr. David Pimentel argues that comparisons between chemical and bioengineered releases are in any case inadequate. "Biotechnology has the potential for much greater hazard than do chemicals. Chemicals introduced into the environment will eventually go away, but a genetically engineered product could multiply and pose a much greater risk,"[15] he says.

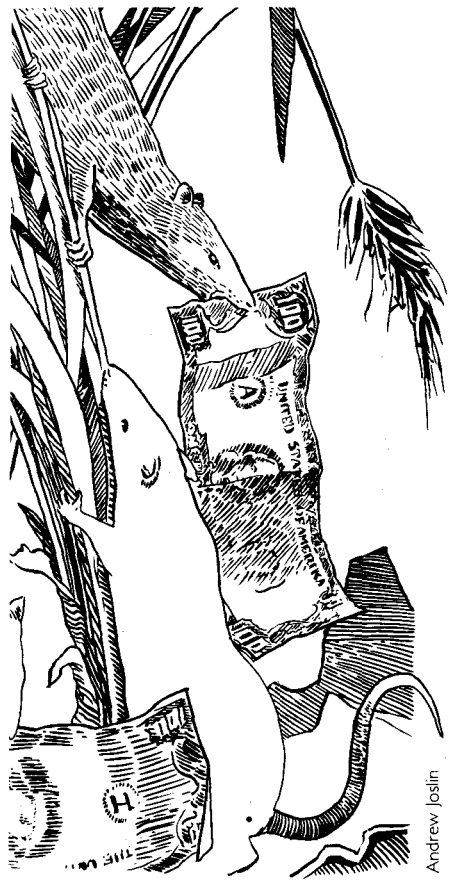
The ice-minus incident also exposed the confused state of the regulatory framework regarding biotechnology. To date, oversight of biotechnology research has been the responsibility of the NIH's Recombinant DNA Advisory Committee. But RAC guidelines only apply to research supported with federal funds, or institutions that receive federal funding. Private institutions submit their experiments to the RAC on a voluntary basis. Technically, then, the firm that supported the University of California research, Advanced Genetic Sciences, is not subject to the same restrictions, and has the legal right to field test the bacteria. (A court challenge by Rifkin has temporarily delayed the company's field test.)

Rifkin and others also have pointed out that because the RAC is dominated by molecular biologists, it cannot help but reflect a professional bias. Says Cornell scientist Martin Alexander, "You don't ask the chemical industry to decide whether the chemical industry creates any problems, but that is what they do at NIH."[16]

After extensive hearings last year, a Congressional committee staff report concluded, "It is clear that the current regulatory framework does not guarantee that adequate consideration will be given to the potential environmental effects of a deliberate release. No single agency or entity presently has both the expertise and authority to properly evaluate the environmental implications of releases from all sources."

This year could well see an improvement in the process of evaluating the impact of genetically altered organisms on the environment. An interagency task force on biotechnology, under the oversight of the White House, concluded that existing laws and agencies can adequately regulate new products, but called for institution of an "expanded scientific review mechanism" to coordinate governmental risk assessment methods, to provide scientific oversight, and promote sharing of information. The task force has also attempted to untangle the regulatory confusion that currently exists regarding oversight of biotechnology, and has produced a notice for public comment in the Federal Register to elicit outside suggestions and input. Several Congressional committees have also scheduled hearings to consider Congress's role in the oversight of biotechnology.

A number of major chemical companies are funding research to develop plants with resistance to their brand of herbicide.



Andrew Joslin

Biotechnology and Public Control

> "In this case the power in question is the power to exploit the genetic resources of plants in order to gain control over future markets. The developing ability to design, create, and patent specific kinds of plants will confer upon the suppliers of plant varieties a greater degree of control over what is grown, over what substances are bought to protect or increase yields, over the price at which seeds are sold and over the purpose for which crops are grown. Through the design of new plants a new structure of dependence on agribusiness is being planned, in return for which some of us will get food."[17]
>
> —From *The Gene Business*, by Edward Yoxen

Even with enhanced government oversight, questions about the less tangible impacts of biotechnology will no doubt persist. The release of new and unique organisms also will have impact on the economic, social and psychological makeup of society.

A movie entitled, "The Gods Must Be Crazy," depicts the impact of a Coca-Cola bottle on an indigenous African tribe. When the people find the bottle, tossed from an airplane passing overhead, they cherish it as a gift from the gods. It is like nothing they have seen before. But over time the bottle creates destructive changes in the relationships between the tribal people.

A new technology as far-reaching as biotechnology could create subtle but dramatic changes in much the same way. Of course, some of these changes may be positive: a bioengineered cure for disease, or development of plants with higher nutritive value, would be an obvious contribution. Since it is not even clear that the most obvious abuses and hazards will be subject to governmental control, what about the more subtle longterm impacts of biotechnology?

The ice-minus bacteria, for example, represents a goal pursued by the first Green Revolution: to manipulate nature in order to produce bigger, faster, better crop yields. If plants can survive lower temperatures, the production season is extended and yields are boosted. But some experts are beginning to suspect that hot-wiring the farm system in this way could have longterm negative impacts. Over-production is already wearing out soils, straining water supplies, and increasing the chemical load on the environment. And soil erosion, exacerbated by soil abuse and over-cropping, is already inhibiting agricultural productivity. A genetically engineered speed-up of the agricultural system may lead to shortterm gain and longterm exhaustion or depletion of our natural resources.

There is also danger that if future markets are dominated by the new, genetically engineered seeds—herbicide resistant seeds, or seeds with resistance to drought —older crop varieties will be disregarded and forever lost. Aggressive marketing of commercial seed stocks has already narrowed the genetic diversity of crop plants, but bioengineering could increase the pace and scope of the loss. Over the longterm, this sort of agricultural homogeneity will make our agricultural system highly vulnerable to attacks from diseases and pests.

Biotechnology may also reinforce the already significant economic forces that are transforming our agricultural system, and increasing the influence of agribusiness interests. Authors Jack Kloppenberg and Martin Kenney have described how biotechnology could further concentrate control among giant corporations:

> Up to the present the farmer has retained a substantial degree of control over the farm production process and his own labor process. Biotechnology permits the external determination of these processes by their embodiment in the seed itself. It would be naive to think that control over the seed by transnational agribusiness will not be used to establish and defend market positions in proprietary input packages. In selecting the seed of a particular plant variety, the farmer will in essence also be choosing his entire production process. Control may be exerted from both the input and product stages, for a number of food processors have joined the inputs corporations as owners of seed companies and investors in biotechnology. The farmer will certainly become more deeply enmeshed in the web of contractual relations which bind him to large-scale capital. . . Biotechnology will help render the farmer ever more a "propertied laborer": on the one hand a landlord and on the other a laborer who cares for corporate plants.[18]

This concentration of control may enhance the trend toward large scale farming, and over the longterm could lead to higher food prices as monopoly control inhibits competitive pricing.

From the beginning, trends in plant biotechnology have been oriented more with an eye to the market than the public welfare.

Biotechnology is often referred to as a revolution, which is an acknowledgment of its potential to alter our environment and our future. But it is a revolution that has been carried out in virtual silence, spawned in test tubes and directed from corporate towers, with little public involvement or oversight.

Can the public gain more control over the direction of biotechnology? Some observers blame the lack of public involvement on a dearth of information. "There is very little public awareness about what is going on in the area of genetic engineering. How, then, can people be expected to make informed decisions?"[19] says Stephan Gliessman, who directs the agroecology program at the University of California, Santa Cruz.

Cornell's Dr. Pimentel believes that the nature of media attention has created a sense that biotechnology is both safe and exciting. "We hear lots of stories about the marvelous experiments going on," says Pimentel. "But we seldom hear reports about possible risks."

Francesca Lyman of Environmental Action, a non-profit environmental organization that is a co-plaintiff in the ice-minus suit, believes that scientists should play a stronger role in public education and risk evaluation. "The scientific community really hasn't spent much time examining the possible effects of biotechnology developments. The research is going full speed ahead, but all the money is going toward developing products rather than toward risk assessment," Lyman points out.

Concerned observers believe that there is a need not only for oversight, but for enhanced efforts to focus biotechnology research on developments that may not be pursued by industry because their profit potential is low. It has been suggested that greater commitment to publicaly funded basic research is the only way to ensure a public focus for biotechnology developments.

Sheldon Krimsky, Tufts professor and head of the International Network on the Social Impact of Biotechnology, supports establishment of a governmental body that would pursue longterm, comprehensive evaluation of biotechnology developments. "For this dramatic revolution," Krimsky observes, "there ought to be some body that is not constrained by narrow rule making, that can also examine the broader aspects of genetic engineering developments and look at the social and ethical issues involved."[20]

Jeremy Rifkin, whose work has helped push biotechnology into the headlines, suggests that foresight hearings should be

established to evaluate the longterm health, safety, and cultural impacts of genetic engineering, as well as other new technologies. Says Rifkin, "The Iroquois Indians used to do something similar. Whenever they had to make policy decisions, they would first ask how this decision would affect the seventh generation to come. They would move into the future and take a look at what the ripples would be, because they understood that decisions made today lock future generations into a certain course."[21]

The atmosphere surrounding biotechnology—the corporate influence, the upbeat predictions about cost and safety, the bland reassurances by scientists, and the reverence of the press—is reminiscent of the early days of nuclear energy. And, as was the case with nuclear power, there seems to be little role for the public, which will ultimately bear the costs of the new technology.

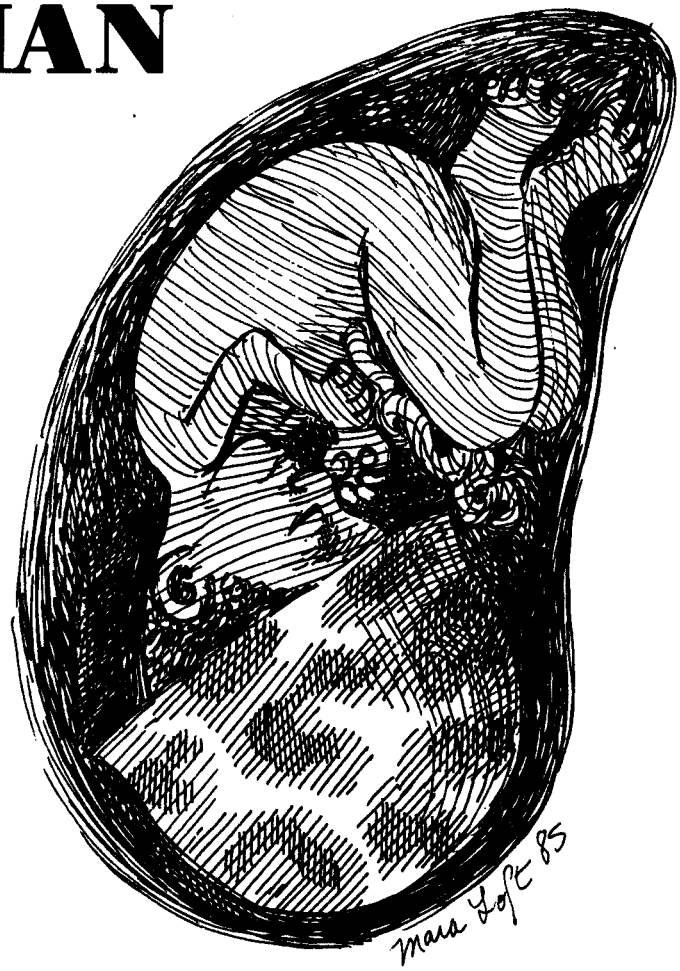
In "The Gods Must Be Crazy," the members of the tribe finally decide they must give the Coke bottle back to the gods in order to save their society. One of the tribesmen carries the bottle for a long distance, and, after politely thanking the gods for the gift, throws it off a cliff. In the case of biotechnology, it won't be that easy. Right now, in laboratories all over the world, scientists are dissolving cell walls and transferring unique traits from one species to another, regardless of the eventual costs to health, the environment, the economy, and our overall way of life. At a certain point in the near future the changes will be part of our biological and social system, and will be impossible to give back. ✦

Experts are suspicious that the high rate of cancer among farmers in the midwest can be attributed to farm chemicals.

REFERENCES

1. Quoted in "Genes on the Move?" *Seed World*, August, 1981.
2. Edward Yoxen, *The Gene Business*, Harper and Row, 1983, p. 119.
3. Figures included in "The Second Green Revolution," *Business Week*, (Special Report) August 27, 1980.
4. L. William Teweles & Co., report announcing publication of *The New Plant Genetics*, December 1983.
5. "The Potential of Genetic Engineering in the Agribusiness Sector," published by The Policy Research Group and the Chicago Group, 1981.
6. Office of Technology Assessment, *Commercial Biotechnology: An International Analysis*, 1984.
7. William J. Netzer, "Engineering Herbicide Tolerance: When Is it Worthwhile?" *Biotechnology*, November, 1984.
8. William J. Storck, "Pesticides Head for Recovery," *Chemical & Engineering News*, April 9, 1984.
9. L. William Teweles & Co., report announcing publication of *The New Plant Genetics*, December 1983.
10. Tom Knudson, series on farm safety published in *The Des Moines Register*, September 1984.
11. I.N. Oka and David Pimentel, "Herbicide (2,4-D) Increases Insect and Pathogen Pests on Corn," *Science*, Vol. 193, pp. 239-240, July 16, 1976.
12. Martin Alexander, Professor of Agronomy, Cornell University, and former Chairman of the EPA's Recombinant DNA Study Group, in testimony before the Subcommittee on Science, Research and Technology, and the Subcommittee on Investigations and Oversight, U.S. House of Representatives, on June 22, 1983.
13. Rudy M. Baum, "Genetic Engineering Engulfed in New Environmental Debate," *Chemical and Engineering News*, August 13, 1984; and J.A. Miller, "Microbial Antifreeze: Gene Splicing Takes to the Field," *Science News*, August 27, 1983.
14. "Jeremy Rifkin and the Courts: Last Line of Containment for Recombinant DNA," interviewed in *Genetic Engineering News*, July/August, 1984.
15. From an interview with the authors, November, 1984.
16. Dianne Dumanoski, "Do Altered Organisms Pose a Threat to Man?" *The Boston Globe*, July 9, 1984.
17. Edward Yoxen, *The Gene Business*, Harper and Row, 1983, p. 121.
18. Jack Kloppenburg and Martin Kenney, "Biotechnology, Seeds, and the Restructuring of Agriculture," *Insurgent Sociologist*, Vol. 12, No. 3, 1983.
19. From an interview with the authors, November, 1984.
20. From an interview with the authors, December, 1984.
21. From an interview in *New Age Journal*, by Connie Matthiessen and Mark Schapiro, July, 1984.

GENETIC ENGINEERING AND HUMAN EMBRYOS



by Shelley Minden

Under the microscope, their long tails furiously lashing, spermatozoa were burrowing head first into eggs; and, fertilized, the eggs were expanding, dividing, or if bokanovskified, budding and breaking up into whole populations of separate embryos. From the Social Predestination Room the escalators went rumbling down into the basement, and there, in the crimson darkness, stewingly warm on their cushion of peritoneum and gorged with blood-surrogate and hormones, the fetuses grew and grew, or, poisoned, languished into a stunted Epsilonhood. With a faint hum and rattle the moving racks crawled imperceptibly through the weeks and the recapitulated aeons to where, in the Decanting Room, the newly-unbottled babes uttered their first yell of horror and amazement.

In 1932, when Aldous Huxley first envisioned a world in which natural birth was considered a disgusting abberation, readers might have been comforted by the notion that human control over the steps of fertilization, embryogenesis and birth was far too crude to allow for the translation of such an image into reality. Today, however, science fiction merges into reality with the development of techniques for the laboratory fertilization and culturing of human ova, and the successful transfer of genes into the embryos of other mammals. The barriers to the genetic engineering of the human embryo are rapidly becoming social and political rather than technical. How will our society be affected by this technology? Although the full answer to this question is hard to imagine, one thing that is certain is that the first people to be affected will surely be *women*, whose eggs, wombs and lives will form the raw material for this intervention.

The ever-increasing reach of technology into conception, pregnancy and birth has been met with concern by feminists. Although these technologies promise things that many women want—possibilities of

---

Shelley Minden is a member of the group Women and Reproductive Technologies, which is a part of the Committee for Responsible Genetics. *She is also a co-editor of the book* Test-Tube Women: What Future for Motherhood? *The author wishes to thank Rita Arditti, Ross Feldberg, and Ruth Hubbard for their helpful comments.*

healthier babies and of reduced infertility—the price that they exact is no less than that of women's autonomy over our own bodies. Genoveffa Corea writes that women are increasingly becoming "mother machines,"[2] incubators for life that is controlled by *man*made technologies from conception to birth. Indeed, as Renate Duelli Klein points out, these technologies are not simply "technical 'problems' or successes, but powerful socio-political instruments of control in the hands of the patriarchy which can be used to reinforce the oppression of women."[3] To what extent might the new capabilities of genetic engineering lead to the further oppression of women?

In this article, I would like to examine some of the recent research pertaining to the genetic engineering of embryos, and to suggest some of the consequences that may emerge for women's lives.

Our society's demand for perfect babies makes a woman vulnerable to any technology that promises to insure them.

The Progress So Far: Experiments on Animals and People

An experiment reported in *Nature* in December, 1982[4] provided the first indications of the dramatic possibilities inherent in the genetic manipulation of embryos. The authors were a team of researchers from five laboratories, who had isolated a gene for growth hormone from rats. They removed eggs from female mice and fertilized them in the laboratory, using a procedure called in vitro fertilization. During the process of fertilization they injected the eggs with the gene for growth hormone, which they had isolated from rats and cloned in the laboratory. Finally, they put the engineered mouse eggs back inside female mice and waited to see how the pups would develop.

The baby mice grew to rat size, acquiring the name "supermice" because they were nearly twice as large as their littermates that had not been tampered with. The researchers enthused about the "practical" ways in which this information could be applied to "commercially valuable animals." With the appropriate growth hormone, they suggested, animals might be made to grow more rapidly and on less food. Furthermore, they suggested that such genetic treatments could help to increase milk yields. And sure enough, their suggestion has already been taken up by researchers in the cattle industry.[5]

But what about those other "commercially valuable animals"—people? Are we, too, subject to "improvement?" Although no researchers have suggested that people be engineered for faster growth like farm animals, genetic manipulations have been proposed as a way to treat genetically based diseases. Some diseases result from disturbances in the many complicated interactions between genes and the rest of the organism, as well as its environment, but others depend primarily on changes (called mutations) in single genes. These single gene disorders are probably the most likely candidates for human genetic manipulations. In theory, they could be cured by the insertion of "normal" genes into cells to compensate for "faulty" genes. Perhaps euphemistically, medical researchers have adopted the term "gene therapy" to describe this human application of genetic engineering.

According to the *Genetic Engineering and Biochemical Monitor*[6] an experiment with gene therapy will soon be carried out by researchers at the University of California and the Salk Institute. The subjects will be children with a devastating disease called Lesh-Nyhan Syndrome, and their treatment is anticipated to consist of the injection of a cloned gene into the children's bone marrow. Because the "germ line," i.e. reproductive cells, of the children will not be affected by the procedure, it is described as "somatic" gene therapy. (In contrast, genes inserted into a fertilized egg would theoretically become incorporated into every tissue of the growing individual, including eggs and sperm, and therefore this procedure is called "germ line genetic therapy.")

The recent burst of medical technologies involving the fertilized egg bring the likelihood of "germ line genetic therapy" closer and closer. The technology of in vitro fertilization (IVF) is particularly connected with the potential for genetic manipulations. This procedure involves the surgical removal of eggs from a woman, to be fertilized with sperm in a laboratory dish (fulfilling Huxley's prediction of sperm "burrowing into eggs" under a microscope.[7]) This procedure was essential to the "supermouse" experiment described above, in which foreign genes were inserted into mouse eggs during laboratory fertilization. Hundreds of women have already used IVF as a treatment for blocked fallopian tubes. The injection of genetic material during fertilization, before the egg is returned to a woman's body for implantation, would constitute only a slight modification of medical procedures already used on women.[8]

So far, no experimental attempt to introduce genes into human embryos has been reported. The lack of research may result in part from the fact that since 1975, Congress has refused to provide government funding for research involving any experimentation on human embryos. But it is easy to imagine that somewhere, perhaps in a privately funded institution or in a country outside of the U.S., some researcher has already begun to experiment with the insertion of cloned genes into human embryos.

Medical Technologists and the Religious Right

For a new technology to come into being, someone has to want it—and one doesn't have to look far to see people who might benefit from the development and applications of human genetic engineering. Both the medical establishment and the religious right have interests that could be well served by the development of human genetic engineering. For the medical establishment, with its interest in technological control over the physical process of birth, gene therapy would be a new source of medical interventions, offering possibilities for control not only over *how* babies are born, but also over the *kind* of babies that women give birth to. And the religious right, should it achieve its goal of bestowing constitutional rights upon fertilized eggs, could find gene therapy to be an unprecedented source of power and control over women's lives.

Human genetic engineering fits in precisely with the medical establishment's increasing "technological takeover" of pregnancy and birth. During the 1960s and 1970s, medical doctors established control over nearly every possible aspect of the delivery of babies, including fetal monitoring, epidural anaesthesia, and even the provision of out-of-the-womb life supports (neonatal intensive care) for increasingly premature infants. With the new technologies of conception, medical researchers are shifting their focus from the end of pregnancy to its beginning. The ability to

Mara Loft

diagnose and treat fertilized eggs would be a logical extension of this new research emphasis.

Not all of the challenges faced by the medical profession are technical ones. The increasing popularity of midwives among middle and upper-class women threatens both the authority and financial status of obstetricians. Seen in this light, the new technologies of conception might be welcomed by medical doctors as a means to lure middle-class women away from the low-technology care of midwives, with the promise that the new technologies will increase women's chances of having healthy babies.

So far, the religious right has vociferously opposed research into reproductive technologies, fearing that the "rights" of fertilized eggs will be violated in the process of research. This group was influential in developing legislation to insure that the uses of in vitro fertilization accorded with patriarchal values: women using the technology were required to be married, or to be in a permanent relationship with a man, and the practice of discarding fertilized eggs (rather than implanting them) was forbidden. A continuing target of the religious right is the practice of prenatal genetic screening, in which women are given the option of aborting a fetus with a known genetic disorder.

The injection of genetic material during fertilization, before the egg is returned to a woman's body for implantation, would constitute only a slight modification of medical procedures already used on women.

Unlike genetic screening, the genetic therapy of embryos would by definition provide "therapy" to embryos, rather than lead to their abortion. The religious right might well lobby to establish such a procedure as a replacement for the current screening tests. With the establishment of legal rights for the embryo, all abortions would be banned, and the only legal means of preventing genetic diseases would be the diagnosis and treatment of embryos and fetuses.

Protection of the "rights" of the embryo, combined with the availability of gene therapy, could even mean that women would be coerced into these procedures against their will. Even with our present abortion laws, women have been brought to court by physicians for refusing to have cesarean sections. Two women have received court orders to undergo cesareans in the interests of the fetus, and one was accused by the judge of being a "negligent" and "child-abusing" mother.[8] Should women be held legally responsible to undergo "embryo therapy," we would indeed lose all freedom of choice.

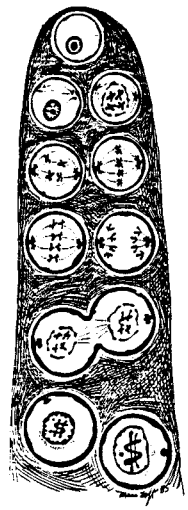
rate of IVF in achieving pregnancy, doctors insert up to four eggs at a time, hoping to increase the chances of pregnancy.) Most women using IVF undergo extensive procedures for fetal testing and monitoring throughout pregnancy, and their babies are usually delivered by Cesarean section.

But will we really have to use such a technology, even if it becomes a technical possibility? The question of choice with respect to the new reproductive technologies has been addressed with urgency by many feminists. For women who cannot afford to pay, the technologies are not even a nominal choice. But even for privileged women, the extent to which these technologies are "choices" is questionable. Barbara Katz Rothman has described how our society's demand for "perfect" babies makes a woman vulnerable to any technology that promises to insure them. Rothman points out that, "in gaining the choice to control the quality of our children, we may be losing the choice *not* to control the quality, the choice of simply accepting them as they are."[10]

Feminists have also pointed out that the very existence of new reproductive technologies creates pressure on women to use them. Now that prenatal screening through amniocentesis is an option, women with access to the test must choose it or know that if they do refuse it, they may later be made to feel "negligent." Ruth Hubbard has described a "not so sci-fi fantasy" of a future in which pregnancy through IVF and embryo replacement is the norm. She writes that "at that point 'in body fertilization' will not only have come to seem old-fashioned and quaint, but downright foolhardy, unhealthy and unsafe."[11]

The issues of prenatal screening and gene therapy have been followed closely and critically by feminists in the disability rights movement. Anne Finger points out the ignorance of both our society in general and the medical profession in their stereotypes about disabilities, showing that the categoration of genes as "good" or "bad" are not simply medical decisions, but political ones.[12] An increasingly thin line exists between efforts to help individual mothers to make choices about their pregnancies, and the societal effort to "improve the gene pool" by urging the abortion of fetuses with genetic traits that medical doctors or government officials may find "undesirable."

Thus, for most feminists who have written about this issue, the concept of "choice" is problematic and even dangerously misleading in light of the general lack of options and support for women, mothers, and chidren in our society. Furthermore, in the present wave of right-wing power and influence, even our present options are tenuous. Should the fertilized egg come to be recognized as a person, technologies like embryo genetic therapy would be totally out of women's control. It would truly be a "Brave New World."



Mara Loft

Protection of the "rights" of the embryo, combined with the availability of gene therapy, could mean that women would be coerced into these procedures against their will.

Feminist Strategies

Women may soon be affected not only by the technology of genetically engineered human embryos, but also, in the present political climate, by regulatory policies formulated by the religious right. Yet we are in a strong position to insist upon a major role in the formulation of policies effecting reproduction. The women's health movement has exercised considerable political clout in promoting women's interests in health care policies. And feminists are already organizing to discuss responses to the newest technologies.[13]

One important strategy for feminists is to monitor and stay informed about research on the development of human genetic therapy. Such information is often difficult to obtain and interpret, given the competition and secrecy among research labs and the fragmented, out of context presentation of reports in scientific journals. Attending medical conferences is one way that we can learn not only about what the current developments are, but where future research projects are headed. Although professional conferences are usually expensive, and often admit participants "by invitation only," one way to be admitted, and without a fee, is to apply for a press pass.

We can also try to forge bridges with women who work in laboratories that do research in this area, and invite them to share information with the feminist media. Recently, social psychologist Robyn Rowland, working with an IVF team in Australia, went to the press in order to expose the practice of "embryo flushing," the transfer of an embryo from one woman to another.[14]

Those of us who are concerned with this issue can urge the feminist media to inform women about the threat to our tenuous control over our bodies inherent in these new technologies. Through feminist newspapers, books, journals, and political networks we can insist that women are included in all policy decisions that effect our health and that of our children. We can also urge groups with related interests to do the same, particularly disability rights groups and ethnic groups that are likely targets for eugenics programs.

The reproductive rights advocacy that feminists have long carried out may be more essential now than ever before. Access to abortion, freedom from sterilization abuse, and the availability to *all* women of child care and child health services: the extent to which we have these rights may well determine whether the new technologies will represent new options or intensified control.

Finally, we will surely benefit from continuing our feminist tradition of sharing the stories of our personal reproductive choices. Several hundred women have now undergone IVF, and it is crucial to know why they chose the procedure, and what their feelings about it are in retrospect. Disabled women have already be-

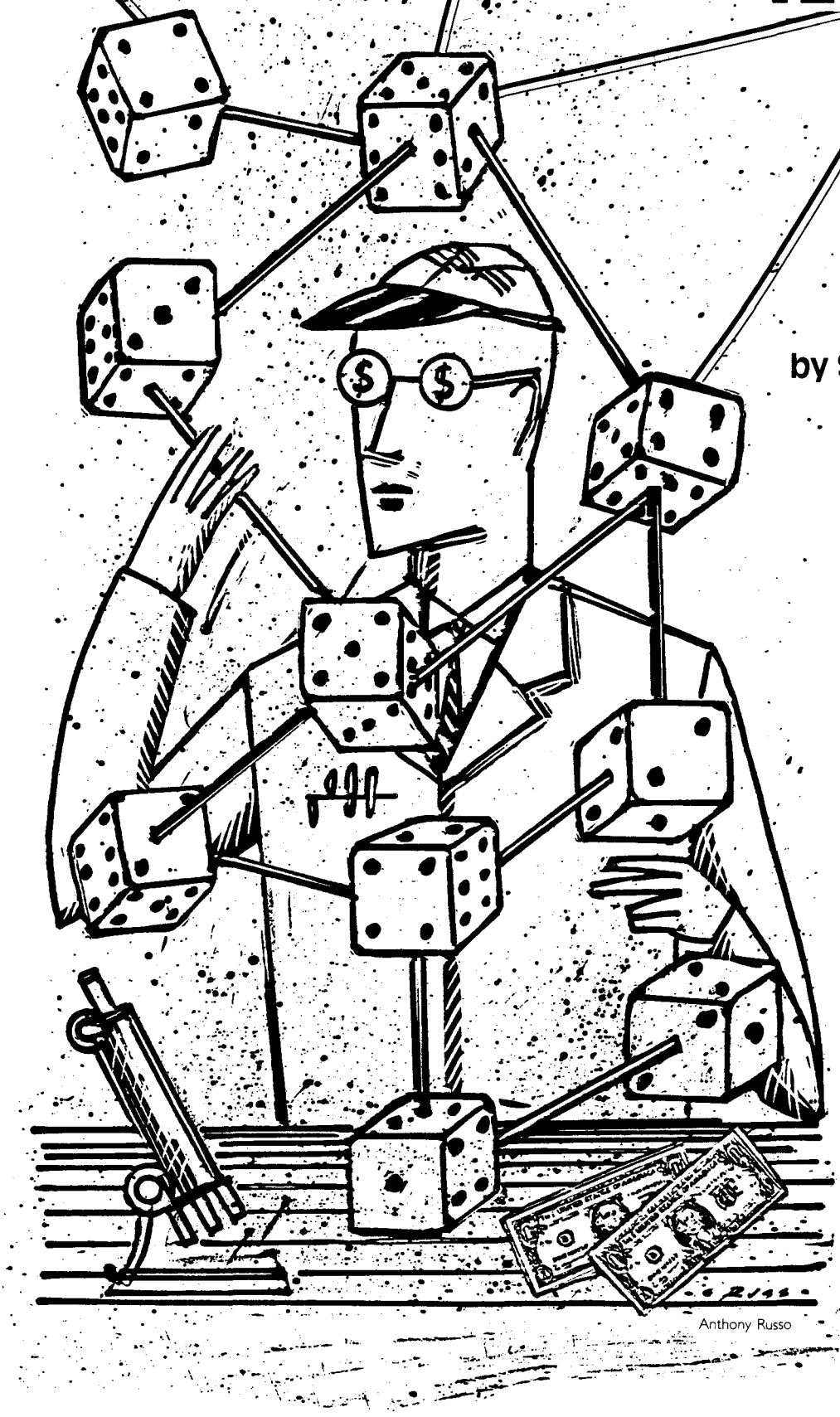
gun to speak about the new technologies both in terms of their impact on disabled people in general, and on women with disabilities who have chosen to bear a child. We also need to hear the stories of women who lack financial access to technologies they might otherwise choose to utilize, of women who have been sterilized without their consent, of lesbians whose doctors deny them the options of artificial insemination and IVF, and of those women who choose to live child-free lives in a society that too often equates womanhood with motherhood.

The medical technologists introduce each new technology with the justification: "women want it, it is in their best interests." Rita Arditti has addressed this claim with skepticism: "I find it paradoxical that the excesses of an impersonal technology developed by males in a sexist society can be viewed as important for the liberation of women."[15] Only women, through the sharing of our personal stories, can define our needs, and only our own organizing efforts can insure that they are met.★

REFERENCES

1. Huxley, Aldous, *Brave New World*, Vintage Books, 1954.
2. Corea, Genoveffa, *The Mother Machine*, New York, Harper and Row, forthcoming in 1985.
3. Klein, Renate Duelli, "Test Tube Women: How the New Reproductive Technologies Reduce Women to Living Laboratories" *Journal of the Society for International Development*, forthcoming 1985.
4. Palmiter, Richard D., Ralph L. Brinster, Robert E. Hammer, Myrna E. Trumbauer, Michael G. Rosenfeld, Neal C. Birngerg, and Ronald M. Evans "Dramatic growth of mice that develop from eggs microinjected with metallothioein-growth hormone fusion genes" *Science*, Vol. 300, December 16, 1982.
5. Rutledge, J.J., and George E. Seidel Jr. "Genetic engineering and animal production" *Journal of Animal Science*, Vol. 57, Suppl. 2, 1983.
6. *Genetic Engineering and Biochemical Monitor*, Issue No. 8, 1984.
7. The term "test-tube babies" is misleading, however, because it implies that the embryos develop to maturity in an artificial womb. Eggs fertilized by IVF are returned to a woman's body for pregnancy; an artificial womb has not yet been developed.
8. Hubbard, Ruth, "Legal and policy implications of recent advances in prenatal diagnosis and fetal therapy" *Women's Rights Law Reporter*, Spring 1982, Vol. 7, No. 3.
9. Rothman, Barbara Katz, "Choice in Reproductive Technology" in *Test Tube Women: What Future for Motherhood?* eds. Rita Arditti, Renate Duelli Klein, and Shelley Minden. Pandora Press, 1984.
10. Hubbard, Ruth "Personal Courage is Not Enough: Some Hazards of Childbearing in the 1980s" in *Test Tube Women: What Future for Motherhood?* Pandora Press, 1984.
11. Finger, Anne "Claiming all of our bodies: Reproductive Rights and Disabilities: in *Test Tube Women: What Future for Motherhood?* Pandora Press, London, 1984.
12. A Women's Emergency Conference on the New Reproductive Technologies will be held during July of 1985 in Lund, Sweden. The conference will consider in vitro fertilization, embryo transfer, artificial wombs, cloning, sex predetermination, genetic engineering and experimentation with human/animal hybrids. Information and application available from Janice Raymond, Women's Studies, Bartlett 208, U. Mass., Amherst MA 01003.
13. Blake, Martin "In vitro row, woman quits" *Geelong Advertiser*, (Australia) may 19, 1984.
14. Arditti, Rita "Women as objects: Science and sexual politics," *Science for the People*, Vol. VI, No. 5, September 1974.

THE CORPORATE CAPTURE OF GENETIC TECHNOLOGIES



Anthony Russo

Scientists' Corporate Affiliations Surveyed

by Sheldon Krimsky

Commercial applications of molecular genetics and cell biology have resulted in a flurry of entrepreneurial activities among academic biologists and universities eager to cash in on the financial side of the biotechnology revolution. The situation is not unique to biology, but is following the path of other academic disciplines that have formed close partnerships with industry, such as nuclear and petroleum engineering, computer sciences, nutrition, electronics, and chemistry. Nevertheless, the current debate that has centered around the commercial ties of academic biologists has been more widely publicized than at any time in the past.

One of the reasons for this may be historical accident. The commercialization of biology occurred on the heels of a widely publicized debate over the safety of recombinant DNA technology. The confluence of debates over the social, ethical, health and environmental impacts of genetic engineering served to focus considerable attention on the commercialization of this science. Another probable reason is that, unlike other scientific and engineering fields that have developed linkages with the private sector, biological re-

Sheldon Krimsky teaches in the Department of Urban and Environmental Policy at Tufts University. He is a longstanding member of SftP, coordinates the International Network on the Social Impacts of Biotechnology and is the author of Genetic Alchemy.

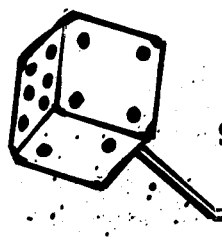
search has been closely associated with public health. The public expectations for this area of research are greater than they are for such areas as chemistry or computer science. Moreover, since the preponderance of funding for biomedical research comes from social resources, academic entrepreneurs in the biomedical sciences tend to be held accountable for their commercial activities in ways that other scientists are not.[1]

An additional factor that helps to account for the vehemence of this issue is that our society, in the post-Watergate period, has become more sensitive to conflicts of interest and to allegations that public funds are being misused or that private interests are exploiting social resources. Further, and lastly, the types of university-industry relationships in biology are more varied, more aggressive, more experimental, and more indiscreet than they had been in similar historical circumstances. Unlike the microelectronics field, for instance, which spawned firms direcly from industries that were recipients of Department of Defense contracts, a significant number of new firms in biotechnology have sprung directly out of academia.

The Current Debate

Much of the debate on the commercial ties of university faculty has centered around a number of issues which highlight the conflicting missions of business and academia. These include the control of intellectual property, openness and accessibility of scientific and technical knowledge, the pooling of public and private funds, the ownership of tangible research property, the use of public research funds for private business interests, and the influence of entrepreneurial faculty on the education of students. These are serious issues and they have been aired to some extent in the media, university debates, and congressional hearings.[2] Several leading universities have already issued guidelines for faculty pursuing commercial interests and have established policies on contractual agreements between the university and the private sector.[3] OTA, 1984).

However, an even more important issue is raised by the role that universities and their faculty play as a national resource in the analysis and formulation of public policy. If a sufficiently large and influential number of scientists or engineers become financially involved with industry, problems raised by the commercial applications of the particular areas of science/engineering are likely to go unaddressed. New values emphasizing science for commerce become internalized and rationalized as a public good, and the scientific community becomes reluctant to raise questions about the social impacts of science. Incrementally, without conspiracy or malice, the disciplinary conscience becomes transformed. Scientists or engineers with a stake in the commercial outcome of a field cannot, at the same time, retain a public interest perspective that gives critical attention to the perversion of science in the interests of the market.



A sizeable academic-industrial association will slowly change the ethos of science away from social protectionism and toward commercial protectionism.

When the number of faculty involvements are small, the effects on public interest science are not likely to be important. As long as a sufficient number of scientists remain free from corporate influence, there will be a disinterested intelligentsia to whom the public can turn for critical evaluation of technological risks, goals, and directions. This suggests that the *individual* instances of faculty-industry ties are far less important than both the aggregate corporate penetration into an academic discipline and the degree to which the major institutions and leading faculty in that discipline are involved. It is thus critical that we develop quantitative information about the degree of corporate-academic interaction in order to assess the reality of this problem.

Scientific Objectivity and Industrial Interests

Public policy formation in a highly industrialized society such as ours is a complex affair. It frequently involves input from experts from many fields. Scientists serve on a labyrinth of public advisory committees, review boards, and risk assessment panels throughout all levels of government. How do we insure objectivity in the contributions of scientific experts to public issues particularly when consensus is difficult to find? Recently the Office of Technology Assessment (OTA) issued a report on biotechnology which posed the argument that the dual affiliation of scientists in the academic and commercial worlds is actually more desirable from a public policy standpoint when expertise is needed.

> An argument could be made that because the public has supported research in universities, it has a right to know whether a particular university faculty member who is giving testimony, for example, has a consulting relationship with a company that manufactures a particular harmful chemical. The negative side of the disclosure policies is that 'objective' information may be judged 'subjective' because of guilt by association. If a faculty member's consulting arrangement with industry is declared openly, it is not necessarily the case that his or her testimony is biased. In fact, the expert may have a more objective view because he or she understands both the research and development aspects of the technology.[4]

There are two arguments here. The first is that when a scientist is testifying before a governmental body, a veil of confidentiality about commercial affiliations prevents bias against the individual's presentation. According to OTA, if the disclosure is required, testimony would not be taken on face value but would be dismissed for reasons of association. The second argument interprets objectivity to mean "multidimensionality." The implication is that the more affiliations a person has, the more objective that person can be.

The OTA analysis confuses objectivity with eclecticism. There are many advantages in having faculty link up with the private sector. Those advantages include a greater awareness of the full life cycle of science, from discovery to manufacture. But OTA makes a serious error when it describes the financial involvement of academic scientists in commercial ventures as a contributor to objectivity. The argument fails because of the financial interests; only a form of eclecticism that is independent of pecuniary interest could indeed enhance such objectivity. Our conflict of interest laws are based upon assumptions of human frailty as exemplified by the aphorism "Don't bite the hand that feeds you." Although it is a mistake to view conflict of interest in terms of conspiracy or conscious design, it is my hypothesis that a sizable academic-industrial association will slowly change the ethos of science away from social protectionism and toward commercial protectionism.

The economic determinants of research and their influence on the latitude of inquiry are both pervasive and subtle. Sometimes this influence manifests itself in the distortion of science. Other times it is ex-

pressed in the control of information. Most frequently it is felt by the kinds of questions that are pursued in the areas where science and social policy intersect. Let me begin with a simple illustration of my thesis.

Imagine that you are heavily funded by a company to engage in research. Is it likely that you would publicly embarrass the company by revealing information or posing questions about its technological direction? Most scientists with a conscience would make their viewpoints known to the firm's directors. But who would want to jeopardize his or her funding by making an issue public? The closer the relationship one has to a firm, the greater the chance that propriety and self-interest dictate that one keep criticisms within the corporate family.

A few years ago I supervised a policy study involving the chemical contamination of a town's water supply. The parties involved included a multinational corporation, town, state, and federal officials, a public advocacy group, and technical people. I chose to do the study for three reasons. First, it served the public interest. Second, it was a useful case for instructional purposes. Third, from a public policy standpoint, it represented a milestone for the implementation of a major federal law. If I had been funded by the corporation in question, however, that research study would never have entered my mind because of the likelihood that the company would not be shown in the best light. If my department had been heavily funded by the company possibly including graduate student stipends and multi-year grants it is extremely doubtful that any faculty member would have chosen to study how the department's corporate benefactor was implicated in the contamination of a water supply, unless there was reasonable assurance that the outcome would not be an embarrassment.

When our policy study on the chemical contamination of the town's water supply was complete, a vice president of the corporation made a personal visit to the president of my university and asked to have the study suppressed or totally disassociated from the university. It is gratifying to report that my university made no efforts to restrict my academic freedom.

However, the economic determinants of research and their influence on the lattitude of inquiry are far more pervasive and subtle. Sometimes this influence manifests itself in the distortion of science. Other times it is expressed in the control of information. Most frequently it is felt by the kinds of questions that are pursued in the areas where science and social policy intersect.

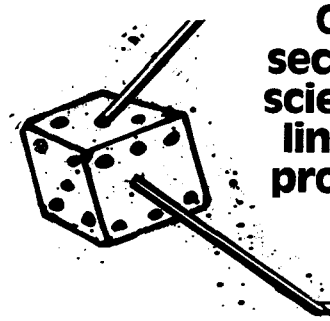
Scientists and the Public Trust

Periodically, a story appears in the media about an academic scientist who expresses sympathetic views to an industry position on a controversial health or environmental policy. The article might then mention the financial association between the scientist and the company that has a stake in the outcome.

It was reported in *Science* that most petroleum engineers in academia did extensive consulting for oil companies and formed part of the university-industry "oil fraternity:"

> Consulting is regarded not simply as a lucrative prerequisite of the profession but as a necessary way to establish and maintain a departmental reputation and create job opportunities.[5]

Another obstacle facing public officials hoping to obtain objective advice from experts who serve on public service panels is that many own stock in the companies that are affected by their decisions.



Given the choice, the public sector would place its trust in scientific experts who are not linked to industry financially; problems arise when the pool of unaffiliated experts becomes scarce.

Considering the amount of industry consulting that takes place, the public only learns about the proverbial "tip of the iceberg" of the associations. While the numbers of documented cases may be small, there is no clear way of knowing the total effect these associations have on social policy formation. Given the choice, the public sector would place its trust on scientific experts who are not linked to industry financially. Problems arise when the pool of unaffiliated experts become scarce.

A situation like this occurred in 1969 when close ties between the oil industry and university experts in academic discipline such as geology, geophysics, and petroleum engineering made it impossible for California officials and federal authorities to obtain testimony relating to the environmental problems arising from massive oil leaks of the Union Oil Company's offshore well in the Santa Barbara Channel. According to the report in *Science*:

> California's chief deputy attorney general ... publicly complained that experts at both state and private universities turned down his requests to testify for the state in its half-billion dollar damage suit against Union and three other oil companies.[4]

The explanation offered by state officials about the difficulty they had in getting testimony from experts is that "petroleum engineers at the University of California campuses of Santa Barbara and Berkeley and at the privately supported University of Southern California indicated that they did not wish to risk losing industry grants and consulting arrangements."

The lesson illustrated by this case is not that petroleum engineers did not testify. They were probably acting ethically in not testifying since their corporate ties might have compromised or cast doubt on their objectivity. The real problem was the scarcity of academic experts who were not affiliated with the oil industry and who could provide a potentially disinterested perspective.

In some situations, research is so highly specialized that only a few scientists in the entire country may have the information necessary to render a decision on the health and safety of a new substance. Several decades ago, it was common practice for scientists to sign restrictive publication agreements with companies. It is still done today in the biotechnology industry. In one important case, information withheld from publication could have prevented a toxic pesticide from being marketed. In the 1950s, a clinical professor of occupational and environmental medicine at the University of California at San Francisco was engaged in toxicological research on the pesticide dibromochlorapropane (DBCP) for the Shell Development Corporation. In the course of the research, he discovered that the chemical caused severe cases of testicular atrophy in test animals. As was common practice at that time, research results were kept out of print to protect trade secrets. While a brief abstract of the toxicological study was pub-

lished in 1956, the full results were held back from publication until 1961, *six years* after the pesticide was approved for marketing.

In the late 1970s, workers in a DBCP plant were monitored, and unusually high incidence of male infertility was reported. At state hearings on DBCP, it was noted that the scientist who studied the pesticide testified at public hearings on other environmental health matters without disclosing his consulting work with firms that had a financial interest in the subject matter under investigation. The chairman of the panel stated:

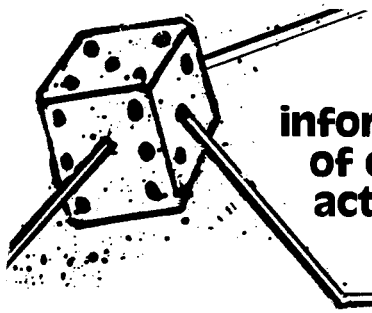
> It is difficult to know in the cases of [such scientists] with 30 years of dual relationships with the university and with Shell where advocacy on behalf of private interests ends and where responsibility as an 'objective' professor begins.[6]

A special feature of the journal *Business and Society Review* reported cases where the public received expert testimony from scientists with undisclosed relationships to companies that stood to gain from the recommendations. Michael Jacobson, Executive Director of the Center for Science in the Public Interest described conditions in the field of nutrition.

> In the area of food safety and nutrition . . . a large percentage of experts has received industry money. Rare is the expert who accepts such funds as an ardent defender of the public's interest.[7]

Similar examples can be found in nuclear engineering, occupational health and medicine, and ecology.

Ultimately, it is socially desirable that there be a balance in the academic community. For any discipline that has a commercial offspring, it is vital that a critical mass of experts remain disassociated from industrial ties in areas related to their field of expertise. And when scientists maintain such ties, it is essential that the public understand the nature of the relationships when their expertise is sought in setting policy. But just how extensive is the problem in biotechnology?



It is critical that we develop quantitative information about the degree of corporate-academic interaction in order to assess the reality of this problem.

Academic-Corporate Linkages in Biotechnology: Some Quantitative Results

For the past year, I have been quantifying the linkage betweenthe academic and commercial/industrial sectors in biotechnology. What follows is a report on the preliminary findings of this research.

The key questions underlying the current study are:

1. As a baseline, what number of academic scientists are formally involved in commercial biotechnology?
2. What is the growth profile of new firms created in the biotechnology industry?
3. Of the scientists involved in the commercial/industrial activities, how many are members of the National Academy of Sciences (NAS); what are their demographics; what percentage serve on study panels or public advisory committees to the National Science Foundation (NSF), the National Institutes of Health (NIH), and the U.S. Department of Agriculture; and what percentage of the specialized sections of the NAS in the biomedical sciences are comprised of dual-affiliated scientists?

I chose to examine formal, long-term ties between scientists and biotechnology firms. To meet this criterion a scientist has to satisfy at least one of the following conditions: serve on a scientific advisory board of a biotechnology firm, hold a long term consultantship with a company, hold substantial equity in a biotechnology firm, or serve in a managerial capacity for a firm. For companies that offer public stock, some of this information is contained in reports to the Securities and Exchange Commission. It is more difficult to obtain information about the scientific consultants and equity holdings of private firms since they are not legally obligated to file reports in the public domain.

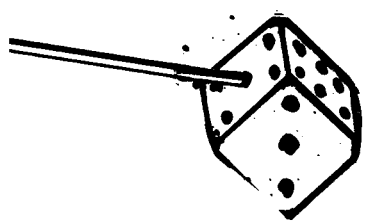
The data base for this study included a list of 212 biotechnology firms, of which 103 issue public stock, 119 are private, and 70 are undesignated. The prospectuses and financial reports have been reviewed for 82 of the largest and most active of the public corporations and a few private companies for information on major stockholders and the composition of their scientific advisory boards. Relevant information from trade literature and media reports of commercial activities in biotechnology brought additional scientific affiliations. The result of this inquiry was a list of academic scientists with formal commercial ties to the biotechnology industry.

Thus far the survey of public firms shows that 393 academic scientists serve on scientific advisory boards of biotechnology firms. The actual number of university scientists with formal ties to the private sector may run several times this number when all public and private firms are reviewed. The quantitative information compiled thus far is summarized in table 1.

An important consideration in interpreting the data is that the number of biotechnology firms has increased rapidly over the past decade. The birth of new firms peaked in the early 1980s and appears to be in a decline (figure 1). The trade magazine *Genetics Engineering News (GEN)* reported that there were a handful of biotechnology companies before 1981. By the next year *GEN* listed 194 firms in its registry. The number climbed rapidly to 220 by November 1983 and current estimates place the number of firms at about 350. The increase in the number of scientists on

TABLE 1. Commercially affiliated academic scientists in biology/medicine/biotechnology. Data base of 393 scientists and 292 biotechnology firms of which 50 were systematically surveyed.

Subclass Category	Number	% Data Base
Membership in NAS	71	17.6
Serve(d) on NIH Public Advisory Committee/ Study Panel, 1982-84	48	13.2
NSF Mail Reviewers, 1983-84	236	64.9
USDA Mail Reviewers	19	5.2



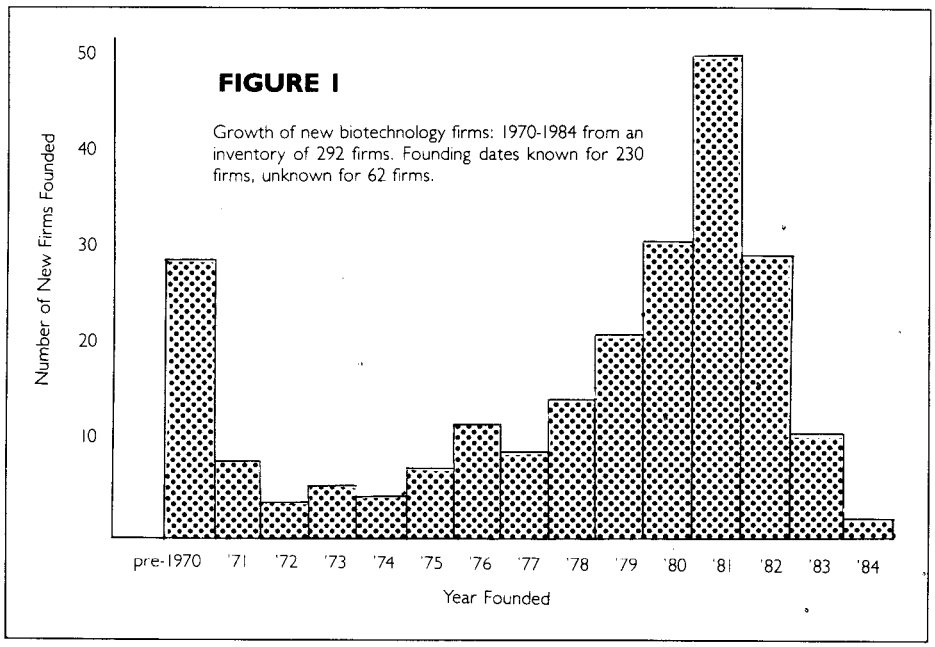


FIGURE 1

Growth of new biotechnology firms: 1970-1984 from an inventory of 292 firms. Founding dates known for 230 firms, unknown for 62 firms.

scientific advisory committees is directly related to growth of the industry. By knowing the number of firms and estimating the average number of scientific advisors on each, it is possible to get an upper bound on the formal linkage between university biomedical scientists and industry.

The data show that a significant percentage of the academic scientists serving on advisory committees of firms are also members of the National Academy of Sciences. The four sections of the NAS most relevant to biotechnology are: biochemistry, celular and developmental biology, genetics, and medical sciences. The NAS members in the data base of dual-affiliated scientists constitute about 25% of the total membership in the four sections of the Academy. The actual number of dual-affiliated scientists from the data base for each of the four NAS sections is given in figure 2. Some scientists on the NAS list are not classified in specialty areas while other NAS members in our data base are not associated with one of the four sections listed above. Since our survey has analyzed only 28% of the 292 firms inventoried for the study, the number of dual-affiliated scientists who are members of NAS could reach over 50% for certain sections. This is particularly significant because NAS is frequently called upon to render decisions on the social and environmental impacts of science and technology.

In addition to correlations between dual-affiliated scientists and NAS membership, the data base was also examined for affiliations with the National Science Foundation, and National Institutes of Health, and the Department of Agriculture. Nearly 65% of the scientists in the data base served as external reviewers for NSF grant proposals. Although confidentiality in such reviews is a part of the scientific ethic, the flow of commercially useful information to industry resulting from such reviews may be impossible to control, when the reviewers have equity in or strong affiliations with firms. The percentage of dual-affiliated academics on NSF study panels and public advisory groups is considerably lower than those on similar NIH panels and those serving as NSF mail reviewers (table 2). It is not clear whether this is an artifact of no special significance, or whether NSF's conflict of interest procedures for study panel participation screen out those with strong industry ties.

This research is still in progress. Demographic data have not been analyzed. It may be of interest to see which universities have the strongest corporate-academic ties. Considerably more work needs to be done to increase the data base of dual-affiliated scientists by accumulating information on private firms.

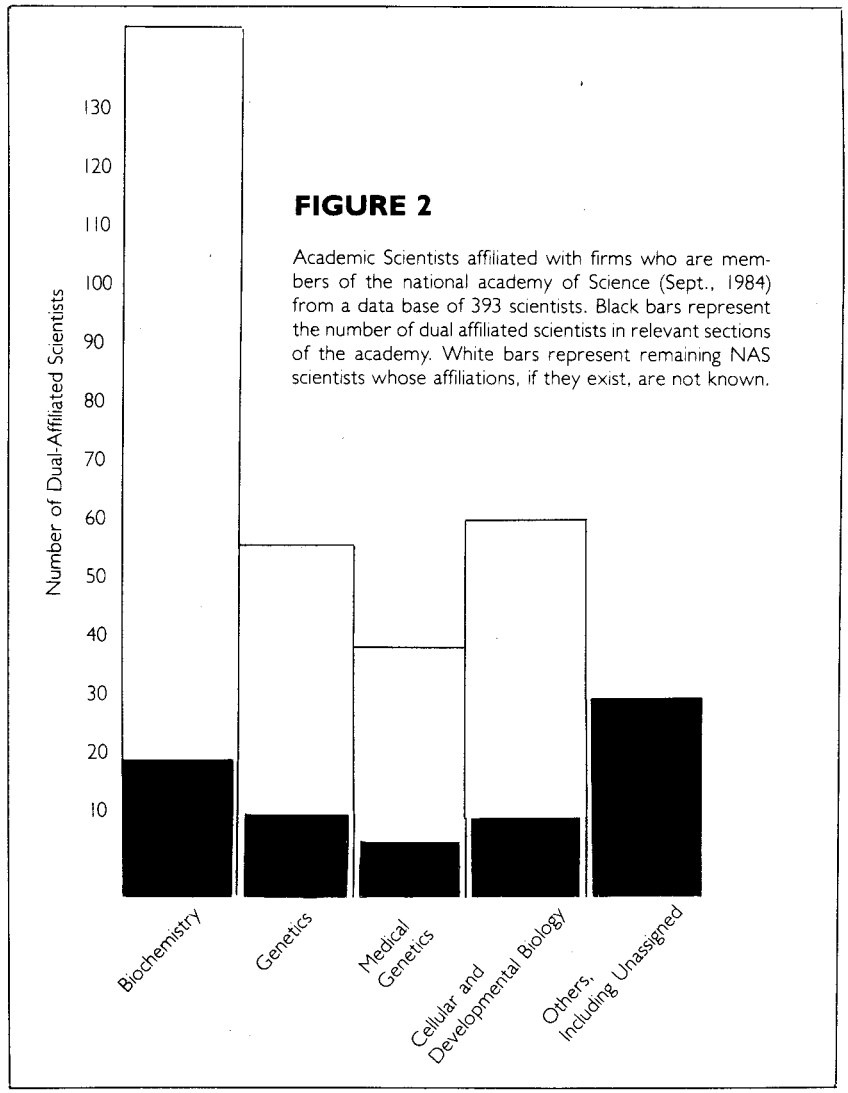
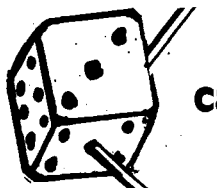


FIGURE 2

Academic Scientists affiliated with firms who are members of the national academy of Science (Sept., 1984) from a data base of 393 scientists. Black bars represent the number of dual affiliated scientists in relevant sections of the academy. White bars represent remaining NAS scientists whose affiliations, if they exist, are not known.



Scientists with a stake in the commercial outcome of a field cannot, at the same time, retain the public interest perspective that gives critical attention to the perversion of science in the interests of the market.

It is also important to study these trends over a long time period to understand how the phenomenon of academic-corporate partnerships evolves as the biotechnology field matures. Until the quantitative assessment of this phenomenon is made we will not be able to fully appreciate the symbiotic nature of industrial partnerships between academe and industry. On one hand we have technology transfer. On the other hand there are changes in the scientific institutions. In particular, it is important to understand how scientists' dual-affiliations affect research programs in molecular biology and change the cultural milieu which has nourished the scientific enterprise.

Conclusion

In conclusion, there is so much that needs to be done to improve the public's attitude toward the role of science in social policy and, particularly, to enhance the image of scientific objectivity. One contribution toward this end is to promote disclosure. The commercial connections of scientists with dual affiliations should be part of their resume and open to the public record when they enter the policy realm or when they serve on public advisory committees. This is not a difficult or burdensome requirement.

A second recommendation which is more difficult to implement would reward scientists who maintain an independence from commercial activities. Such independence might be factored into appointments on prestigious commissions and other policy making activities including service on study panels as well as preference in the competitive grants program.

Without some incentives to reverse the momentum of the phenomenon that is occurring in biotechnology, the pure biomedical scientist may become a vestigial relic of a past generation, with the inevitable results being the foreclosure of an important agenda—the social guidance of a technological revolution—and the increasing erosion of public confidence in scientific objectivity.★

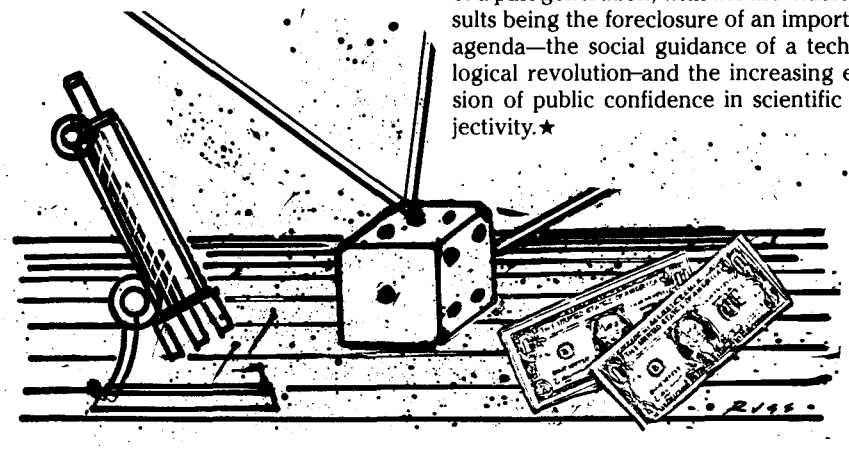


TABLE 2. Dual Affiliated Scientists on NSF Study Sections (FY 1983).

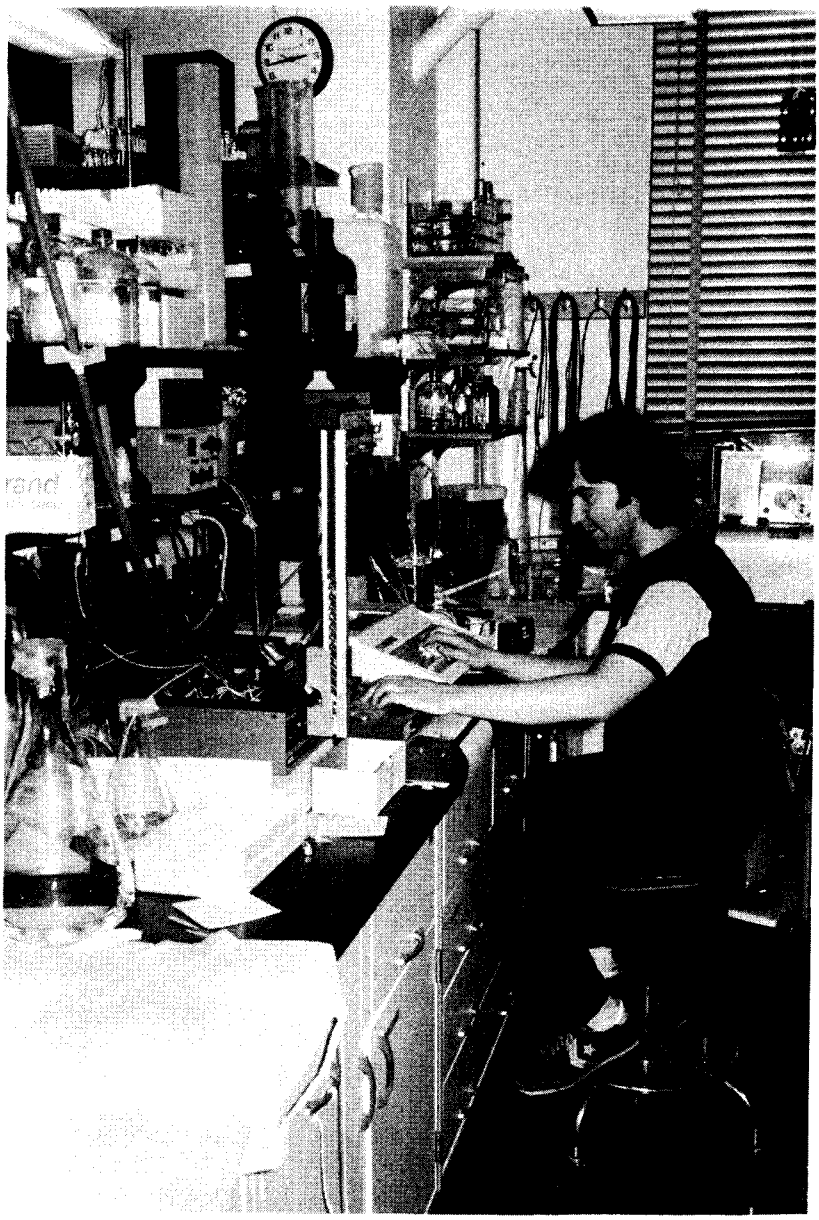
Study Section	No. Scientists in Section on Data Base	No Scientists in Section	% Dual-Affiliated Scientists
Regulatory Biology	0	15	0
Cell Physiology	0	12	0
Cell Biology	0	19	0
Developmental Biology	1	19	5.3
Genetics	1	25	4.0

REFERENCES

1. Charles Weiner, personal communication, 1984.
2. *Hearings on Commercialization of Academic Biomedical Research*, Washington, D.C., U.S. House of Representatives, Subcommittee on Investigations and Oversight, and Subcommittee on Science, Research and Technology, Committee on Science and Technology, June 8-9, 1981.
3. *Hearings on University/Industry Cooperation in Biotechnology*, Washington, D.C., U.S. House of Representatives, Subcommittee on Investigations and Oversight, and Subcommittee on Science, Research and Technology, Committee on Science and Technology, June 16-17, 1982.
4. *Commercial Biotechnology: An Internation in Biotechnology*, Washington, D.C., U.S. House of Representatives, Subcommittee on In-
5. John Walsh, "Universities: Industry Links Raise Conflict of Interest Issue." *Science*, Vol. 164, 1969, pp. 411-412.
6. Jim Cone, "DBCP-UC Research," *Synapse*, U.C. San Francisco, Vol. 22 No. 9, October 10, 1981.
7. Leonard H. Orr, ed., "Corporate Money and Co-opted Scholars." *Business and Society Review*, Vol. 37, Spring 1980, pp. 4-11.

SAFETY AND HEALTH ISSUES REVISITED

by Gerry Waneck



Ellen Shub

The climate of concern of the 1970s, regarding the potential dangers of recombinant DNA (rDNA) technology, has dissipated and instead given way to assurances that this technology is safe and virtually free from hazards. Ten years ago, in 1975, a number of prominent scientists convened at Asilomar, California, to discuss the risks involved in this newly emerging technology.

The landmark conference followed a letter authored by a number of distinguished scientists calling for a voluntary moratorium on all rDNA research until an assessment of the risks could be conducted.[1] In addition, the letter requested the director of the National Institutes of Health (NIH) to establish:

> an advisory committee charged with (i) overseeing an experimental program to evaluate the potential biological and ecological hazards of the above types of recombinant DNA molecules, (ii) developing procedures which will minimize the spread of such molecules within human and other populations, and (iii) devising guidelines to be followed by investigators working with potentially hazardous recombinant DNA molecules.[2]

Several months after publication of this letter, in October 1974, the NIH established the Recombinant DNA Molecule Program Advisory Committee, commonly referred to as the RAC. The first meeting of the RAC took place on February 28, 1975, following the Asilomar Conference, and it began the task of drafting a set of guidelines for rDNA research.

Frist released on June 23, 1976, the Guidelines underwent several revisions over the following five years.[3] They defined and classified experiments that were permitted, those that were exempted from regulation, and those that were considered too hazardous to allow. Consideration was given to the types of hosts, vectors, and the levels of physical containment to be employed. Initially, compliance with the Guidelines was mandatory, but after much academic debate and only a few risk assessment studies, the Guidelines were relaxed. By January 29, 1980, the Guidelines had degenerated into a voluntary code of practice for non-NIH-funded institutions. Moreover, at a RAC meeting in February 1982, the NIH abandoned oversight of rDNA activities. The RAC continued to serve only in an advisory capacity.

Gerry Waneck is a molecular biology postdoctoral fellow at a biotechnology firm in Cambridge, MA and an active member of Science for the People.

Whereas scientists once worried about how to prevent rDNA from entering the environment or crossing species barriers, today—ironically—rDNA is designed to do just that.

What, Me Worry?

In these past ten years, the technology for manipulating rDNA has been radically transformed. In 1975, the understanding of gene structure and expression was elementary, and the techniques for studying it were relatively primitive. Since then, a rapid advancement in this basic knowledge has occurred, and there are several "cookbooks" that make this sophisticated work quite routine.[4] At the outset only a few laboratories were engaged in rDNA research, but now it is conducted at practically every research center, and a whole industry has developed around it.

In reviewing the history of the rDNA controversy,[5] one realizes that the entire issue of safety has been predicated on a few basic arguments which center around issues of the inherent properties of the rDNA being manipulated (its pathogenicity or infectivity) and issues of containment (both physical and biological). Whereas scientists once worried about how to prevent rDNA from entering the environment or crossing species barriers, today—ironically—rDNA is designed to do just that.

The strongest evidence for the alleged safety of rDNA technology comes from the experience of the past ten years, rather than data from an adequate risk assessment program. No epidemics have resulted even though hundreds of laboratories around the world have been cutting and splicing DNA in a multitude of combinations. However, this evidence speaks more to the past than to the future and does not invalidate the theoretical considerations that were debated at the outset. In addition, the lack of epidemics has no bearing on the issue of whether workers are at a higher risk than the population at large.

In effect, there has clearly been a shift in the burden of proof: whereas in the 1970s those who claimed rDNA to be safe had to defend this point, from 1980 onwards it became incumbent upon those who worried about these hazards to demonstrate them. A small number of studies conducted in the late 1970s[6] have been used as a paradigm for risk assessment of a "worse case" scenario. However, it has been shown that these data are statistically insignificant,[7] and other valid interpretations have been offered.[8] Even if one accepts the "safe" interpretation of these studies, it can be argued that extrapolation to present circumstances is unwarranted due to significant changes that have occurred in the field of molecular biology. These changes make previous risk assessments obsolete. Using the same rationale considered initially, it is obvious that a *re*assessment of the risks is required.

Hazardous Potential of Recombinant DNA

One of the early fears expressed by those concerned about the potential dangers of rDNA technology was that random pieces of DNA from higher organisms (eukaryotes), when placed into bacteria by "shotgun cloning," could take on novel hazardous properties.[9] The potential of bacteria to be hazardous if they express (and sometimes secrete) the products of eukaryotic genes is contingent upon their acquisition of novel functions allowing them to interact with tissues of higher organisms. As Stewart Newman has argued:

> Both diptheria and cholera are caused by bacteria containing factors that interact with cellular components found only in higher organisms. Rheumatic heart disease is caused by a bacterium with a factor that apparently mimics a component of mammalian muscle. In each case these factors are dispensible to the bacteria in question. They do not help them to survive and, in fact, usually precipitate their destruction by causing them to mobilize the defenses of the infected patient in ways that identical versions of bacteria lacking these pathogenicity factors do not.[10]

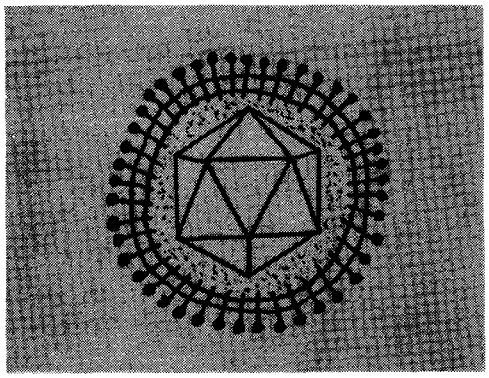
In the early days of rDNA technology, structural and regulatory differences between the genes of bacteria and the genes of eukaryotes reduced the likelihood of bacteria expressing potentially hazardous eukaryotic genes. Bacterial genes are present as contiguous pieces of DNA that can be "read" directly by bacterial enzymes. The genes of eukaryotes, however, are interrupted by nonsense pieces of DNA (introns) and require processing by mechanisms not found in bacteria. In addition, the regulatory sequences that control eukaryotic gene expression are in most cases nonfunctional when placed inside bacteria.

Ellen Shub

Molecular biologists have since devised ways to get around this obstacle to the study of eukaryotic gene expression. Through genetic engineering, scientists have been able to restructure eukaryotic genes to look and act like bacterial genes. In addition, these restructured genes have been joined to specially designed pieces of self-replicating DNA (expression vectors) that make this process more efficient. These accomplishments have rapidly advanced the understanding of many basic life processes and offer enormous benefits, especially in the fields of agriculture and medicine. But with potentially hazardous eukaryotic genes no longer constrained by the natural inter-species barriers that existed previously, these same accomplishments have ironically created new hazards by increasing the likelihood that if something can happen, it will.

Of the many eukaryotic genes, probably only a few are harmful. The problem is that no one seems to know how to decide which genes have this potential. As Susan Wright has explained:

> What possible hazards might be associated with an organism designed, for example, to make cellulase, an enzyme which degrades cellulose and which could destroy roughage in the human gut, or an organism designed to make a powerful human hormone which might disrupt normal physiological processes in humans or animals? It has also been conjectured that bacteria-making products similar to human proteins might trigger an immune response in a human host, giving rise to a form of autoimmune disease. While there has been much debate about these possibilities, very little consensus has developed, and no specific experiments to test hazards have been carried out.[11]



The use of shuttle vectors increases rather than decreases the risk of accidental transmission of harmful genes from bacteria to higher organisms.

Oncogenes

Perhaps the most potentially hazardous eukaryotic genes being manipulated by rDNA techniques are those implicated in the cause of cancer: oncogenes.[12] Oncogenes were first discovered as pieces of eukaryotic genes that had been "captured" by a type of virus (retrovirus) known to cause cancer in a variety of animals. A comparison of the normal version of oncogenes (proto-oncogenes) with the version carried by retroviruses shows that oncogenes of retroviruses have arisen from alterations in the structure and/or function of proto-oncogenes. It has been demonstrated that even in animal and human tumors not caused by a retrovirus, these proto-oncogenes have undergone similar alterations. Thus the cancer-causing, or oncogenic, potential of normal genes may be activated by various mechanisms.

Proto-oncogenes are present in the DNA of *all* eukaryotes, even of lower organisms such as insects and yeast. These genes appear to be involved in important processes affecting the growth of cells. Tumors arise from cells that continue to divide when ordinarily they would stop, and thus it is not surprising that cancer would result from spontaneous alterations in genes which are responsible for cell growth.

It is unclear how these alterations happen spontaneously. Single or multiple mutations may be present, and breakage and rearrangement of DNA can also occur in the vicinity of these genes.[13] These are the same events that occur in the process of cloning random DNA, and it is possible that cloning could change proto-oncogenes into oncogenes. No risk assessments have been conducted to fully address this issue, nor the obvious issue of *deliberately* cloning defined oncogenes. As Ditta Bartels has emphasized:

> It is irresponsible to leave oncogene related risk assessment to coincidental discoveries of independent researchers. A rational experimental program is needed to protect those who are involved in the various stages of oncogene research and its commercial development.[14]

Infectivity of rDNA

Even if hazardous pieces of rDNA have been cloned, if there is no possible way for them to become infectious, then the health risks are minimized. The factors that determine infectivity may have less to do with the piece of DNA that is cloned than with the vectors or bacterials hosts that are used for its cloning. Thus it is desirable to handle rDNA under conditions of adequate biological containment, where the use of appropriate vectors and hosts reduces these risks.

As stated previously, certain vectors have been constructed that allow eukaryotic genes to be expressed in bacteria. One class of vectors is derived from bacteriophage lambda, a well-studied virus of bacteria. The central third of lambda DNA is not essential for the infectious properties of the virus and can be replaced by rDNA. Consequently, this vector is quite capable of transmitting rDNA from one bacterium to another.

In many cases it is desirable to express eukaryotic genes in eukaryotic cells, where they normally function. However, bacterial systems are still required for the initial cloning, cutting, and splicing of the DNA to be expressed. In order to facilitate these manipulations, novel vectors—called "shuttle vectors"—have been constructed that contain sequences enabling their replication and/or expression in both bacterial and eukaryotic cells. It follows that the use of shuttle vectors increases rather than decreases the risk of accidental transmission of harmful genes from bacteria to higher organisms.

One shuttle-vector construction is particularly worrisome, especially since it is intended for use in human gene therapy.[15] This vector is a hybrid between a bacterial vector and a mammalian retrovirus.[16] When placed into specially modified mouse cells, this vector can become a retrovirus that is capable of infecting a broad variety of mammalian cells, including those of humans. Any gene carried by this vector will become a stable part of the newly infected cell with high efficiency.

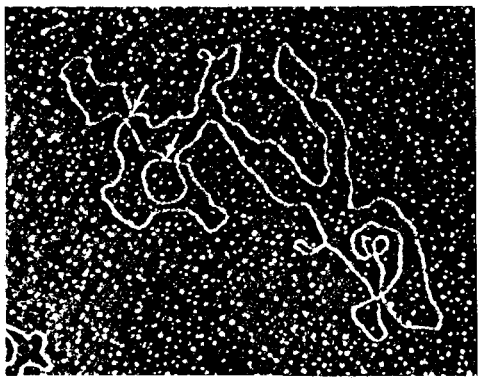
The hybrid vectors are designed to undergo only a single round of infection; that is, in theory, they should no longer be infectious after entering the first cell. Thus, they are called defective retroviruses. However, in preparing defective retroviruses in the modified cells, infectious virus is sometimes generated by mutations and is able to "help" the defective hybrid spread from cell to cell. Thus, the use of these vectors in human gene therapy requires that absolute caution be exercised in preparing defective retroviruses free of infectious virus.

Physical Containment

It was recognized early in the controversy that *physical* containment of potentially hazardous rDNA was no substitute for *biological* containment.[17] Physical barriers are subject to deliberate disregard of regulations, bad laboratory practices due to ignorance, and accidents due to human error. However, physical containment certainly serves a purpose in minimizing risks, since it reduces exposure.

Levels of physical containment have been designated P1 through P4, from low to high containment. The P1 level is used for rDNA work conducted in most laboratories, but those working with human tumor viruses and AIDS virus are *recommended* to "employ at the minimum P2 physical containment conditions for all molecular cloning procedures with these agents."[18] Virtually no work is done at the level of P3, and only the most hazardous agents are handled in a few P4 facilities.

During the period when scientists were debating the effectiveness of physical containment, some relevant comments were made. Paul Berg, an original signer of the letter calling for a voluntary moratorium, thought that "the moderate (P3) containment level was ... 'reassuring to the psyche,' but not something scientists should rely upon foremost."[19] Berg also revealed that "in his own P3 facility at Stanford designed for virus research, almost everyone who entered that lab acquired substantial antibody titres to SV40 [mon-



Presently, there are no federal agencies in place to enforce compliance. Figuratively speaking, the fox has been left to guard the chicken coop.

key virus] (a sign of infection) after one-half to a full year."[20]

Although no degree of physical containment can be foolproof, it is senseless not to employ any. Yet, practically speaking, the use of P1 containment is tantamount to none at all, for P1 containment only involves good laboratory practices that should be standard even for non-hazardous research. Perhaps the worst aspect of working under P1 conditions is the development of lax attitudes about the potential hazards of rDNA work. Attempts to encourage more caution or adherence to containment guidelines seems contradictory in light of what is practiced.

Deliberate release of genetically engineered organisms is planned, and some would argue that concerns about containment are passe. However, the issue of deliberate release has not yet been settled, and there is still debate about how these modified organisms will alter present ecological relationships. While the modification of bacteria for agricultural purposes may present no imminent dangers, the use of hosts and vectors that are intimately connected with human ecology is directly relevant to the issue of pathogenicity. Until the consequences of rDNA research are better understood, it seems appropriate to exercise more caution than exists presently in the level of physical containment.

Biological Containment

Biological containment of hazardous rDNA relies on vectors and hosts that are unlikely to pass rDNA to other organisms. Initially, vectors were constructed from bacterial plasmids (self-replicating circles of DNA) that were not transmitted from one bacterium to another during bacterial mating. As discussed previously, the present use of bacteriophage lambda and other novel vectors makes this point moot. However, as long as the bacterial hosts are too debilitated to survive outside of a laboratory environment (for example, in the human intestine), then presumably even the use of these vectors poses no great risk.

The "debilitated" bacterial host chosen for containment was *E. coli* K12, a resident of the human intestine that had been grown and studied inside the laboratory for so long that it theoretically could not survive outside. Thus, it was unlikely to cause an epidemic. However, when survivability was tested more than two years after this system was approved, it was found that *E. coli* Chi 1776 (an even weaker strain of *E. coli* K12) could survive in some human volunteers up to 500 times the rate mandated by the NIH Guidelines.[21] Later it was also shown that *E. coli* K12 could survive at a rate 10,000 times that of Chi 1776.[22] The survival of these bacteria was facilitated by the presence of a standard vector used in most experiments.

If these host-vector systems can survive for prolonged periods in the human intestine, then they will be excreted into sewage. Detailed studies have examined the survivability of host-vector combinations in sewage and the ability of these to transfer genetic information to hardy, indigenous bacteria.[23] Using a laboratory-scale, model sewage treatment plant, investigators found that the *E. coli* strains used for containment survived in raw sewage at roughly one-half the rate of indigenous bacteria. When bacteria containing vectors that mediate antibiotic resistance were added to antibiotic-treated sewage, the survival rate increased by 70%. When indigenous bacteria contained plasmids that allow "transfer" (a situation more likely to occur in natural systems), the survival rate increased even more dramatically. These studies indicate that the "safe vector" in the "high containment host" had *escaped* at a significant frequency, thus conferring antibiotic resistance on the indigenous bacteria. Surprisingly, these studies apparently had no bearing on the NIH Working Group on Revision of the Guidelines, who concluded that the hazards of using these hosts and vectors were minimal.[24]

At present, many other organisms, including microbes other than *E. coli*, as well as higher eukaryotes, are being used as hosts for rDNA. These organisms are not debilitated and can easily survive outside of a laboratory environment. If a harmful organism is accidentally released into the environment, there will be no way to recall it. Given the present attitude that rDNA technology poses no hazards, it is not surprising that few people seem to be concerned that biological containment is nothing more than an academic debate.

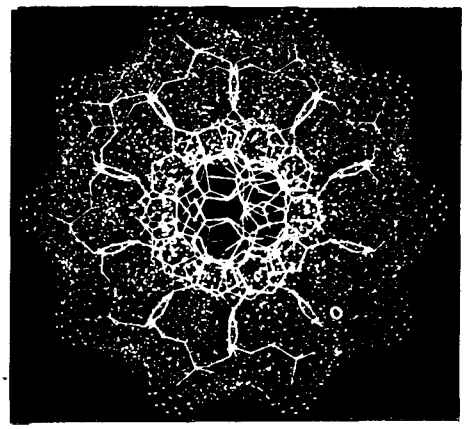
Regulation of rDNA Activities

The NIH Guidelines were designed for use within a system of self-regulation, where much of the responsibility to interpret potential hazards and to implement appropriate procedures rested with the scientists themselves. The Guidelines dealt with *potential* hazards and were necessarily cumbersome. It was clear that changes would be made as data was gathered about the *actual* hazards of particular research.

In spite of the fact that an adequate risk assessment program was never established and little data was actually gathered, regulation of rDNA activities was left to the institutions conducting this work. Responsibility for insuring compliance was vested in the Institutional Biosafety Committee (IBC), the Biological Safety Officer, and the Principal Investigator. Presently, there are no federal agencies in place to enforce compliance. Thus, the fox has been left to guard the chicken coop.

The circumstances that led to the dismantling of the Guidelines are complex and involve decisions that were made within the inner circles of the scientific establishment.[25] Although hearings are now being conducted to determine what type of regulatory policies should be enacted, most of the discussion is focusing on issues related to the commercialization of rDNA technology.[26] The issue of the potential biohazards of routine rDNA work has practically been forgotten.

The lack of adequate federal regulation has resulted in local initiatives in some areas of the country to compensate for this vacuum. In particular, the City of Cambridge, Massachusetts recognized early in the debate that citizens have a right to be involved in decisions about the consequences of any new technology. The Cambridge Experimentation Review Board



Perhaps worst is the development of lax attitudes about the potential hazards of rDNA work. Attempts to encourage more caution or adherence to containment guidelines seems contradictory in light of what is practiced.

(CERB), a citizens' committee created by the Cambridge City Council in 1976, was charged with reviewing the issues concerning rDNA technology. In a report to the city council, the CERB emphasized:

> While we should not fear to increase our knowledge of the world, to learn more about the miracle of life, we citizens must insist that in the pursuit of knowledge appropriate safeguards be observed by institutions undertaking this research. Knowledge, whether for its own sake or for its potential benefits to humankind, cannot serve as a justification for introducing risks to the public unless an informed citizenry is willing to accept those risks. Decisions regarding the appropriate course between the risks and benefits of a potentially dangerous scientific enquiry must not be adjudicated within the inner circles of the scientific establishment.[27]

As a result of the CERB's recommendations, the City of Cambridge established its own Biohazards Safety Committee composed of public health officials and local citizens. The city also enacted an ordinance which mandates:

> All use of rDNA by institutions in the City of Cambridge shall be undertaken only in strict conformity with the [November 21, 1980] 'Guidelines,' . . . and in conformity also with such other health regulations as the Commissioner of Health and Hospitals may from time to time promulgate.[28]

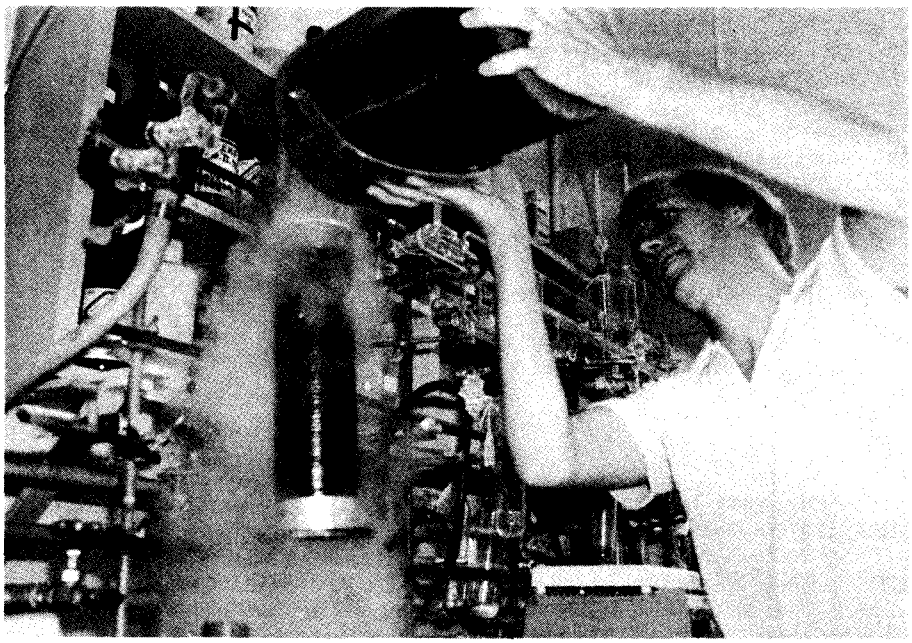
This ordinance was to remain in effect regardless of whether the NIH chose to discontinue or abolish their guidelines.

The Cambridge city ordinance goes beyond the scope of the NIH Guidelines in terms of requiring additional containment facilities, and appropriate education and medical surveillance programs for all persons engaged in the use of rDNA. It outlines a policy by which compliance with these regulations can be monitored and provides for a fine of $200.00 per day for violations and, if necessary, a shutdown of the facility by the Commissioner of Health and Hospitals. In spite of these "strict" regulations, rDNA technology is flourishing at Harvard, MIT, and a number of biotechnology companies in Cambridge.

Other areas of the country have passed similar legislation;[29] yet, it is senseless to rely upon individual communities to take the initiative in dealing with the potential health and safety problems of recombinant DNA. The problem of rDNA safety is of such a magnitude that it must be addressed on all levels, including both national and international. Furthermore, input must be received from an informed citizenry capable of making rational decisions about risks that will inevitably be bourne by all of society.

What of the scientists? There were hopeful stirrings of social responsibility at Asilomar in 1975. But these have faded, as concerns about health and safety have taken a back seat to the achievement of short-term goals. And yet, it is now—before it is too late—that the spirit of Asilomar should be rekindled. The scientists themselves, first and foremost the people most knowledgeable about the technology, should take the initiative and heed the advice of Daniel Singer:

> They cannot remain aloof and greet each new public problem and misapplication by abdication. They have a responsibility to become involved as citizens in the sometimes unpleasant business of public argument and decision-making. . . . If scientists—who continue to startle us with their damnable cleverness—cop out on the problems they create, the public may turn on them and/or they will share the fate of physicists who (probably through no fault of their own) have for a generation been wringing their hands and donning hair shirts to expiate their guilt.[30]



Ellen Shub

REFERENCES

1. P. Berg, et al., "Potential biohazards of recombinant DNA molecules," *Science* 183:303. 1974.

2. *Idem.*

3. For a chronology of events and citation of references, see: S. Krimsky, *Genetic Alchemy: The Social History of the Recombinant DNA Controversy*, MIT Press: Cambridge, 1982.

4. For example, see: T. Maniatis, E.F. Fritsch, and J. Sambrook, *Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor Laboratories: Cold Spring Harbor, 1982.

5. Krimsky, *op. cit.*

6. For a review of risk assessment studies, see: D. Bartels, "Occupational Hazards in Oncogene Research," *geneWATCH*, 1(5-6):6-8, September-December 1984.

7. D. Bartels, "Polyoma Risk Assessment: The Politics of a Worst Case Analysis," (Unpublished).

8. B. Rosenberg and L. Simon, "Recombinant DNA: Have Recent Experiments Assessed All the Risks?," *Nature* 282:773-774, 1979; S. Krimsky, *op. cit.*; S.A. Newman, "The 'Scientific' Selling of rDNA," *Environment* 24(6):21-57, July-August 1982; D. Bartels, "Oncogenes: Implications for the Safety of Recombinant DNA Work," *Search* 14(3-4):88-92, April-May 1983.

9. Paul Berg, letter to DeWitt Stetten, Jr., September 4, 1975, Recombinant DNA Controversy Collection, Institute Archives and Special Collections, MIT Libraries, Cambridge, MA.

10. Newman, *op. cit.*, p. 22 (note 8).

11. S. Wright, "The Status of Hazards and Controls," *Environment* 24(6):12-53, July-August 1982, pp. 15-16.

12. T. Hunter, "The Proteins of Oncogenes," *Scientific American* 251:70-79, August 1984.

13. C.M. Croce and G. Klein, "Chromosome Translocations and Human Cancer," *Scientific American* 252:54-60, March 1985.

14. Bartels, *op. cit.*, p. 7 (note 6).

15. "Recombinant DNA Research: Request for Public Comment on 'Points to Consider in the Design and Submission of Human Somatic-cell Gene Therapy Protocols'," *Federal Register* 50(14):2940-2945, January 22, 1985.

16. R.D. Cone and R.C. Mulligan, "High-efficiency Gene Transfer into Mammalian Cells: Generation of Helper-free Recombinant Retroviruses with Broad Mammalian Host Range," *Proc. Natl. Acad. Sci. USA* 81:6349-6353, 1984.

17. Berg, *op. cit.* (note 9).

18. IBC Memorandum 83-1, National Institutes of Health, June 16, 1983.

19. Berg, *op. cit.* (note 9).

20. *Idem.*

21. S.B. Levy and B. Marshall, "Survival of *E. coli* Host-vector Systems in the Human Intestinal Tract," Progress report to the NIH on NIAID contract No. NIA 72529, July 1979.

22. S.B. Levy, B. Marshall and D. Rowse-Eagle, "Survival of *Escherichia coli* Host-vector Systems in the Mammalian Intestine," *Science* 209:391-394, 1980.

23. B.P. Sagik, C.A. Sorber and B.E. Moore, "The Survival of EK1 and EK2 Systems in Sewage Treatment Plant Models," in S.B. Levy, R.C. Clowes and E.L. Koenig, eds., *Molecular Biology, Pathogenicity and Ecology of Bacterial Plasmids*, Plenum Press: New York, 1981, pp. 449-460.

24. National Institutes of Health Working Group on Revision of the Recombinant DNA Guidelines, "Evaluation of the Risks Associated with Recombinant DNA Research," *Federal Register* 46:59385-59394, December 4, 1981.

25. Krimsky, *op. cit.* (note 3).

26. Office of Science and Technology Policy, "Proposal for a Coordinated Framework for Regulation of Biotechnology," *Federal Register* 49(252):50856-50877, December 31, 1984.

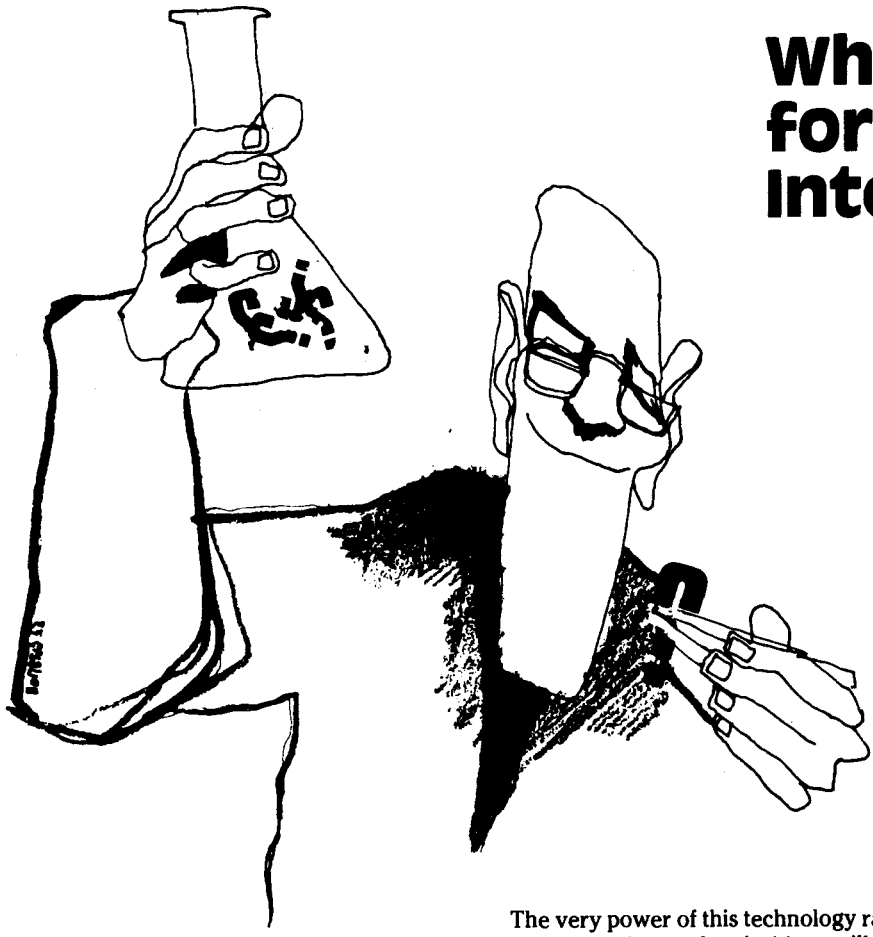
27. A shortened version of the CERB report was published in *The Bulletin of Atomic Scientists* 33:23-27, May 1977.

28. City of Cambridge Ordinance No. 955, Final Publication No. 2092, first published in the Cambridge City Chronicle on April 2, 1981.

29. S. Krimsky, "A Comparative View of State and Municipal Laws Regulating the Use of Recombinant DNA Molecules Technology," *Recombinant DNA Technical Bulletin* 2(3):121-125, November 1979.

30. Speech by Daniel Singer to the Society of Sigma Chi (scientific honor society), published in the *Congressional Record-Senate*, July 23, 1970, p. 25603.

SETTING PRIORITIES IN BIOTECHNOLOGY



Who's Looking Out for the Public Interest?

by Marc Lappé

Recombinant DNA-based technology is likely to revolutionize virtually every field touched by biological and chemical processes. An enormous spectrum of fermentation and genetically-based products will be produced by this new technology, making common biological molecules like growth hormone and insulin that previously were rare or inaccessible to clinicians. Recombinant DNA techniques also promise to break the code of key parasites and viruses that have eluded our best efforts at developing effective vacines by constantly changing their surface proteins.

The very power of this technology raises urgent questions of priorities—will the products chosen for development fulfill the ongoing needs of the broader society, or will they serve only those who can pay? Who will make these choices? Choices of most recombinant DNA (rDNA) products are now dictated almost exclusively by pure commercial interest and feasibility, often leaving unanswered those that might be dictated by human need.

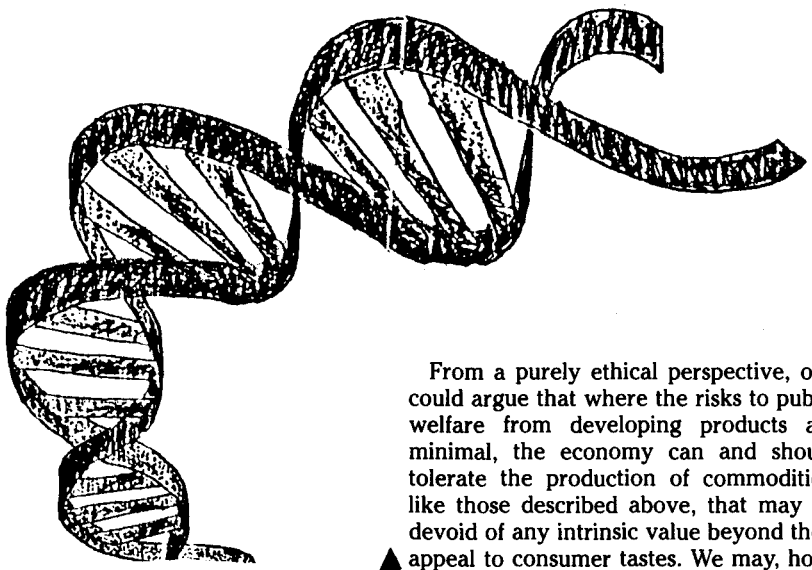
Priority setting is now only being recognized as a crucial element of the biotechnology revolution. Just what kinds of forces now drive the selection of priorities in the industry are difficult to discern, but at least some of the major features became evident in discussions I have had with industry leaders. For some executives, like J. Leslie Glick of Genex Corporation, the factors behind the choices are self-evident: profitability, projected market shares, proportionate risks of potential for growth.[1] In Glick's view, the specter of heavy government regulation in areas like pharmaceuticals looms as a disincentive for development.

Genex's almost unique concentration on specialty chemicals for use in waste and water treatment, food processing, agricultural products and mold removal is the result of a priority-setting scheme that tends to minimize both potential legal pitfalls and competition. Genex's priorities are based on three considerations: 1) avoidance of heavily regulated areas, 2) estimation of the size of the market, and 3) projection of the likely competition and hence Genex's "edge". Although not all companies take this same perspective, many do share some component of it. This alone suggests that the forces which shape the choices of the private sector will not necessarily select for biotechnological products that will have the greatest potential for human benefit.

Indeed, some observers have noted the recent emergence of a "junk biotechnology" industry[2] in which companies emphasize the production of relatively

---

Marc Lappé is the author of the forthcoming book Broken Code: The Impact of the Recombinant DNA Revolution *from which this article is adapted.*



small volumes of scarce and expensive commodities such as flavors, fragrances and perfumes. The 1984 *International Biotechnology Directory* lists 63 different firms worldwide that produce such products. Major food producers and processors such as Campbells and General Foods have invested in research on new processes which can increase their efficiency in mass marketing cookies and other bakery products with an rDNA generated artificial "fresh-baked" smell.

Other companies have devised schemes for exploiting their biotechnology capabilities to produce products which are even less relevant to fundamental human needs. In the early 1980s, the management of Frito-Lay Corporation attempted to launch a program to genetically engineer potatoes so that they would have up to 50 percent less water. This was not motivated by the goal of making potatoes a more nutritive source of carbohydrate or protein. Rather, Frito-Lay consultants noted that the principal cost factor in their potato chip division was the transportation costs of the potatoes. The high weight per volume of the potato and subsequent need for processing to remove unwanted water were the major impediments to efficient production. The project went on the rocks when the principle Frito-Lay scientist voiced his reservations that genetic techniques could really be engineered over the short run to accomplish this major bio-engineering feat.

The question of whether or not such an objective was consonant with human nutritional needs was never asked. We are, after all, not in the habit of holding the food industry in general, or the junk food industry in particular, accountable for the human impact of their production choices. But I would argue that the time and circumstances dictate that we do so for the biotechnology industry.

From a purely ethical perspective, one could argue that where the risks to public welfare from developing products are minimal, the economy can and should tolerate the production of commodities, like those described above, that may be devoid of any intrinsic value beyond their appeal to consumer tastes. We may, however, draw the line when a product is made on such a vast scale that it can only be produced at the expense of other, more essential uses of certain basic resources.

Will the products chosen for development fulfill the ongoing needs of the broader society, or will they serve only those who can pay?

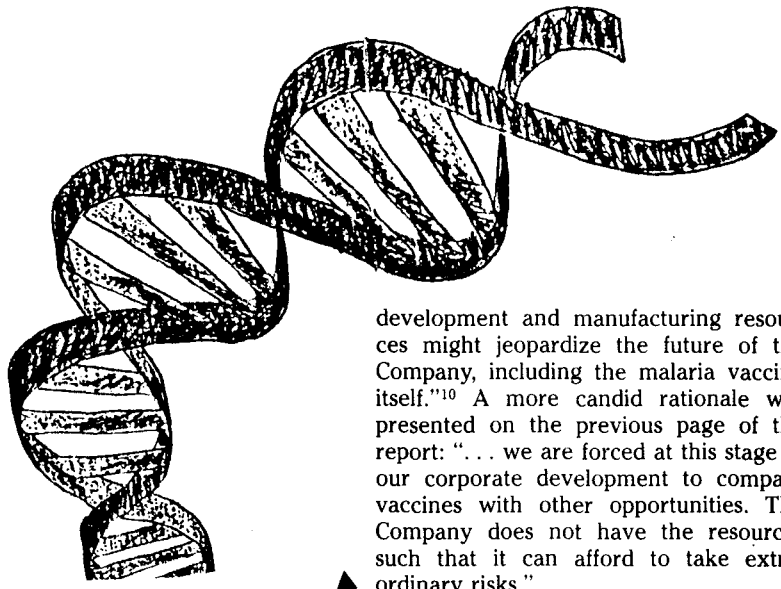
Such a line may also be drawn when a commercial process, such as the elaborate fermentation needed to convert cellulose to an energy source or a food stuff, is so valuable that to divert the hardware to other ends destroys the likelihood of harnessing it for an essential human product or goal. The more usual case, in which companies produce a diversity of products, proves more difficult to assess. However, a common theme that seems to be emerging in an analysis of the industry is the tendency of companies to invest selectively in high "value-added" commodities, such as hormones, blood clot dissolving enzymes or other expensive polypeptides for the treatment of rare human disorders in lieu of investment in products that would benefit a broader cross section of humanity.

Human Health Needs

According to the World Health Organization (WHO), three categories of diseases are responsible for over 80 percent of illness worldwide.[3] First, there are the enteric diseases, including the bacteria-produced dysenteries, cholera, typhoid fever and amoebic dysentery. Together, these are responsible for over 20 million deaths annually.[4] Second in importance are the parasitic diseases such as leshmainiasis, malaria, trypanosomiasis and river blindness. The third category, granulomatour diseases, includes leprosy, which is experiencing a resurgence worldwide.

One of the first statements calling for a broader role for biotechnology in reducing the public health impact of this constellation of diseases was made in a 1982 report of a multinational workshop held under the auspices of the National Research Council.[5] Four points stand out in this report: 1) all of the disease earmarked for intensive high priority biotechnological investigation (included in the list above) are highly prevalent in the Third World and less so in developed countries; 2) most have been undervalued as problems worthy of research investment by major pharmaceutical houses in developed countries; 3) many promising avenues for prophyllaxis or treatment that rely on genetic engineering techniques exist; and 4) a high degree of cooperative effort is essential for realizing success in treatment of these diseases. In the light of these comments, it is instructive to examine the history of one of the major genetics firms in the use of rDNA techniques to develop a vaccine for malaria.

Recombinant DNA-based processes offer a relatively safe and dependable way to generate vaccines with minimal risks of contamination or infection. A malaria vaccine holds out the greatest promise to relieve human sufferings of all those currently being considered, since malarial parasites cause illness in some 200-400 million people worldwide and kill a million children annually in Africa alone. While the development of a malaria vaccine is a difficult task due to the different forms of the malaria parasite assumes, scientists in Australia, England, and the U.S. have isolated antigens from at least two of the stages of the parasite. In particular, the work of husband and wife team Drs. Victor and Ruth Nussenzweig of New York University has brought us to the threshold of feasability in the development of such a vaccine. It was against this background that New York Univeristy and the World Health Organization approached Genentech to assist in actually bringing to mar-



ket a vaccine prototype. One of WHO's basic requirements is that the public have access to any research developed under its sponsorship. Genentech, however, wanted exclusive rights to the vaccine in order to protect its investment. According to published accounts, it was this impasse that led to Genentech's withdrawal from the project.[6] The actual story is more complex.

In early 1984, Genentech's Vice President for Research, David W. Martin, provided the study Committee on Issues and Priorities for New Vaccine Development of the Institute of Medicine of the NAS with some of his company's reasons for declining further participation.[7] Martin pointed out that the products that Genentech produces had been carefully selected to provide their stockholders with a significant return on investment. He described Genentech as a "young and small" company. (It is among the three largest genetic engineering companies in the world—and according to its 1982 annual report, capitalized with at least $85 million of shareholders equity.) In spite of its substantial capitalization, Martin argued that Genentech "has insufficient discretionary resources to provide for the development and manufacture of products for which the market is ill-defined, diffuse and dependent upon governmental sponsorship or advertising."[8] The market for a malaria vaccine covers at least 200 million people in the developing world, and is very well defined in both WHO and CDC publications.[9]

Genentech addressed the "humanitarian" side of the argument in its corporate decision-making process by contrasting different humanitarian goals. According to Martin, "Clearly there is the humanitarian issue, but it was concluded that the necessity to displace other potential products (also having humanitarian value) from our development and manufacturing resources might jeopardize the future of the Company, including the malaria vaccine itself."[10] A more candid rationale was presented on the previous page of the report: ". . . we are forced at this stage of our corporate development to compare vaccines with other opportunities. The Company does not have the resources such that it can afford to take extraordinary risks."

But Genentech clearly took such a risk with its project to produce the Factor VIII. What was the difference? One clue can be seen in their Board of Director's Annual Report of 1982. As stated on page 3 of this report, "Genentech's goal is to obtain the highest return on its substantial research investment by manufacturing and marketing the products it develops. Toward this end, the company has focused on products that will allow early market entry."[10]

The Annual Report also highlighted AAAS President Phillip Abelson's endorsement of Genentech's "judicious choice of projects to tackle."[12] The Company's priority setting scheme clearly did not include the choice of a malaria vaccine, in part according to Martin, because the market for such a vaccine was too "diffuse and global"—Martin cited Genentech's limited familiarity with regulation, marketing and distribution in foreign countries," although this has not served as an obstacle to Genentech's collaborative development (with Eli Lilly) of insulin in the world market. Some of the Genentech's motives with malaria were alleged to be self-protective, since Martin implied a malaria project might bankrupt the Company.

Finally, the paper concluded with a clear-cut statement of preference. The bottom line, in Martin's candid monograph was simple: "Thus it seemed apparent that

the development of a malaria vaccine would not be compatible with Genentech's business strategy."[13] So here was a clear instance where the world may have been denied—in the short run at least—a critical commodity from a company that has its roots in public investments in basic scientific research.

Dislocation

Priority schemes for rDNA projects that rely on this type of "business necessity" argument also raise the question of how much the issue of social dislocation is considerd by biotechnology firms. Some critics have cautioned that major investments in rDNA industries can cause social disruptions in less-developed economies. For instance, the introduction of hybrid seeds by companies under the control of a few multinational corporations can make small farmers dependent on outside corporate interests at the expense of self-sufficiency, or displace ecologically important, traditional seed varieties.[15]

The displacement of traditional sugar commodities by biotechnology-assisted production of high fructose corn sugars constitues another example of potentially undesirable social dislocation. Through the use of immobilized enzymes and the as yet experimental conversion of sucrose to fructose through direct bioengineering, the rDNA industry is augmenting the displacement of sugars, such as sugar cane, that have been largely produced by less developed countries.

Because high fructose corn syrups are capital- rather than labor-intensive, they are more commonly produced in developed countries. With import quotas and the traditional volatility of the sugar market, the U.S. is displacing cane and other Third World sugar crops with high fructose corn sweetners produced under industrial conditions. The possibility that such displacement may also increase the frequency of certain diet-dependent diseases such as diabetes or coronary artery disease, in addition to jeopardizing many weak economies, further reinforces the argument against allowing such major transitions to occur without close public scrutiny.

Public Input

In the absence of public input regarding the priorities that industry should follow, it is highly likely that investments will continue to be made that are proportional to economic gains and not necessarily to public benefit. As Sheldon Krimsky has pointed out, "If social priorities are not set for the use of rDNA technology, then the public will miss out on important applications which private markets will not find profitable to pursue."[16] Krimsky sites the example of "orphan drugs"—therapeutic treatments that have stood by the wayside, waiting for a more profitable picture to assure their development.

One solution has been suggested by the influential scientific planner, Carl-Goran Heden of the Karolinska Institute in Stockholm. Heden believes that rDNA technologies should be given an important role in stimulating the development of novel sources of fuel, fertilizer, food and fodder for the developing countries. Writing in 1981 for the United Nations Industrial Development Organization (UNIDO).[17] Goran proposed that biotechnology could serve the public good most by harnessing natural systems that could provide the direct benefits to people in underdeveloped nations. But, this view of biotechnology is at variance with the commercial view, since it requires investments in basic science as well as start-up costs—and promises very little return.

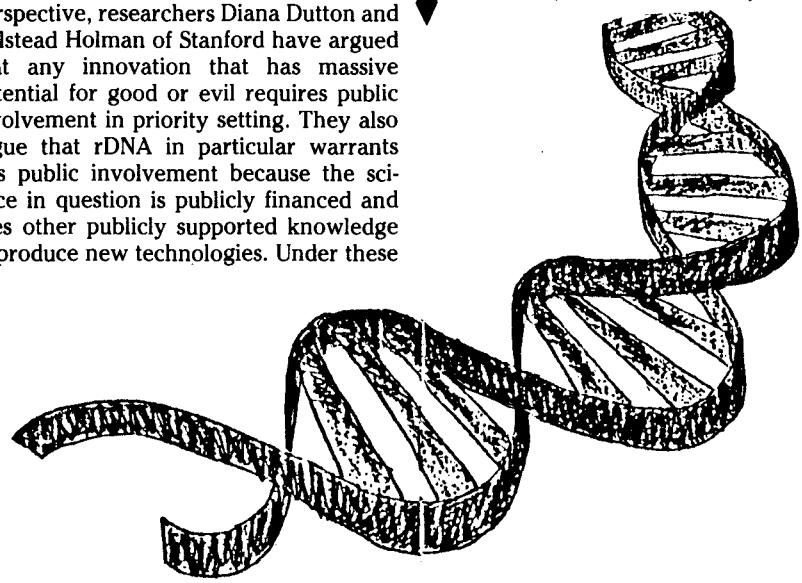
In a world of supply and demand, in which market forces are allowed to shape the distribution and sales of even so basic a commodity as wheat, how can the claim be made that the choice of what products will be produced by rDNA processess warrants closer scrutiny? From a public policy perspective, researchers Diana Dutton and Halstead Holman of Stanford have argued that any innovation that has massive potential for good or evil requires public involvement in priority setting. They also argue that rDNA in particular warrants this public involvement because the science in question is publicly financed and uses other publicly supported knowledge to produce new technologies. Under these conditions, Dutton and Holman maintain that "the fruits of science are a public possession and their distribution a matter of public concern."[18]

Arguments for Priority Settings

At root, two arguments for moving away from the present laissez faire philosophy of regulation that allows the biotechnology industry to be controlled primarily by market forces appear cogent and justified. Both evoke the principle of equity.

The first argument hinges on a growing consensus that equity should be a major determinant of how the results of any new medical research are distributed. This view has been underscored by the President's Commission when it wrote of the imperative to assure equal access of all groups in society to the benefits of medical research.[19] The basis for a similar assertion in the instance of recombinant DNA-based technologies turns on something more than a simple restatement of the investment principle: that because public funds were used to develop this technology, the public at large—at least as much as the late-comer entrepreneur—deserves a portion of the proceeds and benefits. In addition, recombinant DNA-based research may often be the *only* vehicle to

The biotechnology industry has a special obligation to recognize the distributional aspects of human need when determining its internal priorities.



solutions to life-threatening problems of major diseases, resources or energy availability—all of which are unequally distributed among the poor and Third World nations.

The second argument turns on the legitamacy of the assertion that the biotechnology industry has a special obligation to recognize the distributional aspects of human need when determining its internal priorities. These aspects turn more on the degree of need than on the ability to pay. When considering the possibility that biotechnology would someday be able to modify the course of genetic disease, for example, the President's Commission argued that we have a fundamental obligation to use genetic technologies to protect or improve the health of children consistent with assuring "an adequate minimum of health care" as measured across the needs of the population as a whole.[20]

Something beyond passive oversight is needed to ensure that "enlightened self-interest" does not blindly direct all major policy decisions.

Ultimately, the acceptance of a comparable principle of equity in the distribution of the broad spectrum of technological benefits that might come from rDNA research depends on society's commitment to distributional justice. But where does the responsibility for effecting such ends lie? Sheldon Krimsky asserts that it is governments' responsibility "to guide the benefits so that they are at least shared equitably and at most shared in a manner that narrows distributional gaps." Among the examples he cites are the need to insure that small farmers are not disadvantaged by being denied access to new strains of genetically engineered seed stocks, that consumers get better quality products at more reasonable prices, and that environmental health is not traded off for higher rates of return to the producer.[21]

Whether the benefits of rDNA technology reduce or exacerbate existing inequities in the distribution of essential world resources depends on a complex mix of political and economic realities. A more radical construction would require the benefits of rDNA technology to be shaped to fundamental social and ethical ends. These ends would include uses that contribute to: 1) a basic minimum of health and well-being among the world community; 2) more equitable control and distribution of production of essential commodities and resources; and 3) redress of the inequalities of distribution of basic food stuffs and medicines that now characterize much of the developing world.

Of course it is beyond the ability of any single technology to achieve these ideals in and of itself. But it appears reasonable to ask what a technology largely developed with public funds and in the domain of critical medical innovation choose its ends with the public weal in view. Certainly it is reasonable to ask that a new technological development does not exacerbate existing inequalities.

A list of interventions can be examined to determine where rDNA technology can be responsive to inequalities. A major step in this direction was taken at a workshop on Priorities in Biotechnology Research for International Development held in Washington, D.C. and Berkeley Springs, West Virginia from July 26-30, 1982.[21] While participants at this workshop were drawn from developed as well as developing countries, the specific objectives they identified reflect a common commitment to priorities that meet the needs of Third World Countires. The human diseases they identified for vaccine development were those like Dengue, bacterial respiratory and enteric diseases, malaria and lesihmaniasis that are most common in the underdeveloped world. The animal diseases were likewise those causing the greatest depradations of livestock in developing countries.

The agricultural priorities for crop plants reflected a concern that development assistance agencies provide mechanisms that would assure that equitable distribution of rDNA related developments. For instance, among their overall recommendations, the participants advised that funding agencies give "highest priority to proposals that include provisions ensuring that the products of tissue culture technology research farmers and consumers" in the developing countries.[23]

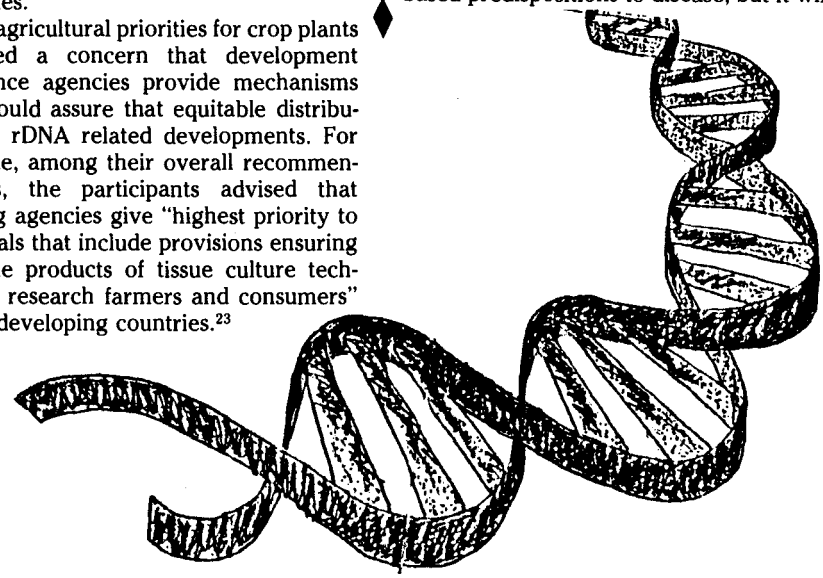
Recently, a group met to define what priorities would be the most desirable for Third World countries were biotechnology to be expanded to centers outside of the U.S., Europe, and Russia. The Council on International and Public Affairs in conjunction with the International Center for Law in Development proposed four objectives for such a study:

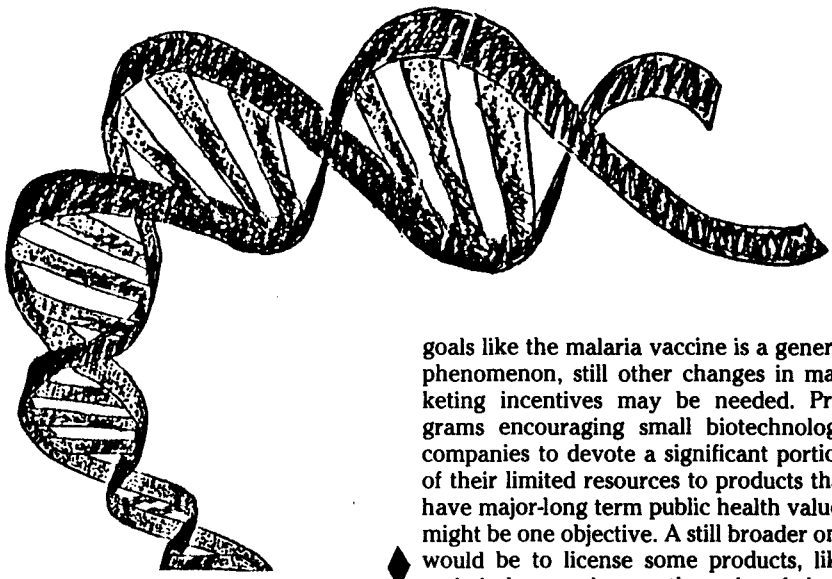
1. to increase the equitable access of developing countries to the fruits of biotechnology;
2. to reduce external dependency an utilizing biotechnological advances to meet indigenous needs of food, energy and related fields;
3. to keep close watch on the social and economic consequences for the poor that flow from the introduction of these new technologies; and to enlarge the scope of public participation in decision making about biotechnology, particularly for communities that are now disenfranchised by their position in the marketplace.[24]

The objectives of this joint work suggest a common recognition of at least two of the themes that have been stressed in this article: the claim for equity and the interest in increasing the scope of public involvement in oversight and decision-making.

Oversight and Alternatives

Now such an oversight committee appears within reach. Under the authorship of Senator Albert Gore (D-Tennessee), a special Commission is planned that will review the ethical implications of recombinant DNA based applications. Its purivew will likely be limited to medical applications interventions for human gentic diseases, or screening for genetically based predispositions to disease, but it will





have the potential for overseeing a much wider swath of biotechnology. Senator Gore invoked the past history of nuclear energy regulation in arguing the merits of this Commission.[25]

Although government regulations may involve some problems, I would endorse the President's Commission conclusion that continuing public involvement is not only desirable but necessary to ensure the responsiveness of the industry to public needs, and to assure that its evolution is done in public view. In concluding their 1982 report, the Commission declared, "Assuming that (rDNA) research will continue somewhere, it seems more prudent to encourage its development and control under the sophisticated and responsive regulatory arrangements of this country, subject to the scrutiny of a free press and within the general framework of democratic institutions."[26]

Clearly, however, something beyond passive oversight is needed to ensure that "enlightened self-interest" does not blindly direct all major policy decisions. One solution is to change the market conditions themselves to favor those investments that would best serve the public interest. Some have suggested that such priority-facilitating schemes could be patterned after the "Orphan Drug Act" that gave pharmeceutical giants incentives to develop commodities with limited market potential.[27] A second alternative is to tighten the public accountability of the industry. This could be done by adopting the models used in regulating public utilities and nuclear energy. A Public Biotechnology Commission could oversee price-setting for certain key or essential biomolecules, establishing broad guidelines for safety now lost in the internecine squabbles among federal agencies. If the apparent unwillingness of some biotechnology firms to pursue broad public health goals like the malaria vaccine is a general phenomenon, still other changes in marketing incentives may be needed. Programs encouraging small biotechnology companies to devote a significant portion of their limited resources to products that have major-long term public health values might be one objective. A still broader one would be to license some products, like anti-viral vaccines, through federal agencies.

Priority setting is now only being recognized as a crucial element of the biotechnology revolution.

The Federal government can clearly assist in providing support for biotechnology firms, perhaps by giving special incentives for investment in desirable products. International cooperation may also be needed, as when WHO strategy made eradication of small pox possible. Given the unique origins and sometimes exclusive value of recombinant DNA based biotechnologyy, powerful moral arguments exist to encourage these developments. Biotechnological products have the potential of affecting the health of every major population group on earth. But as long as biotechnology companies "must" opt for financial security, this opportunity will be lost. ★

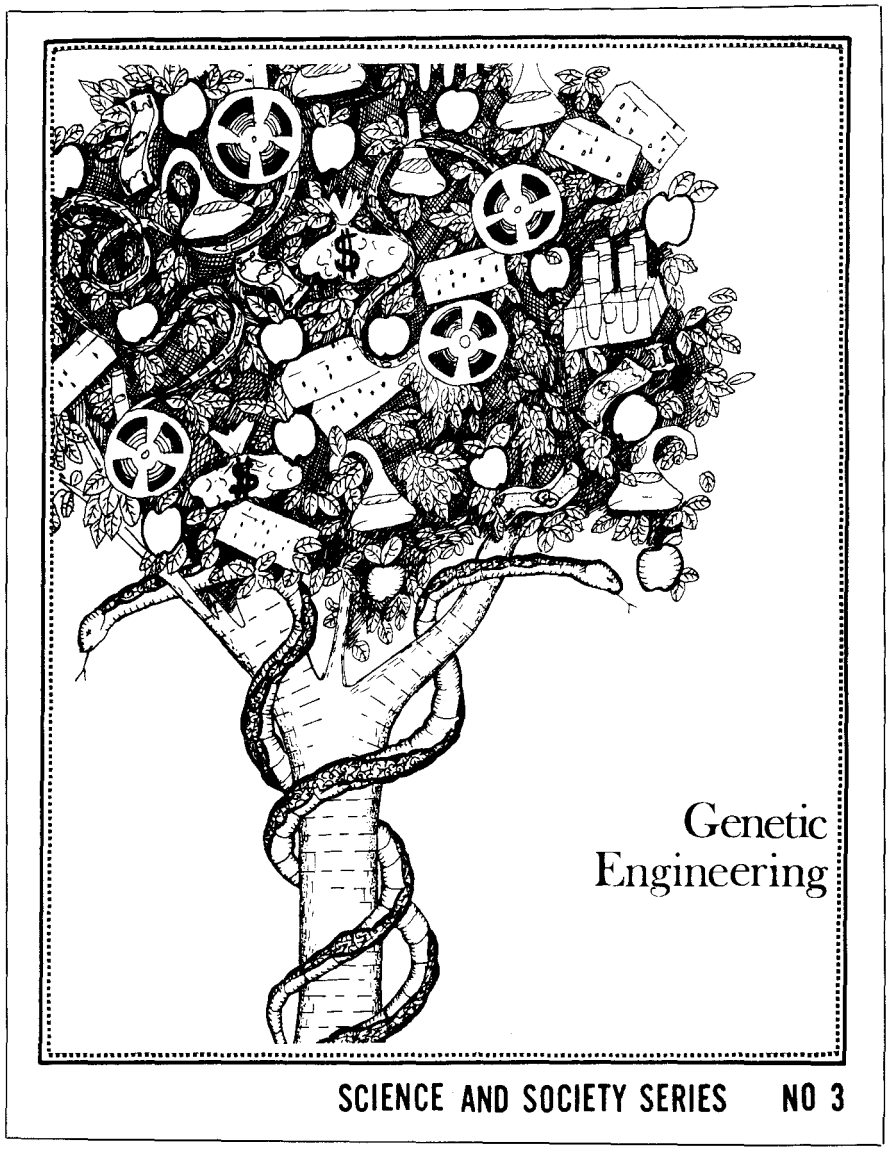
REFERENCES

1. Interview with J. Leslie Glick, CEO Genex Corporation, of February 10, 1984.
2. Burke Zimmerman, personal communications of January 23, 1984.
3. World Health Organization Report, Geneva, 1982.
4. *Ibid.*
5. National Research Council, *Priorities in Biotechnology Research for International Development*, Washington, D.C., 1982.
6. See *"Genetic engineering makes malaria vaccine possible," The Cincinatti Enquirer,* July 3, 1984, p. A-1; A-8.
7. David W. Martin, Jr., "Issues in vaccine development from the perspective of a 'new biotechnology-based company,'" Paper presented to the Committee on Issues and Priorities for New Vaccine Development, Institute of Medicine, NAS, Washington, D.C., 1984.
8. *Ibid.*, p. 4.
9. See in particular, volume 29 of the *American Journal of Tropical Medicine and Hygiene*, 1980, which presents a symposium on "DNA Technology and Parasites." For discussion of the WHO Special Program for Research and Training in Targetted Diseases of the Third World, See *Tropical Diseases Today—The Challenge and the Opportunity*, WHO Geneva, 1975; and *Transactions of the Royal Society of Tropical Medicine and Hygiene* 73: 147-149, 1979.
10. Martin *op. cit.*, p. 5.
11. Genentech, Inc., Annual Report, South San Francisco, CA, 1983, p. 3.
12. Phillip H. Abelson, "New biotechnology companies," *Science* 219: 609, 1983.
13. Martin p. 6.
14. Martin states on p. 6, that Genentech would continue to assist the Nussenzweig's "informally" so that a vaccine might be developed "at another institution."
15. Gary Fowler, "Sowing the seeds of destruction," *Science for the People*, Sept/Oct 1980, p. 8-10.
16. Sheldon Krimsky, "Biotechnology and unnatural selection: The social control of genes," in: *Technology and Social Change in Rural Areas*, Gene F. Summers, editor, Westview Press, Boulder, Colorado, 1983.
17. Carol-Goran Heden, United Nations Industrial Development Organization (UNIDO), Report No. 261, New York, Nov. 27, 1981, 69 pp.
18. Halstead R. Holman and Diana B. Dutton, "A case for public participation in science policy formation and practice," *Southern California Law Review* 51: 1505-1534, 1978. at 1520.
19. U.S. President Commission of the Ethical Problems in Medicine and Biomedical and Behavioral Research, *Splicing Life*, p. 51ff.
20. *Ibid.* p. 66.
21. Sheldon Krimsky, "Biotechnology and unnatural selection," p. 57.
22. *Priorities in Biotechnology: Research for International Development*, National Academy Press, Washington, D.C., 1982.
23. *Ibid* p. 17.
24. International Center for Law in Development and Council on International and Public Affairs, "Work on biotechnology and the Third World," undated publication distributed by The Council on International and Public Affairs, 777 United Nations Plaza, New York, NY 10017.
25. Albert Gore (D-Tenn), "Regulation of biotechnology," *Science* 225: 6, 1984.
26. *Splicing Life* at p. 78.
27. See for example "Gene-splicing protein to have orphan drug status," *Science* 223: 914, 1984, for a report of the first such application.

SftP AND rDNA

Science for the People's Involvement

by Kostia Bergman



The involvement of Science for the People in the genetic engineering issue began before recombinant DNA techniques were invented. As early as 1972 the Science Teaching Group of Boston SftP wrote and distributed a pamphlet called "Genetic Engineering." This pamphlet, prepared as syllabus material for high school science teachers, warned of potential dangers in the social misuse of current and future genetic technologies. In particular, potential dangers involving cloning of mammals and genetic screening were discussed. Subsequently, some of the members of this group were also involved in the controversy over investigations designed to document the alleged connection between the possession of two Y chromosomes (the XYY karyotype) and criminal behavior.

During the Summer of 1974, the famous letter suggesting a "moratorium" on certain genetic experiments involving some newly developed techniques (recombinant DNA techniques) appeared in the scientific press and made headlines in the newspapers. The reason for the moratorium was concern over the escape of potentially dangerous newly-created organisms from the laboratory.

Kostia Bergman is a microbiologist at Northeastern University and a longstanding member of SftP.

At the first Science Teaching Group meeting in the Fall, several members who were also professionally involved in the genetics and physiology of microorganisms expressed particular concern about these new technologies and urged the other members present to become involved in what they felt sure was an important issue and one likely to become a test case in the involvement of nonscientists in the control of a new technology. There was mixed feeling about the importance of the issue but all present felt it was crucial to widen the scope of the debate from narrow issues of containment to issues of eventual use of the technology and questions of who had the right to control the technology.

A working group was set up to participate in three projects: first, to appeal to the organizers and participants at the Asilomar meeting (which had been organized to decide on the future regulation of the new techniques) to broaden the scope of

their meeting; secondly, to accept an invitation to present our point of view at the large annual meeting of the American Society for Microbiology; and third, to organize a group of impacted workers—technicians, janitors, bottle-washers, media preparators, etc.—of the Biology Department at MIT.

Of the three, the plan which was the most exciting to the group was the attempt to organize the laboratory personnel. It was also the least successful because the reaction of the employers—the principal investigators in the Biology Department—was swift. Those who organized the meeting, several post-docs and a professor, were directly confronted and made to feel quite unwise and potentially "out of the club." When a survey of lab safety practices was finally done, the technician who was going to present the results at a national scientific meeting was prevented from going. Because of these setbacks, the other two plans—petitions to the authorities and invitations to speak at various forums—became the main SftP actions on the issues.

As the Asilomar Meeting approached it was unclear how it would turn out. Many supposed that the meeting would be a "whitewash" and that after it was over it would be back to "science as usual." Others suspected that a corner had been turned and it would not be so easy to get out of the spotlight of the press. In fact, everyone was probably surprised at the eventual outcome, which was a "technical fix." The Organizing Committee of the meeting announced that there was indeed a potential hazard to the cloning of recombinant DNA molecules in *E. coli* but that the problem could be solved by using the same genetic technologies that had made the techniques possible to engineer strains of *E. coli* that could never escape from the laboratory.

Despite the opening created by the containment issue, we have seen little progress toward effective public debate on the wider, social impacts of genetic R & D.

This solution to the problem had a profound impact on the future course of the debate and SftP's part in it. On the one hand, a large group of scientists had now opened their own doubts about the safety of their plans to public view. In fact, the nature of their solution entailed the creation of some kind of regulatory structure to set up "rules" for their own endeavors. The nature of this regulatory framework and the guidelines it would eventually construct clearly presented an opening for greater public involvement in the conduct of science in the U.S. On the other hand, SftP and other sympathetic groups had failed to shift the focus of the debate from issues of safety to broader issues of social impact. Even within SftP this became extremely hard to do. It often seemed more urgent to deal with the concrete questions of whether a particular safety precaution was really adequate for the potential hazards. This seemed all the more vital at the time because the organization was achieving a great deal of publicity and acceptance as a respectable critical group. Some felt that there was even the possibility of an end run; that we could gain time for the

Without real public debate the guidelines were loosened. The practitioners of the techniques decided to close ranks and allow each other to live and let live.

public debate on the social issues (questions of human gene manipulation, environmental hazards, military use, commercialization of biology) by vigorously joining the safety debate.

Beginning in 1975, public hearings on the containment issue were held in a number of cities and towns which had university laboratories engaged in recombinant DNA work. When the Harvard Bio Labs applied for NIH funds to install a moderate-risk (P3) facility, the ensuing landmark hearings before the Cambridge City Council became a highpoint of SftP involvement. However, I believe no one was quite prepared for the debate to take place in this highly charged public forum. Although the major outcome of these hearings was a reasoned response by the city to set up its own Experimental Review Board and eventually to require the enforcement of the NIH guidelines for all work done in the city, the highly charged political struggle certainly did not encourage scientists to continue to publicly question their work. Although SftP could point to the reasonable response which grew out of the public involvement, the emotional atmosphere of the hearings rather than the eventual outcome are what seemed to remain in the minds of many involved.

After the hearings, and SftP's involvement, other cities and university towns were inspired to take similar action, but the activity seemed to quickly switch to Congress and the NIH. The type of lobbying and expert testimony required for participation in that arena were not seen at the time as areas where SftP as an organization could be influential; although some help and support was given to other groups such as Friends of the Earth and the newly-organized Committee for Responsible Genetics, active work on the issue waned. After agreeing to require informed public participation on local safety committees and its own Regulatory Advisory Committee (RAC), the NIH did eventually succeed in getting general agreement for its guidelines. Congress did not take up the issue and the local ordinances were allowed to stand.

Formal participation on the RAC of informed non-molecular biologists and even nonscientists had been achieved, but discussions were clearly limited to safety and containment issues. The response of the increasing number of scientists using the techniques was to live within the regulatory framework but to lobby constantly for a weakening of the guidelines based on new evidence of the safety of the techniques. There seemed to be an agreement in this period to keep doubts to oneself and present a more united "we've taken care of things" attitude in public. Eventually without real public debate the guidelines were stripped of their strength and most experiments that anyone was really interested in doing were either exempted altogether or allowed with minimal containment. It is my opinion that this happened because the practitioners of the techniques decided to close ranks and allow each other to live and let live rather than because of any real new evidence of the safety of the techniques. Those who did not favor the weakening of the guidelines were continually outnumbered and found they could not keep the issue continually in the limelight.

A generation has now grown up since the pamphlet on "Genetic Engineering" was published and we are clearly on the threshold of the intentional release of new organisms created by recombinant DNA techniques and the application of the techniques to genetic therapy of humans. Despite the opening created by the containment issue, however, we have seen little progress to date towards the creation of a mechanism for effective public debate on this issue.

The controversy over how modern biology should be used—who will benefit from the many years of federal "seed money," who will be experimented on, how new techniques can become accepted medical practice without interfering with the informed choice of patients, etc.—has not and will not go away. Although we have lost precious time for the public debate over these matters, that debate must still take place. Through this collection and other endeavors, it is important that SftP continues to participate. ★

continued from page 9

Not-So-Future Scenarios

Finally, let me lump into one category a whole range of what I would classify as "not-so-future" scenarios. As a working scientist, I often find myself wincing at the visions of some futurists or the alarming science-fiction projections of some critics of technological change. However, the unbelievably rapid rate of change in the field of genetic technology makes it imperative that we anticipate and explore these issues before they become irreversible realities.

Engineering the Germ Line: Up to now, the techniques I have described have all involved the transfer of genes into either bacterial cells or into animal somatic cells growing in culture. Somatic cells are simply non germ-line cells. With the exception of plants, it is impossible to get a single somatic cell to differentiate into an organ, much less a whole animal. However, if we could implant specific genes directly into germ cells—generally the fertilized egg is used—and if these genes were stably integrated into the chromosome and were properly expressed, then we could begin to manipulate the development of an entire organism. The potential benefits for the treatment of genetic diseases are enormous. Rather than simply treating the symptoms of these diseases, as we are now limited to doing, we could prevent the expression of the disease itself. A possible problem could arise when we come to define what we mean by a genetic disease. There is no doubt that Tay-Sachs disease or sickle-cell anemia or Huntington's Chorea would all be classified as diseases which we would like to treat. But what about milder conditions? Would sickle-cell traits be open to gene therapy? What about shortness again? Or baldness? Or an inability to carry a tune? Although these questions may seem silly, the reality is that market driving forces have in the past often defined what we perceive as a medical problem. Genetic diseases are generally rare events and may provide relatively little profit compared to much more common human conditions such as baldness, which is certainly genetic in origin. Decisions about how we manipulate the human gene pool are too important to be left to the medical or scientific or commercial communities. We must begin to address them now before the decisions are made for us.

Crossing Species Barriers: Another issue that the ability to engineer the germ line raises is that of crossing species barriers. This issue was first raised very early in the debate about the potential hazards of genetic engineering by several senior and very respected scientists. Dr. Robert Sinsheimer, now chancellor of the University of California at Santa Cruz, Dr. Erwin Chargaff, professor emeritus and former chairman of the Department of Biochemistry at Columbia University's College of Physicians and Surgeons, and Dr. George Wald, professor emeritus of biology at Harvard and Nobel Prize winner, all voiced their dismay that humans were about to breach the barriers against the genetic interchange between different species. All three questioned the "right" of scientists to counteract what evolution had perpetuated over millions of years. As Chargaff warned, "No genius will be able to undo what one cretin has perpetuated." However, these arguments were never taken very seriously within the scientific community. First, they were all raised

within a rather abstract or moral context. Second, once again, the risks of doing the work were impossible to evaluate and perhaps nonexistent while the benefits were clear, obvious and considerable. Furthermore, when this issue was first raised, it was in the context of placing eukaryotic genes into the weakened strains of laboratory bacteria. It seemed only to be a theological issue.

In the last few years, however, there has been a dramatic shift in our ability to manipulate genes. We now have the skill to move genes around in ways that were unthinkable when Sinsheimer first raised his objections. Yet, the scientific community has not reexamined this issue in any way. For example, in 1982, the gene for rat growth hormone was placed on a plasmid together with a gene control region from mouse DNA. This plasmid was then injected into fertilized mouse eggs which were then implanted into the uteri of mice. Twenty one progeny mice were obtained of which seven showed up as having copies of the rat growth hormone gene. The animals were found to have 100 to 800 times the amount of growth hormone found in normal mice and they were indeed big—roughly twice the size of a normal mouse.

The scientific community, myself included, was entranced by the beauty of the science that had gone into this work. But no one that I know of ever raised the issue of the wisdom of creating new hybrid species in general or of this specific species in particular. Clearly this work will be exploited in the near future by those in the business of animal breeding. The economic rewards will be considerable. Who will consider the broader questions and implications raised by this work? It will not be the scientists, who view any such questions as attacks on their freedom of inquiry. It will have to be done by those in the community ready to struggle with these issues.

Social and Political Control

There is often a tension between the positive rewards of the application of scientific knowledge and the power of that knowledge to transform the world in unanticipated ways. The lessons of physics in the post-war world suggest to some authors that we must reject the fatalism of the technological imperative and make the positive decision that just because something can be done does not mean that it should be done. In contrast, other authors maintain that the idea that new technologies should be resisted simply because previous technologies have tended to run out of control is both ahistorical and irrevelant. Positions based on fear of technology often tend to paralyze rather than mobilize and are extremely sucesptible to the appearance of tangible benefits.

How we are to balance these two points of view is still an open issue with respect to the new genetic technologies. It may be that the route to balancing these two views lies in dealing directly with who has the legitimate right to make decisions that have potentially broad social effects. This moves the focus from the detailed arguments about the safety or ethical value of a particular experiment or product into the realm of political and economic control. But before we consider this question of control, we should first address what it is that has given so many people pause about the whole issue of genetic engineering. ★

WHO'S INVOLVED

Organizations Concerned with Social Impacts of Biotechnology

by Terri Goldberg

Project Pegasus

Institute of Social Sciences
Technical University of Denmark
Building 301, DK-2800
Lyngby, Denmark

Project Pegasus is a technology assessment project planned to run for three years. It was funded in 1983 by the Danish Technology Council to examine the societal consequences of the development and application of genetic engineering in different areas of production, and to examine the demands of different social groups on the development and application of genetic engineering.

The focus of Project Pegasus is the interplay between genetic engineering and social change. This interplay is being studied through assessment of the consequences of applications of genetic engineering in the chemical industry, the pharmaceutical industry, agriculture, and environmental protection. Through the study of the impacts in these areas, the Project expects to understand the broader social consequences of the new technology. Results of its research will be published at the end of the funding term.

Terri Goldberg is the Executive Director of the Committee for Responsible Genetics, *and the former Magazine Coordinator of SftP.*

International Network on the Social Impacts of Biotechnology

Department of Urban and Environmental Policy
Tufts University
Medford, MA 02155

The purpose of the International Network on the Social Impacts of Biotechnology (INSIB) is to create linkages among social, natural and biological scientists, humanists, science writers, policy analysts, and members of public interest groups. Many individuals interested in the social impacts of biotechnology have little opportunity to communicate with one another because they are either situated in different disciplines or located in different countries. The formation of INSIB is a step toward improving communications transnationally and creating a new disciplinary locus directed at the social function of genetic technologies.

The network publishes a resource guide. It lists the names, interest areas and selected publications and studies of individuals writing about the effects of biotechnology on society.

In addition to the writings of network participants, the guide will provide an annotated list of selected published works. Particular attention will be given to books, papers, and reports that are not widely publicized beyond their country of origin. In the future, the guide will also list unpublished manuscripts of widespread interest. If you have papers or books you wish to list in the annotated bibliography, send them to the INSIB.

The Committee for Responsible Genetics

5 Doane Street, 4th Floor
Boston, MA 02109
(617) 227-8035

The Committee for Responsible Genetics (CRG) is a national nonprofit organization of scientists and nonscientists dedicated to insuring that biotechnology is developed safely and in the public's interest. The group monitors and analyzes the social impacts of genetic technologies. The primary focus of the CRG's activities is educating the public about how the new technology will affect our lives.

The CRG was formed in 1983. Since that time it has initiated several projects, including a bulletin called *geneWATCH* and a resource center for information and referrals. The group is planning a national conference on biotechnology and public policy for late 1985.

GeneWATCH covers social issues in genetics and biotechnology. It includes reports on legislative, scientific, regulatory and commercial activities. Each issue contains two or more articles on topics such as agriculture and biotechnology, genetic screening, human gene therapy, corporate university ties in biotechnology, the impacts of the new industry on the Third World, and military use of biological research. *GeneWATCH* is also a forum for readers to express their concerns and share insights and information.

In recent months, the CRG has organized subcommittees which focus on specific issues, including the Committee on the Military Use of Biological Research (CMUBR) and Women and Reproductive Technology (WRT). The CMUBR has initiated several activities including a "Petition Concerning the Military Use of Biological Research" (see box on page 12). The group has collected over 2,000 signatures on the petition, and is planning to submit it to Congress. The CMUBR is also try-

ing to stop the construction of an Aerosol Test Facility at the Dugway Proving Ground and calling for Congressional hearings on the Department of Defense Chemical Warfare and Biological Defense Program. The group has circulated a statement on the proposed facility called "To Prevent A Biological Arms Race" among scientists, clergy, peace advocates, and others and received substantial support.

The Women and Reproductive Technology Committee is concerned about the impacts of new technology, such as in vitro fertilization and prenatal genetic screening, on women's lives. The group has drafted a statement discussing these concerns, and held discussion meetings to formulate its policies and ideas. The WRT is now considering whether to initiate an educational campaign involving production of publications or video tapes.

The Committee for Responsible Genetics has begun to submit comments to Federal agencies, such as the Environmental Protection Agency, National Institutes of Health, Food & Drug Administration, and U.S. Department of Agriculture, on proposed regulations of biotechnology. In recent months, these efforts have focused on regulation of proposed releases of genetically engineered organisms and proposed somatic cell gene therapy experiments.

For copies of *geneWATCH*, the WRT statement, CMUBR petitions, and general information, please write the CRG.

International Genetic Resources Programme

P.O. Box 1029
Pittsboro, NC 27312

The International Genetic Resources Programme (IGRP) was founded by the Rural Advancement Fund to address the problem of the loss of genetic resources throughout the world. Efforts to end this genetic erosion include: monitoring industry (seed companies, biotechnology, plant and animal breeding) and government legislation such as plant breeding, which can restrict access to germplasm. Cases of genetic erosion are documented and assistance given to governments and other organizations for genetic conservation projects. IGRP supports the full and free exchange of genetic resources and promotes public awareness of this issue, and is concerned with the effect that advances in biotechnology will have on genetic resources in both the developed and developing nations.

IGRP publications include a quarterly newsletter, *IGRP Report*, and a Seed and Nursery directory for North America which lists sources of traditional farm and garden varieties. A slide show, "Agriculture's Vanishing Heritage," is available to interested organizations.

IGRP staff, Cary Fowler and Pat Mooney, recently served as editors of a United Nations publication concerned with biotechnology and the Third World called *Tissue Culture Technology and Development*, Advanced Technology Alert System, November 1984 (available from ATAS, Centre for Science and Technology for Development, United Nations, New York, NY 10017). For a sample copy of *IGRP Report* or more information, write to IGRP.

Environmental Policy Institute

218 D Street, SE
Washington, DC 20003

The Environmental Policy Institute (EPI), founded in 1972, is a non-profit, public interest organization engaged in research, public education, litigation, and lobbying. EPI lobbyists and researchers (21 full-time staff) work on a range of energy, environmental and natural resource issues, at the local as well as national and international levels.

Since 1980, EPI's Agricultural Resources Project, headed by Jack Doyle, has been working on a group of interrelated issues in the area of agricultural genetics, including seed industry consolidation, seed and pesticide patenting laws, and recent business developments and research trends in agricultural biotechnology.

This summer, Viking Press will publish Doyle's book, *Altered Harvest*, one of the first major treatments of the subject of agricultural biotechnology and its impacts on farming, food production, genetic resources and the environment.

Over the next few years, EPI will be working on agricultural biotechnology issues as they emerge in Congress and the federal agencies. Areas of special attention will include: biotechnology's role in the pesticide arena, bio-patenting issues, germplasm conservation, regulation of commercial biotechnology, "nutritional erosion" in food crops, agricultural research policy, and Third World impacts. On the question of regulation, for example, EPI takes the position that an interdisciplinary predictive ecology science base and review capability are needed at the federal level in advance of any federal agency approvals of genetically-altered organisms for release into the environment, and that such procedures be established by federal law with adequate opportunity for public review and comment.

The following is a list of other organizations concerned about biotechnology related issues:

Biological Weapons

The Nerve Center
2327 Webster St., Berkeley, CA 94705

Stockholm Int. Peace Res. Inst.
Bergshamra, S-171 73 Solma, Sweden

Release of Genetically Modified Organisms into the Environment

National Resources Defense Council
1350 New York Ave. NW, Suite 300, Washington, DC 20005

Foundation on Economic Trends
1346 Connecticut Ave. NW Suite 1010, Washington, DC 20036

Conservation Law Foundation of New England
3 Joy St., Boston, MA 02108

Genetics and Public Health

American Public Health Association Genetics Committee
c/o Raymond Kessel, Statewide Genetics Services Network, 445 Henry Mall, Univ. of Wisconsin, Madison, WI 53706

Biotechnology and the Third World

Council on International and Public Affairs
777 United Nations Plaza, New York, NY 10017

In Brief

BOOKS

Test Tube Women
What Future for Motherhood?

edited by Rita Arditti, Renate Duelli Klein and Shelley Minden

Pandora Press, 1984

A collection of 34 essays that discuss women's reactions to in vitro fertilization, embryo transfer and surrogate mothering, sex selection, electronic fetal monitoring, amniocentesis, gene therapy, and the potential for genetic engineering of humans. Reproductive technologies are described in the context of male-dominated medicine, and feminist analyses of reproductive health are explored. To be reviewed in the July/August issue of *Science for the People.*

The Gene Business
Who Should Control Biotechnology?

by Edward Yoxen

Free Association Books, London, 1983

Harper and Row (U.S. edition), 1983

"A technological assault is being prepared that will transform the economies of developed and developing nations. Its substance is the engineering of life processes for commercial ends: biotechnology." With these opening words, Yoxen lets us know that he is as concerned with the application and purpose of this technology as he is with its processes.

The Gene Business is the best study available of the social issues raised by new developments in genetic engineering, within an economic and political context. Yoxen explains the social gains and losses of biotechnology, the effects of economic interests on academic values, and the tensions between profit motives and business interest vs. scientists' responsibility to social welfare and public interest.

Genetic Alchemy
The Social History of the Recombinant DNA Controversy

by Sheldon Krimsky

Krimsky examines the arguments —pro and con—that developed surrounding recombinant DNA technology. He puts these debates within a scientific and social perspective, by asking how the events external to the scientific developments of rDNA affected the form and outcome of the controversy. In addition to his coverage of developments within the scientific community, Krimsky considers the science and politics behind a worst-case experiment designed to test the risks of gene splicing, and critically evaluates evolutionary concerns over breaching species barriers through rDNA. Krimsky frames this controversy within the bounds of public policy, providing the reader with information and analytical questions that are essential to informed participation in shaping and monitoring this revolutionary technology.

The DNA Story:
A Documentary History of Gene Cloning

by James D. Watson and John Tooze

W.H. Freeman and Company, 1981

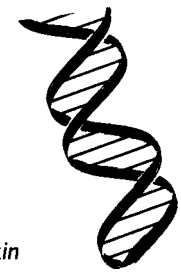
Designed as an introduction to rDNA for nonscientists, this book compiles reprints from newspaper articles, copies of correspondence concerning the early controversies, public statements, petitions, interviews, cartoons, press releases and scientific documents in a scrapbook style to reconstruct the rDNA controversy and the development of guidelines in the U.S. and Europe. Written by two prominent scientists in the rDNA field—James Watson, co-recipient of the 1962 Nobel Prize for his discovery of the DNA double-helix structure, and John Tooze, Executive Secretary of the European Molecular Biology Organization.

DNA for Beginners

by Israel Rosenfield, Edward Ziff and Borin Van Loon

Writers and Readers Publishing, 1983

A cartoon introduction to the wonderful world of DNA, that weaves together history, technical information and key developments in genetics. The scientific and social problems and potentials of genetic engineering and the discovery of split genes and oncogenes are also discussed. Easy to understand and fun to read. Part of the Readers and Writers Documentary Comic Book series, which also includes *Darwin for Beginners* and *Einstein for Beginners.*



Algeny

by Jeremy Rifkin

Viking Press, 1983

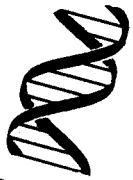
"Algeny" is a term coined by Rifkin to connote the synthesis of alchemy and gentic engineering, which has produced the transformations of a biological revolution through biotechnology. Rifkin believes that our decision to develop biotechnology is potentially far more dangerous than the decision to split the atom. "Our children will grow up in a world populated with their own artifical creations, and thus their conception of the very meaning of life and existence will differ fundamentally from that of every other generation preceding them in hisotry," states Rifkin. In this book, he presages the end of Darwinism and nature, and the beginning of a world of engineered reality. His blanket opposition to biotechnology is too extreme for many concerned and progressive scientists, but his book has brought a much-needed awareness of the social and environmental threats of these new technologies to the general public.

No Fire, No Thunder
The Threat of Chemical and Biological Weapons

by Sean Murphy, Alastair Hay and Steven Rose

Monthly Review Press, 1984

Reviews the technologies used for chemical and biological (CB) warfare, yellow rain, military use of these weapons, international law and the use of CB weapons in Southeast Asia and Afghanistan. Well written and critically informative.



PERIODICALS

geneWATCH

Committee for Responsible Genetics

5 Doane St., 4th floor, Boston, MA 02109

A bimonthly bulletin of the Committee for Responsible Genetics, filled with legislative updates, industry monitoring information, health, safety and workplace reports, lab notes, resources and cogent news articles. *GeneWATCH* is an excellent watchdog of the biotechnology industry.

ATAS Bulletin

Advance Technology Alert Systems

United Nations, United Nations Plaza, New York, NY 10017

A new semi-annual publication of the United Nations' Center for Science and Technology for Development. The November 1984 premiere issue is titled "Tissue Culture Technology and Development." The *Bulletin* is designed to alert policymakers and planners in developing countries to the potential impacts and implications of emerging technologies.

Plant Breeding and Bio-Technology Intelligence Report

Marketplace Intelligence Service

Box 8445, Minneapolis, MN 55408

A monthly compilation of reprinted articles from many sources, designed to keep researchers and activists informed of the most recent activities in the industry. It covers plant breeding and the seed industry, genetic engineering, biotechnology, health and safety and government affairs.

Genetic Engineering News: The Information Source of the Biotechnology Industry

Mary Ann Liebert Inc. Publishing

157 East 86th St., New York, NY 10028

An industry-oriented monthly newspaper that carries late-breaking news about genetic technology developments. Though it isn't a progressive publication, *GEN* occasionally presents opposing viewpoints in editorials, interviews and opinion pieces. The August 13, 1984 edition was a special issue titled "Genetic Engineering: New Issues Arise as Applications Draw Near."

Genetic Engineering and Biotechnology Monitor

United Nations Industrial Development Organization

P.O. Box 300, A-1400, Vienna, Austria

A bimonthly review of international developments in genetic engineering and biotechnology, containing abstracts of current research and studies in the field, as well as listings of recent patents and information on biotechnology meetings and conferences around the world.

International Genetic Resources Programme Report

Rural Advancement Fund International

P.O. Box 1029, Pittsboro, NC 27312

Published four to six times a year, this newsletter covers developments in the seed industry, plant patents, genetic resource conservation and biotechnology.

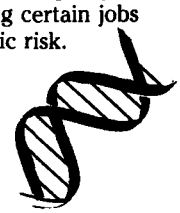
GOVERNMENT DOCUMENTS

The Role of Genetic Testing in the Prevention of Occupational Disease

Office of Technology Assessment

U.S. Government Printing Office, #OTA-BA-195, April 1983

Summary of an Office of Technology Assessment study. Covers legal and ethical issues, policy options, frequency of genetic testing, and the status of current research. The report suggests the possible use of genetic screening to prevent people from taking certain jobs due to high genetic risk.



Recombinant DNA Technical Bulletin

National Institutes of Health

U.S. Department of Health and Human Services

Quarterly report of the office of rDNA Activities, National Institute of Allergy and Infectious Diseases. Contains scientific reports, legal testimony and hearings on genetic engineering, recent actions taken by the NIH on topics related to rDNA research, and a bibliographic citation list of science and technology articles covering rDNA.

Commercial Biotechnology:
An International Analysis
Office of Technology Assessment
U.S. Government Printing Office, #OTA-BA-218, January 1984

Regulation of Recombinant DNA Research:
A Trinational Study
by Howard Eddy
Science Council of Canada, 100 Metcalfe St., Ottawa, Ontario KIP 5MI, 1983
Covers national regulatory issues and problems in the United Kingdom, United States and Canada. Free.

BIBLIOGRAPHIES

Genetic Engineering, DNA, and Cloning: A Bibliography on the Future of Genetics
by Joseph Menditto and Debbie Kirsch
Whitson Publishing Company, 1983

A bibliography most useful for a general audience. It covers a spectrum of issues in genetic engineering, providing extensive attention to social policy topics such as regulation. Part One consists of monographs, government documents and essays. Part Two contains journal and newspaper articles. The index is keyed to authors only, rather than to subjects, but the table of contents is detailed and descriptive enough to use as a resource guide.

Telegren Annual Review Biotechnology Emerges: 1973-1980, the Key Years
Environmental Information Center, 1981

This volume is less useful as a bibliography, but provides good document and sourcebook material. The bibliography lists journals, newspapers, bulletins, newsletters and government documents. As a sourcebook, it brings together substantial documentation: NIH guidelines, chronological tables, monographs, local laws, a glossary, and articles. The index is oriented towards a scientific readership. A word of warning: many of the documents are hard to find. They may be ordered from the publisher, but they are very expensive.

Science Resource Center

PUBLICATIONS

Computing the Future

A unique collection of articles on computers and the high tech industry, focusing on computers and the military, industry health and safety, and a special section on computer use in schools. $4.00

Biology as Destiny: Scientific Fact or Social Bias?

A provocative look at the controversies surrounding genetic theories of human behavior, by the Sociobiology Study Group. $4.00

Decoding Biotechnology

An essential guide to the issues posed by new genetic engineering technologies. Questions concerning hazards and benefits, biological warfare, reproductive technologies, corporate influence over research and development, and the need for public involvement are given comprehensive treatment. $4.00

Feed, Need, Greed

The classic high school curriculum guide on hunger, population and food resources. $5.50

Science for the People Magazine

For 17 years, the only national magazine devoted to the political significance of science and technology. Bimonthly. $15/year

Also available from SRC:

Fate or Fiction: Biological Theories of Human Behavior

A 30-minute slide/tape presentation for college, high school and community groups. Explores the link between genetics and behavior, exposing the use of science to rationalize social and political inequalities. Purchase: $150. Rental: $35

Science and Liberation

An indispensible book, presenting articles that give a panoramic view of the many connections between scientific work and its social context. Edited by Science for the People members Rita Arditti, Pat Brennan and Steve Cavrak. Published by South End Press. $6.50

Biology as a Social Weapon

A landmark anthology on biological determinism. Edited by the Ann Arbor editorial Collective of SftP. Published by Burgess Publishing Company. $11.95

Please add $1 postage and handling for each title. Discounts available for bulk orders.

Send orders, with payment, to:

SCIENCE RESOURCE CENTER, INC.
897 Main Street
Cambridge, MA 02139
617/547-5580

Science for the People
897 Main Street
Cambridge, MA 02139

Does technology raise more questions than it answers?

★ Do you wonder whether genetic technologies should be entrusted to entrepreneurs?

★ Do you question the idea of letting computers decide when to launch our nuclear weapons?

★ Do youwant to know how science can help serve human needs instead of corporate interests?

Then it's time to subscribe to Science for the People!

☐ **SIGN ME UP!** Send me my first issue of SftP and bill me. If satisfied, I'll send $15 for my one year subscription (6 issues). If not, I'll mark "cancel" on the bill and send it back. The issue is mine to keep.

☐ **MY CHECK IS ENCLOSED!** Start my subscription immediately.

☐ **CONSIDER ME A MEMBER!** My $25 check for one year will entitle me to six issues of SftP, the National Newsletter, and a copy of **Biology as Destiny.**

☐ **WHAT A GREAT MAGAZINE!** Along with my own subscription, please send a gift subscription for $7.50—for a 50% savings.

Name _____

Address _____

City/State/Zip _____