

Yale Law & Policy Review

Volume 3, Number 2, Spring 1985

Overview: Regulating Biotechnology

Introduction

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The three papers in this symposium may appear on first reading to be concerned with just a single piece of biomedical research — the recombinant DNA technique and its technological offspring now known familiarly, and in the long-run perhaps regrettably, as “genetic engineering.” Two possible applications of the technology are the primary sources of public worry: 1) the risks entailed in a purposeful release into the environment of genetically altered species, for one or another commendable and profitable use, and 2) the hazard in any purposeful correction of a genetic abnormality in human beings.

But there is a lot more going on. The immediate technical problems may seem, on the surface, to represent a rather narrow issue for public policy and for science, easy to solve. Bring together, as has been done here, an eminent working scientist with direct working experience in the field, a legal scholar in possession of an encyclopedic store of detailed information about the law and ethics involved, and a statesman with direct responsibilities for the political adjustments needed to assure the public safety. Let them work it out.

Not surprisingly, the problem of genetic engineering does not turn out to be a narrow issue at all, certainly not one amenable to any quick and easy administrative solution. Instead, some of the ar-

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guments posed in these three papers carry the matter far beyond the specific technology under review, raising larger questions about the role and value of scientific inquiry itself in the evolution of modern society.

Such questions are posed most directly in the last several pages of Stephen Carter's paper. Although he has affirmed, earlier on, his deep admiration for scientific researchers (he is, in his words, a "passionate technophile"), he comes down at the end arguing that the scientific community has failed to justify any of the controversial actions performed in today's research. He concludes that "unimpeded scientific inquiry" may not be the unqualified good that it has always been assumed to be, and that the scientists must now find ways not only to explain themselves but, hardest of all, to *restrain* themselves. The old creed of knowledge for its own sake may have to be set aside, he remarks in passing.

Until I read Professor Carter's paper, I had no idea how deep is the trouble caused by that term "genetic engineering," which I wish had never been invented. Because of this eye-catching, bragging metaphor, the new field of molecular genetics is near to being transformed, in the public's mind, into a surrogate for all of biological science, just as began to happen a while back with nuclear weaponry and modern physics.

But the things that are feared, even detested, are items of technology, which is a totally different enterprise from science itself. Not divorced, of course, but different enough to require its own kind of regulation and control. Technology is, by and large, the result of applied science. In turn, applied science is almost always the result of basic science. And, if I read Professor Carter right, he is proposing that the scientific community should be monitoring this chain of intellectual events from the bottom up, by "restraining" the acquisition of new knowledge. Or, more simply, by staying away from the kinds of new knowledge that can lead to the risky technologies.

But science cannot do this and remain science. Maxine Singer points out that the recombinant DNA technology had its real beginnings in the 1940's, when it was first discovered that genes are made of DNA. In the early 1950's came the Watson-Crick delineation of the molecular structure of DNA, and the first glimpse of how that structure might allow the molecule to replicate itself. Almost two decades later, after an immense amount of study of this molecule and the cellular enzymes that react upon it, splitting it into predict-

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able segments, came the realization that isolated genes could be taken from the genome¹ of one species and inserted into that of another. This last discovery, which led to the Asilomar meeting,² came as a complete surprise to everyone. It could not have been predicted at any earlier time in the research that such a thing would ever be possible; I doubt that any working scientist at any time in the preceding twenty years ever imagined such a fantasy.

So, in the early 1970's, the recombinant DNA technique turned, in part, into applied science and, more recently, into a commercial technology. But only in part and, looked at objectively, a relatively minor part at that. The overwhelming importance of the recombinant DNA method is still what it was before the cloning of marketable products: the most powerful research technique for the study of biological phenomena in general. Maxine Singer is not exaggerating when she writes that it is a way of getting at "the fundamental nature of human beings;" it is more than this, it is the opening of a new approach to the very nature of life.

Still, recombinant DNA is only a part of what has happened to produce today's biological revolution. Other kinds of totally new and unpredicted information are emerging from immunology, developmental biology, virology, biochemistry and — perhaps soon to be the most surprising of all — neurobiology. To a considerable extent, each of these rapidly expanding disciplines in biomedical science depends on all the others and, in turn, feeds new information to the others. My own field, medicine, will certainly be deeply changed, perhaps transformed altogether into a genuinely effective technology for the cure and prevention of our most disabling and chronic diseases, by some of this new information. But medicine will always tend to lag behind the rest of biology, because any comprehension of the underlying mechanisms of disease must always await a deep understanding of the normal processes of life.

Looked at from this viewpoint, my own apprehensions about the hazards of genetic engineering are small indeed compared to my fear of what the public perception of hazard may do to the future prospects for basic research. I cannot see how any committee or

1. The *genome* is the set of genes within an organism which expresses the entirety of its genetic makeup [editor's note].

2. The Asilomar Conference was called in response to concerns voiced by several leading scientists over the potential danger of the accidental release of genetically engineered viruses into the environment. See Swazey, Sorenson & Wong, *Risks and Benefits, Rights and Responsibilities: A History of the Recombinant DNA Research Controversy*, 51 S. CAL. L. REV. 1019 (1979) [editor's note].

commission, or any regulatory agency at any level of government, can undertake the task of predicting how a piece of basic biological research will likely turn out, much less predict whether it will lead to a useful or hazardous technology. Basic research is, as I interpret the process, an inquiry into how mechanisms work in nature. It begins as an act of the imagination, in an atmosphere of uncertainty. It requires solid data at the outset, to be sure, but it uses this information to construct a hypothesis about something to which none of the data point directly. The hypothesis is then tested for validity by experiment. If the experiments seem to confirm the original guess, it is then the investigator's duty to set up as many experiments as he can in a deliberate effort to prove himself wrong. This latter step is both obligatory and prudent, for if he does not run all the conceivable controls, someone else in another laboratory will, and his reputation may be damaged.

But there is no product in this kind of research, only new knowledge. The investigator may have on his mind a possible commercial development sometime far in the future, but he can have no certainty of this. What drives the work along is not the marketplace, but curiosity. And what determines the quality of the outcome of that work is the quality of the imagination that initiated it.

Applied research is very different. This kind of science begins with an appraisal of facts derived from basic research (usually done elsewhere and for different reasons). It is predicted that something useful and usable, perhaps even marketable, can be produced by capitalizing on the facts at hand. Before beginning on an applied science project, it is usual that the predicted outcome must carry a high degree of certainty — the opposite of the situation in basic research. Once launched, the investigators (who usually do work of this kind in teams) must agree to follow a fairly detailed protocol on a fairly rigid time schedule, and there are unlikely to be many opportunities to change directions in mid-course.

The basic science leading to the vaccine against poliomyelitis began with the prediction that a virus of some sort must be involved. After several decades, it was learned that there are actually three viruses, each antigenically distinct, and that all three could be grown to abundance in cell cultures. With these pieces of solid information, the time for applied research had obviously arrived: it could now be predicted with certainty that an effective vaccine could be produced. Then, in the early 1950's, Jonas Salk and his colleagues rapidly achieved one of the most elegant pieces of applied

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science in the record of medicine, proving conclusively that poliomyelitis is an easily preventable disease.

In the early, basic phase of this work, nobody would have thought of the need for legal intervention or governmental regulation. However, in today's climate, I can imagine certain kinds of outcry: complaints from groups in Baltimore or New Haven that the work on these highly contagious, potentially lethal viruses might accidentally spread beyond the monkey laboratories, or charges in Boston that John Ender's laboratory might be creating even greater danger in those flasks of live virus growing in freakish cells.

But in the final stage of applied research and development, there is no question in anyone's mind about the need for tight regulation and governmental oversight. Once the vaccine could be prepared on an industrial scale for injection into millions of children, all decisions about its use became matters of public policy, subject to close public supervision.

I have no argument with those now demanding regulation and supervision of the applications, whatever they are, derived from recombinant DNA research. Indeed, I am reassured by Senator Gore and Steve Owens' thoughtful analysis of the bureaucratic complexities involved, and glad to learn that the matter is regarded as one of high priority in Washington. If the products of recombinant DNA research are to be sold, distributed, consumed, or sprayed on open fields or into deep mines, the public needs assurance that they are both safe and effective. I do hope, as Senator Gore and Mr. Owens recommend, that the oversight responsibility will not be spread out over multiple Federal agencies, for the inevitable bureaucratic delays will then unnecessarily restrict applied research. But I cannot for the life of me see why technologies of the kind now being proposed should be regarded, as they are in some quarters, as *uniquely* threatening or dangerous to the environment, simply because of the way they are made.

Maxine Singer acknowledges the need for sensible, informed regulation of biotechnology, even though she believes that apprehensions over such things as non-frosting mutant bacteria have been wildly exaggerated. She is worried more about the appalling lack of knowledge, particularly within the legal community, about the detailed scientific issues involved. It is her position that in this most scientific of all centuries, lawyers should be receiving a better education in general science than they seem to have been getting. Regulatory laws are generally put together by lawyers, and the

mechanisms for judicial and legislative review are principally their responsibility. Dr. Singer asks, skeptically, whether lawyers are "up to the task." I find this a rather surprising question, thinking back on the newspaper accounts of numberless medical malpractice suits in which lawyers seem to acquire and comprehend biomedical knowledge in the deepest detail whenever they need it, and with lightning speed.

The truth is that the essential factual information required for understanding the disputes over issues in biotechnology is readily available, and not hard to understand or explain. I agree with Stephen Carter that the scientists should be doing a better job at explaining, and I hope the lawyers will match them by listening. But some of the issues cannot be settled this way; they are in another domain, touching questions in philosophy, to be answered differently depending on how one looks at the world. The deepest of these is the question about altering the human genome. I have no trouble in thinking about somatic alterations for the purpose of treating otherwise fatal human diseases; I am all in favor, and hope that the technology moves fast enough to make Tay-Sachs disease, say, a curable disorder. But I have no such quick answer to the question about altering the human germ plasm and producing heritable changes that will last through all the generations to come.

Or rather, I do have a quick answer and it is that biomedical science should not do such a thing, now or ever. But that, I must quickly qualify, is my personal judgment and not in any sense a scientific opinion, to which I do not in this case feel entitled.