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Social Responsibility in Genetic Engineering: Historical Perspectives

What are the ethical limits to human genetic intervention? This question should be high on the public agenda as we enter the twenty first century. New technologies, pervasive commercialization, and extraordinary claims by researchers, funding agencies and entrepreneurs provide relentless pressure to continuously shift the line of ethically acceptable applications of human genetic engineering. The policy decisions that must be made require full public participation and should take into account societal values, relevant technical information and the cumulative experience gained from past efforts to anticipate and control the consequences of the uses of genetic knowledge. I will provide several historical perspectives on these issues to reveal patterns that may be useful in understanding the present. My focus is on how scientists in the field have dealt with the ethical, social and political consequences of genetic engineering.

Social responsibility in science

The concept of social responsibility and accountability of scientists took on a special meaning after the atomic bombs were dropped on Hiroshima and Nagasaki in 1945. Individually, and in organizations formed around issues such as arms control, many scientists in the postwar decades saw the need to exercise responsibility in their research and its applications. They wanted to avoid doing harm and to prevent abuse of research results. This included examining the context in which scientific work is done, anticipating negative or unintended consequences, and refusing to participate in projects deemed to be socially harmful. Concerned scientists also felt the need to provide early warning to colleagues and to the larger society and to provide information to the public by speaking out publically.

Social accountability was especially important for biologists because of the relevance of their work to life, health, and the environment. For example, in

the postwar decades many biologists campaigned against biological warfare research emphasizing that they were committed to the life sciences and the improvement of health, not to "death" science which caused destruction and disease.¹

Genetic engineering and ethics in the 1960s and 70s

Rapid progress in genetics in the 1950s and 1960s, including the discovery of the double helix structure of DNA and the unraveling of the genetic code, raised expectations about the ability to understand life processes at a fundamental level and to eventually apply this knowledge to the manipulation of genes. Biologists' excitement about these prospects was often accompanied by concern about the political, social and ethical implications of the new genetics.

The message was strongly stated by one of the first distinguished scientists to speak out, the president of the Nobel Foundation, Swedish biochemist Arne Tiselius who was a professor at the University of Uppsala and had received the Nobel Prize in 1948 for his work on electrophoresis. In 1961, on the occasion of the 60th anniversary of the prize, Tiselius spoke about the moral obligations of scientists in the applications of their work in weapons of mass destruction and also in "the search into the very basis of the life process." He said that "it is possible—many think even probable—" that the new biological research "will lead to methods of tampering with life, of creating new diseases, of controlling the psyche, of influencing heredity, even perhaps in certain desired directions." He warned that this could "result in a still more refined and perhaps still more dangerous way of abusing the results of research than that implied in the instruments of mass destruction." Tiselius argued that because of this prospect "we see the demand for an international moral code governing the use of scientific results as a self-evident necessity."²

Subsequent discussions among biologists in the 1960s focused on when and where to draw the line in the applications of human genetic engineering. This was an anticipatory concern since recombinant DNA and related genetic manipulation techniques were not available at that time. Discussion at scientific meetings of the prospects for human genetic intervention and its ethical limits soon reached the media and the political process and some biologists feared that public "overreaction" would interfere with their research interests and their funding. They tried to reassure the public that the work would be beneficial or that it was too early to worry about negative effects. Others argued that the ethical consequences of genetic engineering should be anticipated and discussed in advance, before it was too late as in the case of the atomic bomb. This was very vivid imagery. It is worth looking at in some detail, because of its relevance to our current discussions.³

In January 1962, a few months after Tiselius' statement, a *New York Times* editorial, "The Code of Life", observed that the recent deciphering of an important part of the genetic code could lead to "a revolution far greater in its potential significance than the atomic or hydrogen bomb." Quoting Tiselius' warning, the editorial concluded that "It is not too soon to be prepared against such potential abuses."⁴

In 1963, the *Times* made an editorial comment on the 11th International Congress of Genetics which had just concluded in Europe:

Geneticists are on the threshold of a historic breakthrough in their efforts to probe the secrets of heredity... Is mankind ready for such powers? The moral, economic and political implications of these possibilities are staggering, yet they have received little. . . organized public consideration. The danger exists that the scientists will make some of these God-like powers available to us in the next few years well before society—on present evidence—is likely to be even remotely prepared for the ethical and other dilemmas with which we shall be faced.⁵

The appropriate time and place for discussing ethical consequences was also an issue at a small private meeting of leading biologists held at Rockefeller University in 1966. The invitation to the meeting reviewed work being carried out in several laboratories that seemed promising for human genetic engineering, noting that "the problem is obviously immense and almost fantastic in implication. Unless a massive frontal assault is made, it will be many years before something that could be accomplished in the foreseeable future will be achieved." The intention was to set up a committee "to discuss and program what could and should be done and after deciding this and its cost to get support and hire the proper scientists."⁶ The minutes of the meeting reveal the participants' views on the advent of genetic engineering, and their reluctance to discuss it publicly.

After discussing how to build and test genetic material, the participants asked: "Do we use it?" Their answer was that if such reagents were made they would "be used whether we like it or not. What can be done, is done, and what can be used, is used. The main variable is the rate of development and application. Proper use depends on active supervision by interested persons who are involved in the original accomplishment."

Then they discussed whether they should stimulate anything of this kind, asking if any step would be an escalation. They concluded that "if it is not done by us, others will do it and they won't do it as well." They also pondered whether they could discuss the feasibility of such endeavors without discussing the desirability. One participant noted that eugenic potential had been available for many years and had not been used. Another noted that "eugenic measures generally have negative elements which involve large social structures and are therefore resisted while genetic intervention is mostly positive

and on an individual basis and as such has qualities analogous to those which sell soap.”

The participants decided that there would be no publication of their discussion nor an official report. They felt that “there is too little in the way of hard materials,” and that “this area is so highly charged that no matter how carefully anything is said, it gets overplayed and over-interpreted”.⁷ Their decision to control the information and keep it from the public was paternalistic and unrealistic since the research was publically funded (as was their meeting) and the possible applications to human genetic engineering clearly were of public concern. The prospect of genetic engineering was already public, and it continued to be. Eight months later in an editorial in *Science* magazine, Marshall Nirenberg, the biologist whose work on the genetic code had contributed one of the important steps to the new genetic revolution, and who was to win a Nobel Prize in 1968, took a different position:

Man may be able to program his own cells with synthetic information long before he'll be able to assess adequately the long-term consequences of such alterations, long before he'll be able to formulate goals and long before he can resolve the ethical and moral problems which will be raised. When man becomes capable of instructing his own cells, he must refrain from doing so until he has sufficient wisdom to use this knowledge for the benefit of mankind. I state this problem well in advance of the need to resolve it because decisions concerning the application of this knowledge must ultimately be made by society and only an informed society can make such decisions wisely.⁸

The new developments in genetics were also discussed publicly by the geneticist Joshua Lederberg in a series of columns in *The Washington Post*. The Nobel Laureate's reassuring views were challenged by Leon Kass, a young biologist at the National Institutes of Health, who had organized a bioethics seminar there. He responded in the *Post* in November 1967:

The possibility of genetic manipulation in man raises fundamental and enormous questions, theological, moral, political. These questions must be carefully stated, the issues clearly articulated and the alternative policies fully and soberly considered... The development of science and technology, once begun, often proceeds without deliberated and considered decisions. Considerations of desirability rarely govern the transition from “it can be done” to “it has been done.” Biologists today are under strong obligation to raise just such questions publicly so that we may deliberate *before* the new biomedical technology is an accomplished fact, a technology whose consequences will probably dwarf those which resulted from the development of the atomic bomb.⁹

In 1969 Jonathan Beckwith, a young molecular geneticist at Harvard Medical School, and his colleagues held a remarkable press conference to announce that they had achieved the first purification and isolation of a bacterial gene, a significant step in the direction of genetic engineering. Their purpose was not

to seek acclaim for their results but to sound the alarm about the possible negative social and political consequences of manipulating genes.¹⁰ The popular press response included headlines about "genetic bombs", and the scientific press vehemently criticized the researchers' actions as irresponsible behavior that might cause a threat to scientific funding. Beckwith and his colleagues responded in a letter to the journal *Nature*:

As we see it, scientists are obligated to inform the public about what is happening in their secluded fields of research so that people can demand control over decisions which profoundly affect their lives. If our arguments mean [as our critics say] that "the progress of science itself may be interrupted," that is an unfortunate consequence we will have to accept. It certainly should not inhibit us from speaking out on crucial issues.¹¹

Several months later, in April 1970, when he received the prestigious Ely Lilly Award for his work, Beckwith included a political critique and plea for social responsibility in his acceptance address entitled "Gene Expression in Bacteria and Some Concerns About the Misuse of Science."¹² In the decades since then he has continued his research while acting on his sense of social responsibility in critiques and studies of abuses of genetic screening, the use of genetics to promulgate eugenic and racist policies, and the growing tendency to overemphasize the role of genetics in disease and social problems.¹³ He persisted despite resistance from the professional structures of science, and received recognition for this integrated role in 1993 when the Genetics Society of America awarded him their Medal for both his science and his social policy role.

Biologists' concerns about where and when to draw the line in genetic engineering were highlighted in a 1970 London conference on "The Social Impact of Modern Biology." The speakers included leading biologists and many non-scientists were in the audience of more than 800. In one discussion, a geneticist argued:

We are just deluding ourselves if we think that human genetic engineering is so in the realm of science fiction that we don't need to start thinking about it. My worry is that the advances will be extremely slow and minor to begin with. For instance, I would estimate that within four or five years it will be possible to cure, to a very minor, limited extent, by genetic engineering, certain genetic deficiencies. Nobody will object to that. And so we will go on to the next step, and the next step, and so on. If we don't start discussing these matters now we shall get to the state as we did with the atom bomb, when nobody knows what is going on.¹⁴

The continuing emphasis was that prior discussion provided time to think about the issues, before technological momentum builds up and applications are imminent, and before vested interests take over. The symbol of the mushroom cloud was intertwined with the symbol of the double helix.

Specific concern about the claims being made for gene therapy were expressed in July 1971 by two geneticists, Maurice Fox of MIT and John Littlefield of Harvard, in a *Science* guest editorial entitled "Reservations Concerning Gene Therapy". They called for a realistic appraisal of its potential and a sober consideration of its liabilities. They cautioned that many of the procedures were likely to be mutagenic and that many dominant effects visible only in the whole individual might appear. They noted that most of the viruses under consideration as vectors were tumor-producing and that "damaging alterations of regulatory processes and even uncontrolled tumor-like growth could easily be the consequences of introducing additional chromosomes or a host of viral genes." Fox and Littlefield concluded:

The promises offered by the proponents of gene therapy largely ignore its limitations and hazards. To mislead the public in this regard risks another period of disappointment and reaction. We are still primarily in a descriptive phase in our understanding of human genetics, with little, if any, idea of how to intervene safely at any level. Let us not do to ourselves what we have done to our environment. Let us now seek public support for research for better understanding of normal and abnormal human biology, rather than promise quick glamorous cures.¹⁵

One other example of this early concern is the 1972 statement by French Anderson who has consistently pushed the limits of acceptance of gene therapy since then: "The potential uses and misuses of genetic intervention are so great that now is the time to examine closely what is being done and where it may lead. Society does not want to learn of the consequences of a scientific accomplishment only after great damage has already been inflicted, as was the case with nuclear power."¹⁶

There are many more examples of the anticipatory interest in the ethical problems of genetic intervention that was expressed within the international community of biologists in the pre-recombinant DNA period. But things began to change when public interest in the subject increased, culminating in the United States with congressional hearings in the late 1960s to consider the need for a national commission on health, science, and society. The purpose: to anticipate, to examine in advance, and to report on the legal, ethical and social implications of biomedical research, including genetic engineering. It was meant to be a study commission, without the intention of interfering with research. The focus was on new, emerging, medical technologies such as the artificial heart, organ transplants, new reproductive technologies, and also genetic engineering, which was not possible at the time, but on the horizon.

Although some of the biologists who participated in the hearings showed genuine concern about the issues raised, others feared that their funding might be cut off or severely curtailed and were defensive about the nature and usefulness of their work. They worried about what they perceived as public inter-

vention in the scientific process and the possibility of loss of control. Several of them tried to reassure the public by arguing that concerns about human genetic intervention were premature and that it was too early to deal with them. Some pointed to several immediate, visible problems arising from new medical interventions, and maintained that they were more worthy of concern than "the more lurid speculations" about the future applications of genetics. They argued that government intervention would stop progress and delay cures for dread diseases, and that more funds were needed for beneficial research.¹⁷

While the efforts to anticipate and study the ethical and social implications of genetic engineering faded, the new recombinant DNA techniques were being developed. In 1970 a planned experiment at Paul Berg's Stanford laboratory would have introduced the SV40 tumor virus into a bacterium as a step in developing tools for genetic manipulation. When scientists at Cold Spring Harbor learned of this they were alarmed about the possible safety hazards of the work and urged Berg to abandon the experiment. Berg postponed it and sought other alternatives. The focus was on the biohazard problem, not on the larger ethical implications of genetic engineering. A notable exception was the effort by Leon Kass to raise the ethical issues with Berg in a dinner conversation followed up by a long letter to him in October 1970. This remarkable document outlined questions of efficacy and safety, limits to uses, possible undesirable consequences, and monitoring and control of human genetic manipulation.¹⁸ But these concerns were submerged in the subsequent efforts to develop the technical tools for manipulating genes.

At the Gordon Conference on Nucleic Acids in July 1973, scientists revealed startling results using the newly discovered restriction enzymes to cut strands of DNA at precise points, to combine them with the DNA of other organisms and even other species, and to clone myriad copies of this recombinant or hybrid DNA. Participants expressed concern about the possible implications of the work, but that concern was limited to the possibility of immediate laboratory safety hazards associated with the research being launched. They were worried that recombinant DNA experiments could unintentionally create human pathogens through the introduction of antibiotic resistance, that the work might produce dangerous toxins, and that it might transform benign materials into cancer-causing agents. In November 1974, during the six-month period when a temporary moratorium was invoked by the scientists in the field on those particular experiments thought to be potentially hazardous, two university biologists in California applied for a patent on the recombinant DNA technique. Thus, the age of genetic engineering was underway with the commercial applications protected and discussion of the ethical implications postponed.

The February 1975 Asilomar Conference brought together scientists in the

field to consider the hazards of recombinant DNA research and to find ways to reduce them. In his opening remarks at the Asilomar Conference, David Baltimore expressed the views of the meeting's organizers:

Although I think it's obvious that this technology is possibly the most potent potential technology in biological warfare, this meeting is not designed to deal with that question. The issue that does bring us here is that a new technique of molecular biology appears to have allowed us to outdo the standard events of evolution by making combinations of genes which could be immediate natural history. These pose special potential hazards while they offer enormous benefits. We are here in a sense to balance the benefits and hazards right now and to design a strategy which will maximize the benefits and minimize the hazards for the future.¹⁹

Their concerns were narrowed to the immediate technical problems of laboratory safety, and they developed technical solutions to these problems. During the political controversy in the mid 1970s about whether these "tech fixes" were adequate, leading scientists in the field argued that the imminent practical benefits of the research and the absence of demonstrated risk meant that it was imperative that the research proceed as rapidly as possible. Public expectations of valued benefits were raised while possible hazards were downplayed. Ethical issues related to the potential applications of the new research tools and techniques were largely ignored. *They focused on the means, not the ends.*

Commercialization in the 1980s

Recombinant DNA techniques had an enormous scientific and social impact. They made possible new basic research on the structure and function of genes, opened up new fields of inquiry and led to a variety of applications in industry, agriculture, and medicine. Biology has been transformed and so have been the biologists. Starting very rapidly in the early 1980s, academic biologists never before involved with industry became consultants, advisors, founders, equity holders, and contractees of new biotechnology firms or new divisions of multinational corporations. Current disputes over patents on DNA sequences, human cells, tissues and body parts, and experimental processes and products are prominent in the scientific and public media. New companies are continuing to form around the developing technologies in agriculture, pharmacology, gene sequencing, genetic testing, DNA profiling, and human gene therapy. Universities are aggressively setting up companies and cutting multi million dollar deals with industry.

The rapid, large scale commercialization of academic biology has created conflicts of interest that may seriously erode public trust. Now more than ever biologists' expert advice is urgently needed on questions of public policy. But

the commercial roles and possible conflicts of interest of many biologists and their institutions have influenced their perceptions and their willingness to speak out, and limited their effectiveness as credible public advisors.

The Uppsala Code of Ethics from 1984

Before turning to the past decade, let us return to Sweden and Uppsala where Tiselius worked. As I noted earlier, his strong and prestigious voice in 1961 was one of the first to call attention to the potential power and possibilities of abuse of the new biology and he argued for establishment of a moral code for scientists. Twenty years later, in 1981, a new generation of scholars at Uppsala University began to study and discuss research ethics focusing on the responsibility of scientists for applications of their results. In 1984, the same year that the Swedish Gene Ethics committee issued its report on Genetic Integrity, the Code of Ethics for Scientists was published by the Uppsala group. It calls on scientists to assess the practical consequences of their research and to discontinue ethically doubtful research and inform others about this decision. The emphasis is on ecology and war, but it is meant to apply to all fields including biomedicine.²⁰ The Code was widely discussed in Sweden and stimulated continued thinking about these issues. In 1989 two of the participants in the group that formulated the Code offered an important observation: "the existence of ethical discussions and rules may be used to legitimate activities rather than to change them."²¹ This warning has special relevance to the current approach to ethics in the human genome projects and discussions about human gene transfer.

Genetics and ethics today

How does the Human Genome Project's approach to ethical issues differ from the past? Although there are many similarities, one apparent difference is that the Project is making an effort to identify the ethical, legal and social issues in advance, preparing society to deal with the "non-beneficial" uses of the vast amount of genetic information the project is designed to produce. But if this effort is compartmentalized and insulated from the main mission of the project without influencing its policies and priorities, then it once again separates the technical from the ethical, and defers the ethical issues, defining them as a societal and not a scientific concern. George Annas observed in 1989 that "ethics is generally taken seriously by physicians and scientists only when it either fosters their agenda or does not interfere with it. If it cautions a slower pace or a more deliberate consideration of science's darker side, it is dismissed

as 'fearful of the future,' anti-intellectual, or simply uninformed."²² Fortunately there are some notable exceptions to this criticism.

Many scientists feel frustrated in approaching the issues. Witness, for example, a biologist's response to my question about the meager amount of discussion of ethical issues at a small conference he attended at Cold Spring Harbor in the early 1980s on the prospects for human gene therapy. He answered:

I wanted more discussion on it... I did, and I didn't. There's a sense in which it's more fun to talk about the science. You're actually doing things in science. . . I think everyone who lived through the Asilomar period in the late 1970s and the regulatory period came to recognize that at the end of the day, when you're working with scientific things, you're in control. You, yourself, are in control of what you're doing, of your laboratory, or of your scientific environment in advance. When you get involved in regulatory, ethical, or political issues, you have to share that control and often you have very little input into what happens. I think that scientists like being in control. I think all of us find such situations at best ambiguous and at worst profoundly unsettling.²³

Control over discussions, actions and policy in human genetic engineering has been a central issue in the past and continues into the present. When I interviewed biologists in the late 1970s about their roles in the recombinant DNA safety controversy, I also asked some of them for their views about limits to genetic manipulation. They felt that the line should be drawn before human gene therapy and that the ethical issues were too important to be decided by the scientists involved. They said that the society as a whole should decide whether to undertake human somatic cell therapy, and volunteered that they were personally opposed to germ line interventions. These were private, not public, statements. Soon after, the scientists in the field and their academic institutions and funding agencies were involved in the pervasive commercialization of biotechnology and genetic engineering. Despite government committees and commissions and the involvement of bioethicists, the marketplace is a major force today in national policies or lack of policies in gene therapy.

Discussions of informed consent, safety, patients' rights and other standard biomedical ethics topics seem to take place under the assumption that human gene therapy is inevitable. Instead of "just say no", it has become "do it right."²⁴ The focus of scientists in the field and of many bioethicists is not about drawing the line, but about shifting the line—from somatic cell interventions to germ line, from germ line to its components, medical and enhancement. The germ line taboo is giving way to campaigns for gaining public acceptance, otherwise known as "marketing." Today's approach brings to mind the statement from the minutes of the 1966 private meeting to explore human genetic engineering that I quoted earlier: "Genetic intervention... has qualities analogous to those which sell soap."

Today, some academic scientists and the companies they are affiliated with

publicize genetic engineering research that they fear might be resisted on ethical grounds. Their motive seems to be to get the ethicists' blessings and the public's approval or acquiescence. They talk of potential benefits, the need to initiate public debate, and their conviction that "rational" decisions will be made. A current example is the claim of a U.S. company that it had made human cells revert to the embryonic state by fusing them with cow eggs to create a hybrid cell. The company scientist said that he was making the technique public now "because I want to be very open and level with everyone. We need to get the ethicists to talk about it so as to encourage a rational response to these new technologies... Any technology can be abused, but once the public understands how these cells can be used to treat any disease caused by loss or malfunction of cells, from Parkinson's to diabetes to heart disease, the concerns will be overshadowed."²⁵

Another example is the conference at the University of California-Los Angeles in March 1998, proclaimed by its organizers as "the opening of the public debate about germ line therapy." Their intended outcome was clear when they went on to say that the conference would focus on "how, why and when germ line engineering should proceed." Eight of the ten speakers were prominent scientists, all advocating human germ line intervention, and the two non-scientists were not in opposition. The list of the scientists' prestigious scientific affiliations, prizes and editorships of key journals omitted their commercial involvements in biotechnology firms.

What did they have to say? You can take your pick from the newspaper and magazine accounts of this well publicized meeting or consult the proceedings themselves on the website [www.ess.ucla.edu/huge] set up by the organizers. Here are a few quotes from the proceedings that are especially interesting.

French Anderson: "The unfortunate fact is that, with the exception of a few anecdotal cases, there is no evidence of a gene therapy protocol that helps in any disease situation."

If that is the case why persist in referring to these attempts as gene "therapy"? Gene transfer might be a better term, and less misleading.

James Watson: "If we could make better human beings by knowing how to add genes, why shouldn't we do it?..." and at another point, "If you could cure a very serious disease, *stupidity*, that would be a great thing for the people who otherwise would be born seriously disadvantaged."

Leroy Hood noted that it will be "only a matter of time" before the results of the Human Genome Project are used in germline engineering to enhance the human species. Several of the speakers rejoiced in their claim that "we are seizing control of our own evolution".²⁶ These statements by leading figures in

the field raise serious questions about their motivations and ethical perceptions. After the meeting the organizers made several policy recommendations to promote germ line gene therapy and to resist regulatory or legislative barriers to its exploration.

Concluding remarks

These issues should be discussed and decided with full public participation. Public interest organizations such as the Council for Responsible Genetics, patients and public health groups and concerned citizens should have a role in setting the agenda for policy forums, rather than just reacting to the formulations of scientists and bioethicists. Community and campus forums can air the issues in response to citizens' interests. Perhaps this would avoid the pattern in recent conferences where scientists involved in human genome projects and in gene transfer start off the program by explaining the science (and then leave), and the bioethicists remain to explain the ethical problems. Instead, interested citizens, students, faculty and patients' groups can decide what they need to know in order to make policy decisions. The "Science Shops" approach in the Netherlands and in Denmark might be useful, as would the "Community Research Network" being developed by the Loka Institute.²⁷

Here are some criteria or guidelines to consider for this important process of public decision making regarding human genetic intervention:

Disclose fully any potential conflicts of interest.

Examine and challenge assumptions about progress and research freedom.

Refrain from simplistic genetic causality and misconceptions that specific genes will be discovered for complex genetic traits.

Avoid the loose language and exaggerations of genetic reductionism and the misleading claims of biohype.

Seek moral, scientific, medical and social policy alternatives and consider diverse views within the research community, the public health field, and public interest and consumer groups.

Set research priorities to meet public health needs rather than commercial goals.

Develop increased public literacy among scientists and a stronger sense of social responsibility by exposing them to the writing and thinking of others in the history, ethics, politics and sociology of the life sciences.

Do it sooner rather than defer it until it is too late.

Notes

1. I am completing a book on the history of social responsibility in science which will contain detailed accounts of these efforts.
2. Tiselius, 1961, pp. 14–15. See also Wiskari, 1961 and Kekwick, Pedersen, 1974, p. 416.
3. Several of the historical accounts that follow have been included in Weiner, 1994.
4. *New York Times*, 1962.
5. *New York Times*, 1963.
6. Hollaender, 1966.
7. Zinder, 1966.
8. Nirenberg, 1967.
9. Kass, 1967. Kass was responding to Lederberg, 1967a. See also Lederberg, 1967b.
10. Reinhold, 1969.
11. Shapiro, Eron, and Beckwith, 1969.
12. Beckwith, 1970.
13. Beckwith, 1993.
14. Pontecorvo, 1971, pp. 119–120.
15. Fox and Littlefield, 1971.
16. Anderson, 1972, pp. 109–110.
17. United States Senate, 1968.
18. Kass, 1970. See also, Krinsky, 1982, pp. 33–36.
19. Asilomar, 1975. Audiotape of the International Conference on Recombinant DNA Molecules (Asilomar Conference), February 24, 1975. Recombinant DNA History Collection, MIT Institute Archives and Special Collections.
20. Gustafsson, Rydén, Tibell, Wallensteen, 1984.
21. Gustafsson and Tibell, 1989, p. 72. See Rydén, 1990 for a full discussion of the code and the response to it.
22. Annas, 1989, p. 21.
23. Interview, 1984.
24. Kass, 1997, especially pp. 24–26, provides a perceptive critique of the response of the field of bioethics to human cloning. The same criticism is applicable to the response of many bioethicists to human germ line interventions.
25. Wade, 1998.
26. Quotations are from the proceedings as published on the website.
27. Information on these approaches can be found on the Loka Institute website, <http://www.loka.org>.

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