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Genetic Engineering, Scientific-Industrial Revolution and Democratic Imagination

1. Introduction

Philip H. Abelson, the editor-in-chief of "Science," the leading American scientific journal, recently wrote the following remarkable lines in an editorial in his magazine about the future of genetic engineering:

"Changes that will have effects comparable to those of the Industrial Revolution and the computer-based revolution are now beginning. The next great era, a genomics revolution, is in an early phase. Thus far, the pharmacological potential of genomics has been emphasized, but the greatest ultimate global impact of genomics will result from manipulation of the DNA of plants. Ultimately, the world will obtain most of its food, fuel, fiber, chemical feedstocks and some of its pharmaceuticals from genetically altered vegetation and trees."[1]

These strong words from Abelson on the future potential of modern biotechnology–after all, one does not so hastily announce the beginning of an industrial revolution–do indeed have quite a long tradition in the not-so-very-long history of genetic engineering. Beginning in the 1950s, it was first molecular biology and then genetic engineering that were described by resorting to the metaphor of revolution. And even when the new methods and techniques of research in molecular biology and genetic engineering are not characterized as a revolution, then at least as a deep-seated upheaval and a shift of historical proportions. For example, Horace F. Judson has compared the emergence of molecular biology to the development of the nation-state in early modern Europe. In his classic work on the history of molecular biology, "The Eighth Day of Creation," the very title of which evokes the story of creation, Judson wrote:

"Revolution takes place within a frame of comparatively unyielding continuity…Molecular biology is no single province, marked off by national boundaries from the rest of the realm. It is, rather, an intellectual transformation–indeed, a new conceptual dynasty–arisen within the realm." [2]

Molecular biology is, in Judson's words, a "new conceptual dynasty." And by the early '70s, once this field had brought forth one of its most masterful achievements– namely, the formation of new combinations of genetic material–it was also quickly identified as the foundation of a new industrial sector, the so-called modern biotech industry, which was already being regarded in the early '80s in the US and somewhat later in other countries as the manifestation of a new Industrial Revolution–as a follow-up, so to speak, of the revolution in information and computer technology.[3]

Thus, during the early phase of development of genetic engineering, there was quite a lot of talk about "revolution," and it was initially molecular biology, then genetic engineering, and finally the biotech industry which were interpreted as catalysts of imminent, radical socioeconomic transformation. There were, however, also less euphoric views regarding the potential of this new biological research. Once the first successful genetic engineering experiments had been conducted, there began a debate on the new biotechnology's risks, dangers, and wide-ranging, problematic political, sociocultural, economic, and ecological implications which occasionally reached a fevered pitch. In contrast to, for instance, nuclear technology–the civilian use of which was not a subject of social controversy for many years– genetic engineering was practically born in a state of conflict. Genetic engineering processes were developed and immediately surrounded by heated controversy[4] that has not subsided to this day. Particularly in Europe, it is now increasingly generally accepted that the future of genetic engineering is inseparably linked to a process of democratic negotiation and a broad social acceptance which has yet to be produced.[5] In other words, even in light of the totally revolutionary character of genetic engineering, these biotechnology revolutions which are already observable or which can be expected in the future will actually take place only if society really wants them to occur. In this connection, it will be important to come up with appropriate mechanisms for the democratic process of opinion-formation and decision-making in the matter of genetic engineering. Indeed, opinion-formation with respect to genetic engineering is now characterized by strong polarization. Many of its proponents see genetic engineering as a scientific-industrial revolution that ought to be regarded positively, and view its critics as "irrational enemies," whereas many opponents of genetic engineering perceive modern molecular biology and its strategies of research and application as the expression of science gone astray on a path that must ultimately lead to ecological and social disaster. In the limited space permitted to me in this paper, I will attempt to outline how it could have come to this state of polarization in the field of genetic engineering and I will reflect a bit on how democratic politics might find a way out of this polarization. As a rough breakdown, we can identify the following phases in the development of and confrontation surrounding genetic engineering:

1. The phase of hopes and fears (the ’70s)

2. The phase of exaggerations (the ’80s)

3. The phase of fantasies being overtaken by contradictory realities (the ’90s)

2. The Phase of Hopes and Fears

The first successful experiments in genetic engineering took place in the early ’70s–experiments that gave rise to great hopes as well as tremendous fears in light of the unpredictable consequences and implications of the human intervention in DNA. The potential manipulation of a human being’s genetic make-up had already made many people uneasy. Even though genetic engineering and its capability of recombining various different genetic materials were phenomena of the early ’70s, it had become apparent much earlier over the course of the ’60s that molecular biology stood on the threshold of dramatic technical-scientific breakthroughs. The 1962 Ciba Foundation Conference entitled "Man and His Future" brought together a select group of leading scientists from the fields of genetics, medicine and biochemistry–among them Francis Crick who, together with James Watson, identified the double helix structure of DNA–in order to reflect upon the future of mankind in light of the latest developments in biological research. The Ciba Conference participants came to the conclusion that the so-called "new biology" and especially the developments in molecular biology could enable mankind to ultimately become the "master of evolution," among the implications of which was that manipulation of genetic germ lines would become possible in the future, which would thereby provide the biological-technical means to foster positive inherited characteristics.[6] The publication of the conference proceedings triggered the first major debate in Europe and the US on the possible eugenic implications of the "new biology"–that is, potentially discriminatory on the basis of genetics and genetic argumentation.

When, in the early ’60s, deep-seated changes began to manifest themselves in the various fields of research that are today subsumed under the heading of life sciences, science was still far away from the concrete technical feasibility of processes like germ line therapy. Molecular biological research took a giant step in this direction during the late ’60s and early ’70s with the development of genetic engineering. Scientifically, something remarkable had occurred during this phase. Up until the end of the '60, the classic biochemical and genetic techniques were aimed at coming up with a model that replicated the environment of a living cell–that is, the extracellular representation of an intracellular configuration. Genetic engineering turned this situation around, since the essential tools of genetic engineering such as replication enzymes, plasmides and vectors are of the same nature as the molecules themselves. The tools of genetic engineering are thus themselves molecularized; they are of the same nature as the processes in which they intervene. From this point on, it became a matter of the intracellular representation of extracellular projects; the organism itself became, in a manner of speaking, a laboratory.[7]

It was clear to the pioneers of genetic engineering from the very start that their step to turn organisms into laboratories did indeed represent a major scientific breakthrough and could be of tremendous economic and medical significance, but was, at the same time, highly problematic in many respects. Stanford University scientist Paul Berg, who had conducted the first successful genetic engineering experiment, recalled the reaction of a group of scientists at a symposium in Sicily upon hearing about his experiment for the first time:

> I came to lecture on protein synthesis to this sort of a school for Europeans, and the lecture, as a sort of rap session, that I was asked to give, was about the work we were doing in the construction of this hybrid DNA molecule of SV***40*** and lambda virus. And I did give that, and there was a very, very strong response on the part of the young European students, that this was really sort of the beginning of a new era and potentially dangerous, and raising the spectrum of genetic engineering in humans, behavior control… And they asked, could we have an informal session to discuss the political and social consequences of it. And this German fellow organized an evening session up in the ramparts of the old castle…and we sat up till about midnight, this whole crew drinking beer, about eighty people, back and fourth discussing the possible hazards, prospects for genetic engineering.[8]

Paul Berg was also the man commissioned by the US National Academy of Sciences to head a Committee on Recombinant DNA Molecules, Assembly Life Sciences which was asked to investigate the dangers of genetic engineering. In 1974, this committee published a report in which it initially advised against carrying out certain genetic engineering experiments. The debate culminated in 1975 in the so-called Asilomar Conference at which there was an extremely heated discussion of the basic principles of the political-regulatory process of dealing with genetic engineering. At the Asilomar Conference and later in legal regulations in countries including the US, Germany, France and Great Britain, the following security philosophy regarding the potential risks of genetic engineering was established: genetic engineering is dangerous, to be sure, but it is of such tremendous importance to mankind that a certain degree of risk has to be accepted. Furthermore, the only way to get control of the dangers of genetic engineering is by doing more research in this field and thus making more knowledge available about genetic engineering. In the meantime, however, according to this line of argumentation, the potential dangers of genetic engineering can be kept in check for the most part by means of so-called biological and physical containment. Biological containment calls for the use of bacterial strains produced by means of genetic engineering which are incapable of survival in a natural environment and that only those vectors will be used that can develop only into certain stem cells that can be kept discrete and isolated. Physical containment means employing certain laboratory security measures such as airlocks and hatches that are designed to prevent genetically modified organisms from escaping from the laboratory.[9] According to the security philosophy embodied in the regulation of genetic engineering which took shape in the early '70s, if both containment strategies are deployed, then there is actually nothing that can go wrong.

Subsequent to these considerations, relatively similar guidelines for dealing with genetic engineering in the laboratory were put in force in most industrialized countries. And these guidelines had a number of important functions. They established certain minimum security standards with respect to all possible dangers associated with genetic engineering. Furthermore, genetic engineering was conveyed legitimacy by the very fact that the state proceeded to institute official guidelines–thus, concrete regulatory measures as well as symbolic governmental actions undertook to protect the population from the dangers of genetic engineering. At the same time, boundaries were drawn between experts and laymen, the general public and science, and politics and science. These boundaries also gave rise to those protagonists who were permitted to participate in the supervision of genetic engineering and those who were relegated to the role of spectators of the process of risk control. In the US and in Europe, regulation of the risks of genetic engineering became the privilege of a small group of experts from various different scientific fields from molecular biology to medicine, who usually worked together in commissions whose ranks were sometimes augmented by individual representatives of interest groups like unions or trade associations. This formulation of the political process of dealing with genetic engineering had a number of strengths as well as weaknesses. It functioned well and had a certain calming effect on the general public as long as genetic engineering was being conducted in secluded laboratories. At this time, the field was indeed regarded as a technology of the future but one that still had no practical application, and, in real life, it continued to be traditional protagonists like unions or the established political parties which determined the dynamics of the policymaking confrontation. This constellation would change dramatically during the ’80s.[10]

3. The Phase of Exaggerations

Following the major disputes of the 1970s, the genetic engineering debate seems to have calmed down for the most part in the early ’80s. An OECD report on genetic engineering summarized the situation:

> In the early 1970s, when the technology of genetic manipulation was first acquired, predictions of scientists ranged from panacea to pandemic. A public storm followed and it was not at all surprising that national authorities in many countries, having been told that this technology was capable of creating new forms of life and that scientists themselves had requested a moratorium for this type of research, responded by setting up groups and committees to consider the social and political acceptability of the risk. A public feeling of instinctive mistrust towards scientists promoting genetic engineering was widespread. However, finally after considerable public debate and advice from scientists, medical and epidemiological experts, the general conclusion has been reached that, provided suitable precautions are taken, the benefits of the technology far outweigh any conjectural risks.[11]

Nevertheless, a series of developments imparted a new dynamism and a new dimension to the genetic engineering debate. Here, foremost mention should be made of the use of genetic engineering beyond the confines of the laboratory, particularly in large-scale industrial production and agriculture. But the public representation and interpretation of genetic engineering also played an important role in bringing forth a new dynamism in the conflict surrounding genetic engineering. In the early ’80s, the biotech industry in the US was launched in dramatic fashion. Initial successes in the industrial application of genetic engineering by pharmaceutical firms like Genentech–new enterprises that had been financed by venture capital–quickly imbued investors in the US with the vision that modern biotechnology was bringing about a revolution comparable to those in microelectronics and computers. The first tangible, though limited, successes in the industrial application of genetic engineering research were interpreted as the first step in a wide-ranging process of economic transformation, whereby the entire spectrum of fields in medicine and pharmaceuticals, and one major industrial sector after another including agriculture, mining, chemicals and the production of foodstuffs would undergo fundamental changes as a result of high-tech biotechnology. Breathless prognostications about the future of biotechnology spread the message about a future world in which nothing would remain the way it had once been– agriculture would be completely restructured, the health care system totally revamped, and, moreover, millions of new jobs would be created in the biotech industry. In these scenarios, the manipulation of genetic material had become a central project of late modern society.[12]

These predictions would prove to be gross exaggerations (as I will discuss in detail a bit further on). The picture of the "brave new world of genetic engineering" which they pained, though, had a number of different consequences. Not only did they fill investors with hope; they also increasingly filled many segments of society with apprehension. These groups began to overestimate and exaggerate genetic engineering and its potential consequences just as the prophets who advocated genetic engineering had done, though the signs and omens the two groups invoked were diametrically opposed.

Another important development during the ’80s was the emergence of the ecological discourse, at the center of which was a reconceptualization of the relationship between mankind and nature, and which took up a wide range of issues including the use of natural resources and the problem of responsibility in bringing about changes in nature. This ecological discourse constituted an important referential and orientational framework for a series of new actors who assumed places on the political stage and for the new social movements that had coalesced over the course of the ’70s and went through a consolidation phase during the ’80s, manifestations of which included the parliament seats won by the Green parties in the Federal Republic of Germany and in Austria.[13] It was particularly these new political protagonists who began during the ’80s–initially in Germany but to a significant extent in many other industrial nations as well–to critically confront genetic engineering and to develop a multifaceted front to resist the idea of a society that would be fundamentally transformed by it.

An essential point of approach for these critics were the first so-called field experiments conducted by genetic engineers–that is, tests in which genetically-modified plants like tomatoes and potatoes were actually cultivated in fields. The opposition got worked up about such experiments which were said to be extremely dangerous, but in doing so–as mentioned above–they had recourse to the same basically less-than-realistic "brave new world of genetic engineering" fantasies of the biotech advocates.[14] The consequences of this opposition were intensified regulatory efforts directed at the practice of genetic engineering, outlawing certain products such as the genetically-engineered cattle growth hormone rBST that was banned in Europe, as well as a certain opening up of the risk regulation process to participation on the part of the general public.[15] Already by the second half of the ’80s–in a stark contrast to the way the genetic engineering debate had subsided in the late ’70s–advocates of the "brave new world of the biotech industry" were somewhat surprised to find themselves confronted with a disparate assortment of critics and opponents of genetic engineering who not only lodged all-encompassing demands like the one for a total moratorium on the release of genetically-manipulated organisms, but also became a social force to be reckoned with over the course of the ’80s. They were elected with increasing frequency to seats in parliament, such as the German Greens, and even joined the governing coalition, like the Greens in France during Mitterand’s term in office.

4. The Phase of Fantasies being Overtaken by Contradictory Realities

In the ’90s, the smoke of the often heated confrontations and exaggerations of the ’80s slowly began to clear. Certain arguments or demands that had been hotly disputed only a short time before were increasingly accepted as "social realities" and were accorded a certain degree of legitimacy. And ultimately, as an upshot of approximately 20 years of research and development in the field of genetic engineering, a series of important new interpretations of the "realities" of the potential and the capabilities of genetic engineering emerged.

First of all, the construction of reality whereby genetic engineering was said to be a form of "high technology" with a broadly effective transformative potential similar to that of semiconductor technology became increasingly problematic over the course of the ’90s. The original assessment of genetic engineering as high technology was based upon a rather imprecise definition of high-tech. The problem with most definitions of high technology is that they primarily measure innovation-inputs but not innovation-outputs. A high level of innovation-inputs does not necessarily produce a high level of innovation-outputs. It makes more sense to differentiate between widespread and newly-emerging technologies. Widespread technologies like microprocessor technology have applications in a broad spectrum of fields and exert a clear effect on the overall economy.[16] The concentration of biotechnology in the product sector of medical diagnostics and therapeutics as well as in the slowly-developing agricultural area makes its characterization as "widespread"–at least during the ’80s and ’90s–appear to be exaggerated. It seemed that genetic engineering had by no means delivered what it had originally promised–namely, a sort of revolution in a multitude of fields ranging from the pharmaceutical industry to agriculture, and the creation of "millions of jobs" across the economic spectrum.

In the biotech industry today, there is a lot of talk about "research bottlenecks" and the enormous difficulties a product faces in making its way from initial conception to actual marketing. A clear indication of this "long and winding road to the market" is the number of "product failures"–that is, statistics on the biotech industry’s abandonment of development of what had, in many cases, been highly-touted new medications. In fact, the number of genetically-engineered products available today in the pharmaceutical sector is still extremely small and, with rare exceptions such as the US firm Genzyme, there continue to be hardly any newly-founded biotech enterprises that are operating profitably. Whereas a rather pessimistic assessment of the biotech industry such as this one would have been tantamount to heresy in the ’80s, there is increasingly a consensus in this regard today. Just recently, this situation was brought up at the Forum Biovision, a major international genetic engineering convention bringing together leading scientists and businessmen. On this occasion, Nobel laureate David Baltimore spoke about the necessity of reorienting genetic engineering research and particularly emphasized that current research in genetic engineering increasingly concentrates on the cartography of the human genome and does not pay sufficient attention to the cell.[17]

What Baltimore thus indirectly addressed is a problematic issue that has been increasingly occupying the focus of current attention–the epistemological dominance of the central dogma of molecular biology in research, a dogma that proceeds under the assumption that, in every case, a DNA sequence either directly encodes a certain protein, or that this DNA sequence is necessary for a neighboring segment which then encodes the protein. This "DNA -> mRNA -> protein -> everything else, like diseases etc." dogma exhibits a number of problems. Most of the important diseases that effect large numbers of human beings, such as cancer, cardiovascular diseases, and most psychological illnesses are not caused by a certain gene or a defect in a particular gene. Most diseases are polygenetically determined, the course of events by which they develop is complex, and this is inseparably linked to environmental factors. But it is difficult to acquire a grasp of this complexity by means of the reductionist paradigms of molecular biology that is, first and foremost, fixated on the "one gene, one illness" pattern.[18] There is a certain connection between this issue and the previously-mentioned problems of product development in the pharmaceutical sector. But it is also remarkable that, despite the plethora of announcements, there is still not a single example of a successful genetic therapy, not even in the case of monogenetic diseases like cystic fibrosis.[19] Not surprisingly, the areas which are currently beginning to gain importance and prominence in both genetic engineering research as well as product development are "genomics" and "proteomics"–the former having to do with the characterization and sequencing of the genome and the relationship between genetic activity and cell function, and the latter with systematically drawing up protein profiles, just as genomics has been doing for the genome. The idea of genomics and proteomics is to develop a more precise understanding of the connection between genes and disease, and to come up with new therapeutic strategies based on these findings.[20] Within the biotech industry today, genomics and proteomics are among those undertakings which are associated with the greatest hopes of yielding totally innovative products and health care strategies. This was expressed quite well in the words of the editor-in-chief of "Science" quoted at the beginning of this essay, who even spoke of a "genomics revolution" similar to the Industrial Revolution. Nevertheless, what is true in the case of genomics is precisely that which applies to genetic engineering in general: at least for the time being, an ever-increasing body of theoretical knowledge about human genetics stands in powerful contrast to actual therapeutic possibilities, which continue to be quite limited.[21]

However, the above-mentioned flops in genetic engineering have not only led to a pause to reflect, sort things out, and reorient efforts on the part of a number of scientists and firms; paradoxically, it has been precisely these previously referred-to "bottlenecks" in molecular biological research in the medical area that have most recently breathed new life into genetic engineering strategies which, in the past, had continuously been rejected on the basis of the most profound ethical concerns. One of these is germ line therapy, genetic therapeutic interventions which do not just manipulatively intervene in an individual’s genes without these manipulations being able to be inherited, as is the case with somatic genetic therapy, but rather have effect on egg and sperm cells and thus intervene in the genotype. At a symposium entitled "Engineering the Human Genome" held in Los Angeles in March 1998, prominent physicians and molecular biologists such as James Watson and W. French Anderson convened to discuss the future of genetic therapy. As a respected German newspaper laconically remarked in a report on the symposium: "This was not a matter of discussing whether society ought to dare to get started with germ line therapy, but rather only a matter of when and how."[22] An important motivation for these considerations was, to put it simply, the previous flops in somatic genetic therapy, which, according to James Watson, "would persist until the end of time." The symposium’s plea for a germ line therapy that is "technically simpler" to perform–and which has been perfected particularly on mice during the last few years–must, however, be viewed in the larger context of a discourse that has taken shape over recent years. At its centerpoint stands a figure not totally unknown to us from the history of molecular biology–the genetically "optimized man" who goes through life as a happier, healthier, and more successful creature than the specimen with which we are familiar today. In the words of Leroy Hood, another prominent genetic engineering researcher and father of the human genome project: "We could probably engineer people totally resistant to AIDS, or to certain kinds of cancer. We might engineer people to live much longer. I would say these are good qualities."[23] Leroy Hood’s statements and the "Engineering the Human Genome" symposium testify to an unbroken "revolutionary spirit" in genetic engineering which, as we are certainly aware, has already led to extreme polarization in the past, and is, in my opinion, completely at odds with the equally valid, and more prudent line of argumentation put forward by representatives of genetic engineering research and development.

The ’90s, the "phase of multi-layered realities" in genetic engineering, thus present a thoroughly ambivalent picture of the development and application of biotechnology. For one thing, we still find the familiar revolution metaphor in scientific discourse. The ’80s, though, were also a phase of disillusionment in which–after almost 25 years genetic engineering development–the prior lack of success became evident and was also widely taken note of. At the same time, genetic engineering can also point to many successes, from genetically-manipulated agricultural products to the sequencing of the human genome and, closely related to this, the formation of a highly sophisticated biotechnology testing sector in the pharmaceutical industry.

Another important aspect of this "phase of realities" is the resistance against genetic engineering that has nowadays become an established structure particularly in Western industrialized countries. Whereas in the ’70s, the agitation surrounding genetic engineering could still be dismissed as the "exaggerated reaction" of a minority, and criticism of genetic engineering during the ’80s still seemed to be strongly associated with Green parties and similar groups (particularly in German-speaking areas and in Denmark), a series of polls conducted in recent years very clearly shows that today both in the US and–even more strongly–here in Europe, a large segment of the population regards genetic engineering with disapproval and skepticism. This disapproval varies from country to country and from one area of application of genetic engineering to another. For instance, the attitude of the population toward genetic engineering seems to be more positive in the US than in Europe, and the acceptance of medical applications of genetic engineering is generally higher than support for the use of such methods in the production of foodstuffs.[24] But the question remains as to how a democratic system ought to go about dealing with those who reject or criticize genetic engineering, a phenomenon that is neither temporary nor attributable to a mere subculture.

5. The Political Process of Dealing with Genetic Engineering: Administrative Routine or Democratic Political Imagination?

Conflicts on the use of certain technologies often tend to produce polarized political landscapes. Certain technologies–for instance, the civilian use of atomic energy–produce yes/no decision-making situations, as it were, on their own. Either one accepts nuclear technology as an integral element of energy production or one does not; between the two positions, there is little leeway to seek a compromise. Other technologies such as genetic engineering, as a rule, permit much more latitude in the decision-making process. Nevertheless, the political debate often assumes polarized forms, whereby opponents tend to fundamentally reject genetic engineering across the board from agriculture to medicine, and the proponents–revealing themselves as a spitting image of the opponents, only reversed–see in genetic engineering a unique blessing for mankind. Both groups tend to disparage the opposition–one side portrayed as unscrupulous or naive, dangerous techno-fetishists, the other as adherents of the Stone Age who would deprive mankind of significant achievements.

Once a technology has become the center of conflict, politics is soon brought into play in an effort to regulate the process of dealing with the controversial technology–be that in the sense of its proponents or its opponents. In this way, conflicts that emerged in the technical-scientific or industrial field are carried on in the field of politics and governance, often shuttled back and forth between the respective fields, whereby the upshot of such seesawing is frequently to make the boundaries between science/technology, the economy, and politics/statecraft extremely fuzzy. Scientists and businessmen act like politicians, politicians play the role of scientists, and the result of such travesties is often utter confusion and further polarization of the conflict.[25] It is difficult if not impossible to reach a compromise solution under such circumstances. The conflict surrounding genetic engineering is an outstanding illustration of this dilemma of democratic politics.

As previously mentioned, genetic engineering was, to a certain extent, born into conflict, and was thus already an object of controversy in its earliest phase of development. From a historical perspective, its various accomplishments and activities–from the work in the laboratory to the release of genetically-manipulated organisms and the sale of genetically-modified foodstuffs–have been initially confronted with categorical rejection and demands that they be outlawed, and were later the objects of legal regulation measures which had frequently been preceded by a phase of institutional deliberation. After the first experiments in genetic engineering had been successfully conducted, groups of scientists in the US initially demanded a moratorium on research in genetic engineering. These demands for a halt to research were withdrawn at the Asilomar Conference in 1975, at which the potential risks of genetic engineering and risk limitation strategies were discussed. Following Asilomar, bans applied only to certain groups of experiments whose number steadily diminished over time. One result of the Asilomar Conference in the US was the establishment of the Recombinant DNA Advisory Committees (RAC) which developed guidelines for dealing with genetic engineering in the laboratory. The first step taken in Great Britain was the creation in 1974 of the so-called Ashby Working Group, whose task was to consider whether the state ought to intervene in the regulation of genetic engineering and, if so, how. Later there was the Williams Committee which followed the US model in conceptualizing a regulatory authority, the Genetic Manipulation Advisory Group (GMAG), which subsequently developed and supervised a system for regulating genetic engineering in Great Britain. During the ’70s, all Western industrialized nations set up systems resembling more or less the US regulatory model to implement state surveillance of the process of dealing with the risks of genetic engineering in the laboratory.[26]

The ’80s and ’90s then brought new challenges to the political confrontation with genetic engineering. Progress was being made in biotechnology–for instance, genetic engineering methods were increasingly used in industry and large-scale production, the first experiments were conducted in which genetically-manipulated organisms were released in the environment, and the massive project to achieve the total sequencing the human genome was launched. In Europe during the ’80s, Green parties and a wide variety of new grass-roots movements were experiencing a strong upsurge and were employing novel and frequently unconventional means to challenge traditional policymaking in areas that included biotechnology. Whereas the basic question "Genetic engineering, yes or no?" had been at the center of attention in the ’70s, the debate now focused on more specific issues such as a moratorium on field testing, the problematic human genome project, and medical applications of genetic engineering.

Particularly in Europe during this phase, we can observe an intensive use of thoroughly innovative, imaginative instruments of democratic politics, such as the German Bundestag’s appointment of a commission to investigate the risks and potential rewards of genetic engineering, which over the course of two years from 1984—1986 expended tremendous efforts to thoroughly discuss the pros and cons of all relevant areas of biotechnology. The Austrian parliament also established an investigative commission–with a much smaller budget, though with a great deal of commitment–which looked into genetic engineering as a political-social phenomenon. Denmark and the Netherlands set up "dialog models" or "biotechnology consultation groups" designed to foster a discourse among foes and advocates of genetic engineering. In France in 1998, a "citizens’ conference" was staged by the parliament’s office for the assessment of the consequences of technology. For this purpose, an opinion polling organization selected 14 "average citizens," who then spent two days being presented with expert opinions and discussing the problems and challenges of genetic engineering, and who finally came to a "verdict" concerning the political steps which needed to be taken in this matter.[27]

Despite these political developments and steps, it would hardly be an exaggeration to maintain that the debate of genetic engineering and its institutionalization in the form of a series of commissions, bodies of official regulations, and innovative venues of deliberation has still not been brought to a satisfactory conclusion. Indeed, the impression which suggests itself–particularly in Europe–is that the genetic engineering debate has not even approached its highpoint. There are a variety of reasons for this situation.

First of all, the process of openly addressing the subject of genetic engineering in a broad-based public debate with clear political consequences has not yet been successfully carried out in convincing fashion. Especially the imaginative political instruments like the above-mentioned "citizens' conference" or the investigative commissions have, in the past, been distinguished by a certain lack of political resonance or tangible consequences, in that the debate and the discourse within these institutions were certainly lively, but this activity did not result in concrete political decisions. The various different discourse-oriented institutions were indeed permitted to go about their business, but the actual decisions were frequently reached by others, such as bureaucrats on the administrative or governmental levels acting in routine procedures and without taking the work of these various deliberative bodies into consideration. The illegal release of genetically-manipulated organisms in a number of countries, and efforts by conglomerates like Monsanto to commingle genetically-manipulated and non-genetically produced soybeans in order to deprive consumers of the opportunity to choose between these two types of products, together with scandals like the BSE affair–which had nothing to do with genetic engineering but which shook public trust in regulatory authorities to its very foundation–all combined to produce a deep-seated skepticism toward genetic engineering on the part of a majority of the population.

This skepticism was even intensified by the style of argumentation employed by the so-called proponents of genetic engineering, which has often belittled thoughtful reflection and mistrust as ignorance and stupidity. It has been precisely this tactic that has stabilized a state of political antagonism and which has found its perfect match in the frequently-encountered intransigence of the opponents of genetic engineering. Such antagonism in politics can be overcome only by that which Chantal Mouffe refers to as the transformation of political antagonism into an agonistic pluralism. Here, agonal is used in the sense of the Greek *agons,* athletic or intellectual competition. Implicit in this is mutual recognition on the part of both sides, respect for differing positions, and not repudiating the fundamental legitimacy of opposing views. Therefore, what we need more of in the future is a new culture of negotiating the present and the future of genetic engineering, a new culture that is characterized less by utopias and exaggerations and rather more by composure, political imagination, and trust in the democratic capacities of the citizenry. If it is so that nobody today is in a position to stop genetic engineering, then it must also be acknowledged that it cannot be forced upon society–neither by governments, nor by giant corporations. Transforming this tension into a political dialogue that also leads to concrete political decisions will be a major challenge to genetic engineering policymaking in the future.

Notes

[1] Abelson, Philip H., A Third Technological Revolution. *Science,* Vol. 279, 27 March 1998, 2019.

[2] Judson, Horace Freeland, *The Eighth Day of Creation,* New York: Simon & Schuster, 1979, 201.

[3] Gottweis, Herbert, *Governing Molecules: The Discursive Politics of Genetic Engineering in Europe and in the United States,* Cambridge, Mass.: MIT Press, 1998, 153—163; Robert Tetelman, *Profits of Science. The American Marriage of Business and Technology,* New York: Basic Books, 1994, 183.

[4] See, for example, Krimsky, Sheldon, *Genetic Alchemy. The Social History of the Recombinant DNA Controversy,* Cambridge, Mass.: MIT Press, 1982.

[5] Gottweis, ibid.

[6] Wolstenholme, Gordon, *Man and His Future,* A Ciba Foundation Volume, The Ciba Foundation, London: J.&A Churchill, 1963.

[7] Rheinberger, Hans-Jörg, "Experiment, Difference, and Writing, Part I" and "Tracing Protein Synthesis, Part II: The Laboratory Production of Transfer RNA" *Studies in History and Philosophy of Science,* Vol. 23, 1992, 305—331 and 389—422; Rheinberger, Hans-Jörg. *Experiment, Differenz, Schrift: Zur Geschichte Epistemischer Dinge,* Marburg/Lahn: Basilisken Presse, 1992.

[8] Interview with Paul Berg, 1, May 17, 1975, The Libraries-MIT, Institute Archives and Special Collection, Recombinant DNA History Collection.

[9] Gottweis, ibid., 77—152.

[10] Gottweis, ibid., 147—152.

[11] OECD, Bull, Alan T.; Holt, Geoffrey; Lilly, Malcolm D., *Biotechnology. International Trends and Perspectives,* Paris: OECD, 1982, 60.

[12] Gottweis, ibid., 157—159

[13] Hajer, Maarten A., *The Politics of Environmental Discourse: Ecological Modernization and the Policy Process,* Oxford: Oxford University Press, 1995, in press; Spaargaren, Gert; Mol, Arthur P.J., Sociology, Environment, and Modernity: Ecological Modernization as a Theory of Social Change. *Society and Natural Resources,* Vol. 5, 1992, 323—344, 328—329; World Commission on Environment and Development, *Our Common Future,* Oxford: Oxford University Press, 1987; Simonis, Udo E., Ecological Modernization of Industrial Society: Three Strategic Elements. *International Social Science Journal,* Vol. 41, 347—361; Huber, Joseph, *Die Regenbogengesellschaft: Ökologie und Sozialpolitik,* Frankfurt am Main: Fischer Verlag, 1985; Tesier, Robert, Ethique Environmentale et Théorie du Fait moral chez Durkheim. *Social Compass,* Vol. 40, 1993, 437—449; Tschannen, Olivier; Hainard, François, Sociologie et Environment: Tropismes Disciplinaires ou Nouveau Paradigme? *Schweizersiche Zeitschrift für Soziologie,* Vol. 19,1993, 421—443.

[14] Levin, Mores; Strauss, Harlee S., Introduction: Overview of Risk Assessment and Regulation of Environmental Biotechnology., *Risk Assessment in Genetic Engineering* (Levin, Mores; Strauss, Harlee S., eds.), New York: McGraw Hill, 1991, 1—17; Brill, Winston J., Safety Concerns and Genetic Engineering in Agriculture. *Science,* Vol. 227, 1985, 381—384; Colwell, Robert; Norse, Elliot; Pimentel, David; Sharples, Frances; Simberloff, Daniel, Genetic Engineering in Agriculture. *Science* Vol. 29, 1985, 111—112; Sharples, Frances E., Regulation of Products from Biotechnology. *Science*, Vol. 235, 1987, 1329—1332; Davis, Bernard D., Bacterial Domestication: Underlying Assumptions. *Science*, Vol. 235, 1987, 1329—1335; Tiedje, James M.; Colwell, Robert K. ; Grossman, Yaffa L.; Hodson, Robert E.; Lenski, Richard E.; Mack, Richard N.; Regal, Philip, The Planned Introduction of Genetically Engineered Organisms: Ecological Considerations and Recommendations. *Ecology,* Vol. 70, 1989, 298—315, 298;Hagerdorn, Charles, Potential and Risk in Commercial Use of Microorganisms. *Forum for Applied Research and Public Policy,* Vol. 4, 1989, 84—91; . van Elsas, J. D.; Trevors, J. T., Environmental Risks and Fate of Genetically Engineered Microorganisms in Soil. *Journal of Environmental Science and Health,* Vol. 26, 1991, 981— 1001; Regal, P. J., Scientific Principles for Ecologically Based Risk Assessment of Transgenic Organisms. *Molecular Ecology,* Vol. 3, 1994, 5—13; Abbott, Richard J., Ecological Risks of Transgenic Crops. *Ecology and Evolution,* Vol. 9, 1994, 280—282; Ryder, Maarten, Key Issues in the Deliberate Release of Genetically Manipulated Bacteria. *FEMS Microbiology Ecology,* Vol. 15, 1994, 139—146.

[15] Gottweis, ibid., 318—321

[16] McArthur, R., Replacing the Concept of High Technology: Towards a Diffusion-based Approach. *Environment and Planning A,* Vol. 22, 1990, 811—828.

[17] *Les Echos,* March 30, 1999, Perez, Alain, Les Biotechnologies en mal de financement et de respectabilité.

[18] Strohman, Richard C., Ancient Genomes, Wise Bodies, Unhealthy People: Limits of a Genetic Paradigm in Biology and Medicine. *Perspectives in Biology and Medicine,* Vol. 37, 1993, 112—145, 117.

[19] Smglik, Paul, Gene Therapy. The Next Generation. *The Scientist*, May 11, 1998, Vol 12; Zipkin, Ilan, Cystic Fibrosis: Failing the Test Case? *The Berstein Report on BioBusiness,* March 29, 1999, 17.

[20] Aldrige, Susan, Proteomics Complementary to Genomics. *Genetic Engineering News,* Vol 18, January 15, 1998; Brown, Patrick O.; Hartwell, Leland, Genomics and Human Disease. Variations on Variation. *Nature Genetics,* Vol. 18, February 1998, 91—93; Persidis, Aris, The Business of Pharmacogenomics. *Nature Biotechnology*, Vol. 16, February 1998, 209—210.

[21] Cohen, Jon, The Genomics Gamble: Biotechnology Betting on the Genome. *Science*, Vol. 275, February 7, 1997, 767—772; Schafer, Alan J.; Hawkins, J. Ross, DNA Variation and the Future of Human Genetics. *Nature Biotechnology,* Vol. 16, January 1988, 33—39.

[22] *Frankfurter Allgemeine Zeitung,* July 29, 1998

[23] Taylor, Robert, Superhumans: Like It Or Not, In a Few Short Years We'll Have the Power to Control Our Own Evolution. *New Scientists*, October 3, 1998, 25—29, 29; Gordon, Jon W., Genetic Enhancement in Humans. *Science*, Vol. 283, 2023—2024.

[24] Commission of the European Communities, Eurobarometer 35.1 Biotechnology, June 1991; Zechendorf, Bernhard, *Public Opinion on Biotechnology*, Manuscript, Brussels 1992; Büro für Technikfolgenabschätzung beim Deutschen Bundestag (TAB), *Gentechnologie und Genomanalyse aus der Sicht der Bevölkerung. Ergebnisse einer Bevölkerungsumfrage des TAB,* TAB-Diskussionspapier Nr. 3, Bonn 1992.

[25] Jasanoff, Sheila. *The Fifth Branch: Science Advisers as Policymakers,* Cambridge, Mass.: Harvard University Press, 1990.

[26] Gottweis, ibid., 77—126.

[27] Catenhusen, Wolf-Michael; Neumeister, Hanna (eds.), Enquete-Kommission des Deutschen Bundestages, *Chancen und Risken der Gentechnologie. Dokumentation des Berichts an den Deutschen Bundestag,* Munich: Schweitzer Verlag, 1987; Behrens, Maria; Meyer-Stumborg, Sylvia; Simonis, Georg, *Gen Food. Einführung und Verbreitung, Konflikte und Gestaltungsmöglichkeiten,* Berlin: Edition Sigma, 1997; Les citoyens appellent à la prudence face aux plantes transgéniques. *Le Monde*, June 23, 1998.