

Evolution in human hands: the implications of biotechnology for society

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Evolution in Human Hands

The Implications of Biotechnology
for Society

Working Paper of the
Research Group on the Global Future
Center for Applied Policy Research (CAP)

Munich, June 2000

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I. The molecular revolution

The advances in molecular biology confront mankind with a fundamental transformation of our conception of nature, the depth of which can only be compared with the birth of the modern natural sciences in the seventeenth century and the revolutions in physics at the beginning of the twentieth century. At the centre of the molecular revolution is the recognition that all carbon-based life forms are based on a self-reproducing sequence of data, whose "programming language" is based on the same "letters" for all organisms. The universality of the genetic code allows an abundance of recombination possibilities for organic life. If "this century was the century of physics and chemistry", as the American chemist and Nobel Prize winner Robert Curl pronounced four years ago, then "it's just as clear that the next century will be the century of biology".

In the space of just a few decades scientists have discovered how to decipher the code of life and make alterations feasible – through genetic technology. Even allowing for due caution in terms of estimates of the time frame for the thinkable and doable – consider the extraordinary degree of speculation regarding human cloning – it's certain that the story of the molecular revolution will complete itself in this new century. The nature of this technological quantum leap can be reduced to four elements:

- The ability to intervene in the raw material of inheritance is the heart of the molecular revolution. The applications of the future, whether in human medicine, agriculture or environmental

Biotechnology will
define the 21st
century

Reprogramming of
genetic blueprints is at
the heart of the
molecular revolution

technology, will be based on the reprogramming of genetic blueprints.

- Genetic resources will become the raw material and capital of a new, globally active business area, whose diversification will be based on the phalanx of computer technology and genetic research, and which will nourish itself from the potential to process, patent and possess DNA as a company-owned asset.
- Human beings will eventually become the object of their own creative will through the retooling of the genetic material. The natural history of humans will pass into a new age, where the design of life is possible.
- The effects of this new ‘editability’ of humans will touch our lives in quite immediate, practical and concrete ways. They will force everybody to come to terms with this and arrive at their own position one way or another.

‘Editability’ of humans will force everybody to confront this personally

It is not necessary to call on any creation myths to realise that modern biotechnology touches on our own fundamental understanding of what constitutes life, death and being human. This is exactly what is new about this technology. On the other hand, what was true for previous technological advances is also true for this one: the questions and problems which are bound in with the new opportunities cannot be simply reduced to either/or solutions, or indeed to the black and white view of them in exaggerated emotional terms as blessing or curse, opportunity or peril. The advantages of the potential applications are great, just as their impact on society and individuals will be enormous. Thus the scientific-technical revolution becomes an

ethical, political, economic, social and psychological challenge, which demands decisions: concerning values, goals and the way to get there.

II. Life as information: the way we handle genetic data in the age of genetic analysis

In a few years, roughly about the time the human chromosome is decoded, the means will be available to systematically investigate the genetic strengths and weaknesses of broad swathes of mankind. This knowledge of genetic dispositions demands an answer to the question of who can access this genetic information, and under what circumstances. The age of genetic analysis requires yet another decision: societies will have to make up their minds about the extent to which they want to make the new discoveries of genetics the basis for a new standardisation of human life.

Standards for the use
of genetic
information are
required

A legal framework for the use of genetic data

The ability to test people and find out if they are carriers of genes which can predispose them towards numerous illnesses will belong to the standard diagnostic repertoire within the next two decades. It will be possible to carry out hundreds of genetic tests as routine and enable doctors to assess the risk for diseases, physical limitations and handicaps. In many cases this knowledge will be accompanied by new diagnostic and therapeutic possibilities (e.g., tailored medicinal treatments, gene therapies, recommendations for diets or lifestyle adjustments), which can save lives or make them healthier and longer.

And yet, doctors will still frequently be faced with a predicted condition where they are helpless, whenever diseases are detected which are either untreatable or for which no treatment has yet been found.

The right not to know

The characteristics of genetic analysis – comprehensive insight into the genetic makeup, while holding no guarantee for therapy and cure – have a great many legal consequences. In the future the right not to know will become as important as the liability of those who offer prognoses which turn out to be false. The right will, however, especially hinge on the extent to which third parties are informed, or not, about the results of genetic diagnoses. This is particularly so in relation to insurance, the job market and the penal system, where this question will require precise rules within a clearly defined legal framework:

- Thus private insurance policies (life insurance, unemployment insurance, supplementary health care insurance, inter alia) will increasingly argue that genetic information allows a more precise assessment of the risks, and therefore a more equitable calculation of the individual premiums. Particular diagnoses may lead to people with certain genetic defects being classified as being too high-risk and excluded from the protection provided by insurance. In other cases they might perhaps be accepted, but would have to pay significantly higher premiums. In such a situation it would become a decision for society to make, as to what extent (health) insurance systems, public as well as private,

Genetic risks will lead to differentiated insurance coverage

should provide a basic minimum system of benefits irrespective of whatever genetic information that might be available.

- Information from genetic tests will also have an effect on the job market. It will have to be resolved to what extent genetic evidence can be consulted when judging potential employees or those already working for a company.
- In the field of penal justice the genetic fingerprint will at some point no longer merely be used to identify the perpetrators of crime. Its potential lies far more in the area of general crime prevention through databanks which store comprehensive genetic profiles. Followed logically to its endpoint, this form of prevention would lead to a databank which would store all genetic profiles from birth. Such a national genetic register would be, especially for a democracy, the inevitable and only just solution, if one takes the view that particular subsets of the population (ex-convicts, asylum-seekers, ethnic minorities) should not be discriminated against in that one screens them more intensively than the "normal" population.

Difficult relationship
between personal
integrity and working
relationships

New opportunities in
the war against crime
must not be allowed
to lead to
discrimination
against particular
sections of the
population

*Genetics as the basis for a transformation of the norms
of human society*

Legal regulations will in the future reflect how a society handles the issue of genetic privacy and how it categorises forms of discrimination based on the knowledge of genetic profiles. Beyond this immediate consequence of the stockpiling of genetic information, it will be increasingly difficult to duck the question, to what extent predictions about the genetic makeup of citizens will create pressure

towards a societal standardisation in the direction of a new definition of the norms of human life.

This question can be most clearly isolated from the example of prenatal diagnostics: prenatal diagnostics will be able within the next decade to make an abundance of information about the still unborn life available, which it will be possible to apply to a far greater degree than has hitherto been possible. This will then make it possible, to a certain extent, to select the types of children who should be delivered. It's already possible to diagnose over 800 inherited diseases such as cystic fibrosis, Down's syndrome and predisposition for various types of cancer with the aid of genetic tests. At the moment, however, it is still impossible to treat the causes of virtually all of these diseases, with only a very few which can be treated up to now. It is, however, to be expected that many of these inherited conditions can be treated at their source in the future.

Sexual selection of children in the womb is already a fact. In a country like India, this leads to pregnant women mostly deciding to abort in the case of the child being identified as female. What should make us reflect on such future developments in the light of these decisions is the fact that they are not taken in a social vacuum, but rather in the context of social norms and attitudes.

In western societies the preference for male progeny may be unlikely. However, a plausible scenario – especially under the paradigm of a performance society – is the decision of parents to abort where the genetic investigation of the foetus revealed the tendency towards a later handicap, or perhaps merely because genes had been identified which are suspected of being the cause of disadvantageous conditions

Quantum leap in
prenatal diagnostics
raises legal and social
questions

Social norms gain
increasing influence
on human evolution

such as obesity. Parents who, for whatever reason, despite such diagnoses decide to bring children with "defects" into the world, would probably then be confronted with the attitude that "that sort of thing" doesn't need to happen any more. Groups representing the handicapped in the USA and Europe already argue that genetic tests would influence the conception by society of what constitutes an unacceptable handicap. Their concern is that the acceptance of the handicapped will fall because of the distorting effect of genetic tests on public opinion as to what normal and desirable attributes are, and what not.

Conscious selection through individual and social preferences – the 'eugenic dynamic of concerned parents'

The conclusion of these reflections has to be that the greater the knowledge of the human chromosome, the clearer the positions that society must draw in terms of the degree to which it makes the genetic knowledge the basis of value judgements and social norms. This is also where the decision belongs, whether it is to be defined as irresponsible to bring children into the world without having checked their genetic data. Also the answer to the question as to how far prenatal diagnostics and abortion may be committed to the goal of bringing healthy progeny to the world and thereby reducing the social costs of the care of the handicapped, is one that cannot be avoided.

Repercussions for the social acceptance of the handicapped

It will also be a question of how to avoid genetics being used to lay the basis for a slavish determinism, which, due to inadequate knowledge of the scientific fundamentals, leads to an exaggeration of the power of genes in many cases, whereas in others it underestimates how much influence social conditioning and environmental factors

Danger of a slavish determinism

can wield in the development of the individual.

The knowledge of the structure of the human chromosome undoubtedly opens up a new dimension in the recognition and successful treatment of genetically-linked diseases as well as the ability at some point to select for certain genetic traits. Since Plato the idea of producing a more perfect human being has been almost continually addressed by philosophers. Apart from the fact that there will probably never be agreement as to what physical and character attributes such an ideal should possess, the philosophical discourse as to what makes a good human being oscillates between the poles of "good breeding" (determinism) and "good upbringing" (humanism). The perspectives of molecular biology have given a new facet to this timeless debate. The idea of the genetically engineered breeding of a "Gutmensch", with which the German philosopher Peter Sloterdijk just recently unleashed an emotionally charged controversy in Germany, overlooks the boundaries of genetic manipulation. Human life is not the mechanical result of a predetermined genetic configuration, but rather unfolds its specific form only as it interacts with its physical and social environment. To this must be added the complexity of genetic cause-and-effect relationships and structural patterns. The predictability or the ability to steer genetic interventions becomes less possible the greater the extent of the intended transformation. Inherited behavioural patterns and cognitive traits especially, e.g., high intelligence, are the result of the interaction of many different genes. Whereas on the other hand most genes have not one but rather several different functions. Sloterdijk's allusion that one could combat the socially decadent symptoms of today with a

Genetic predisposition,
socialisation and
environment have a
reciprocal influence on
each other

”genetic reform of the racial attributes” of human beings will accordingly have to remain a philosophical parable. The nightmare vision of the perfect ”generated” human obstructs the view of the real societal questions which arise from the potential of gene technology. Up to now the philosophical debate has too often taken place in an ignorance of the realities of the genetic laboratories. Rational discussions about the already existing applications of genetic technology or those to be expected in the near future have remained the exception. This creates the danger that the factual – e.g., the increasing role of genetic engineering in agriculture, the conflicts about the ownership of genetic resources or existing medical applications – becomes a norm, without any significant debate in society having taken place. On the way to finding societal norms in our relationship with the new courses of action open to us, a continual, interdisciplinary exchange among philosophy, sociology, the law and science is an absolute prerequisite.

Deeper interdisciplinary exchange among the science, law and social sciences is necessary

Modern societies will not be able to avoid accompanying the molecular-medical advances with a comprehensive, wide-ranging and thus costly awareness programme, which may resemble the consciousness-raising of the AIDS campaigns, but which in terms of expense will be significantly higher. This awareness campaign will have to deal with sensitive issues such as genetic discrimination and genetic determinism and make them into public educational themes for all social classes. This effort to engender a rational acquaintance with the issue will start with lessons in schools, ranging from there all the way to a medical counselling system, which will put people in the

Molecular medical progress must be accompanied by comprehensive public education campaigns and societal dialogue

position of being able to understand the genetic basis of the human makeup and make responsible decisions for themselves and their children.

Strengthening the opportunities for informed and responsible decisions

III. Live longer, work longer: the influence of biomedicine on the age structure and the social security systems of the industrialised societies

Advances in molecular biology will contribute substantially to a further shift in the age pyramids in the prosperous industrial nations. The numbers of the "young elderly" will rise and people will be able to work at a greater age than before. Reforms of the employment market will therefore become unavoidable as the pressure to modernise the system of retirement insurance grows. Whether or not this also increases pressure to reform the health system depends on how thoroughly biomedical advances are translated into affordable treatments.

The possibilities of biotechnology will accelerate the demographic transformation

Consequences of the new age structures for labour market politics

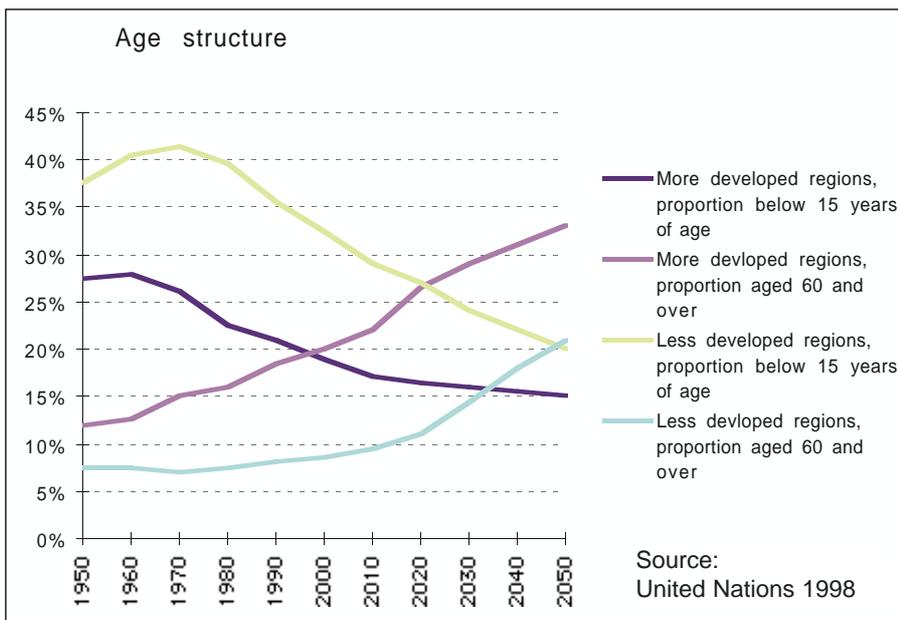
The earth's population is growing, migrating and getting older. Each of these three aspects is of global importance, but population growth is and will remain the largest problem for the earth's development, particularly for the less-developed countries.

The aging of humanity is, however, becoming an increasingly important element of the demographic structural changes. There have never been so many old people as today. The UN population report of 1998 predicted that the number of over-60s, currently c. 578 million,

will grow in the next 50 years to c. 1.5 billion. A fifth of the earth's population would then belong to this age group, which in China, for example, is growing six times as fast as the total population.

The aging of society is particularly a feature of the industrialised nations. The proportion of over-60s in those countries is already over 13.5% and is likely to reach the 33% mark by the middle of the century. Germany, Japan, Italy and Sweden, for example, belong to the group of most rapidly aging countries, where the proportion of over-65s is already greater than 20% and will be around 40% in 50 years time.

The phenomenon of aging societies will principally affect the industrialised states in the medium term



Therefore, biomedicine will play a role as a factor which affects the aging of society, especially in the industrialised countries with the relatively highest prosperity levels. Biomedical progress, which is taking place in these countries, will contribute to a further shift of the age pyramid. The current state of research clearly indicates that future generations will have the prospect of living longer, healthier lives.

Extended working lives needed

This also means that people will be able to work at an older age, probably well into their seventh decade. The number of the "young elderly" will grow – a demographic change, which will have two fundamental consequences:

The pressure for reform, which social security systems are faced with anyway, will grow stronger. People will have to work longer to maintain the financing of the pension system.

The shifts in the structure of the age pyramid have already for some time knocked the relationship between those working and those claiming pensions out of kilter. This applies especially to pay as you go pension systems, which take money from the workers of today to pay for the pensioners of today. According to the calculations of the Worldwatch Institute, in industrialised economies an average of five "workers" support one pensioner. By the year 2030 this relationship will be 3:1; in Japan it will fall from the current 6:1 to 2:1. The American example serves as a classic case to demonstrate the rise in the costs of the pension system. When the retirement age of 65 was introduced there, the standard life expectancy was 68. Today it is 76.

The pressure on the pension system to adapt will increase

The list of possible strategies for reforming the old-age-insurance systems is long; a series of measures (e.g., reduction of the amount received as pension, partial or complete transition to (defined contribution plans have already been undertaken, with varying degrees of success. Despite detailed attempts to correct the existing systems it is increasingly obvious that the deepest cut – raising the retirement age – is inevitable. This will mean first of all that the

industrial nations will have to renounce all incentive programmes which further early retirement. This may especially in Europe seem unpopular, running as it does against current phenomena such as early retirement programmes or reductions in the length of the working week. In the medium term, however, such a step will be unavoidable in a growing number of industrial nations, which find themselves with ever more older people facing ever fewer younger. In principle this situation could be addressed by permitting the immigration of younger generations (in western Europe for example with increased migration from the states adjoining the Mediterranean or central and Eastern Europe). It is doubtful however if such a policy of immigration would find acceptance in these societies, if only because of emotionally-charged issues such as the integrity of the national cultural heritage or the conservation of the national identity.

Immigration can only partly offset the demographic trend in the industrialised countries

Many of the "young elderly" will try to maintain their working identities and work for longer, simply because they can work longer. Modern societies will have to integrate working at previously unaccustomed ages into their job market policies. It will partly be a matter of strengthening the competence of these older workers through further training and partly simply a matter of taking account of and exploiting the knowledge and experience of these "young elderly" in the first place; in community projects, but indeed also in the real employment world, especially in the realm of knowledge transfer, and the training of the following generation.

Measures are needed to integrate the "young elderly" in working and political society

The if-then relationship between medical progress and the costs of the public health system

For the health system the effects of biomedical advances are not so obvious as for the job market and the old-age-insurance systems. The decisive question is clear: will it be possible to reduce spending on health with the help of these advances in biomedical and gene technology? The answer is, however, less clear. Whether a significant reduction in costs is possible or not depends on two factors:

- It will be necessary to ensure that not only are more years added to people's lives, but also that the quality of life at an advanced age is kept as high as possible. The goal is an older person who remains self-sufficient for a long time and requires no intensive care. Put in another way: the costs for health, care, medicine and care of the elderly will only grow further if an increased life expectancy mainly boosts the share of the population who will have to battle with broken bones and the diseases of aging later than before.
- Biomedical advances will also have to be converted into affordable medicines and genetic treatments. Today, the answer to this is far from clear:

It speaks against such a conversion that medical progress has up to now always shown itself to be extremely cost-intensive. Most of the currently applied uses of gene therapy for example (in combination with drugs, counselling and other, supporting forms of therapy) are strongly targeted, specially tailored to the individual needs of the patients. To treat a large number of

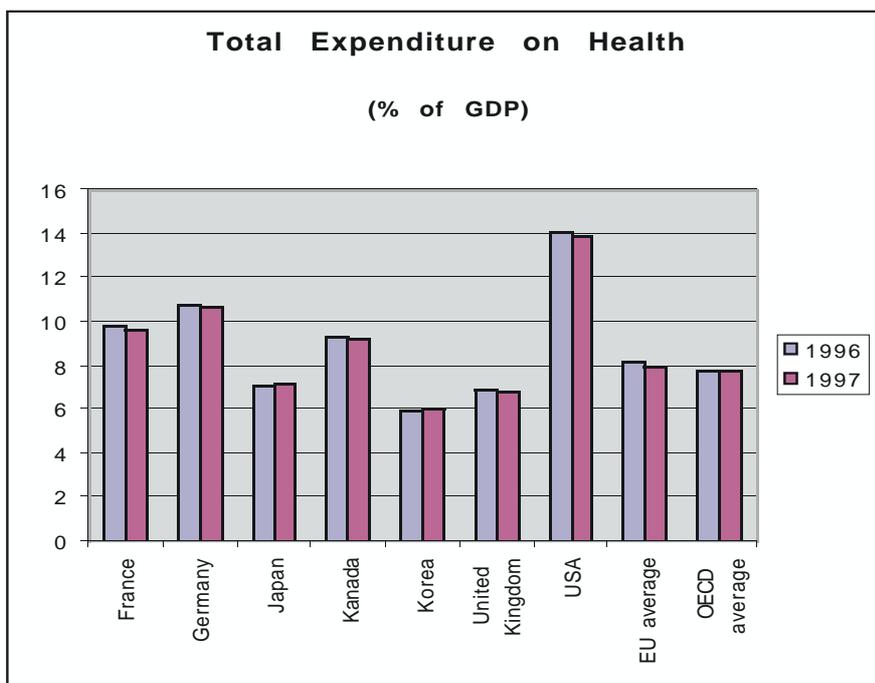
Access to medical progress will become a question of social justice

Medical progress has up to now always been associated with rising costs...

patients in this way would overwhelmed the basic coverage systems of even the richest nations. The hi-tech rescue option comprising gene therapy and corresponding medical support would remain then as the privilege of those who can afford such expensive treatment.

What does speak in favour of a translation of biomedical progress into products which are reasonably priced, and therefore effective on a broad scale, is a basic principle of free market organisation, which also applies in the health market: the larger the market, the greater the chance of the supply (in this case drugs and therapies) satisfying the demand. The market of the "young elderly" represents a market with growth potential. A redistribution of wealth on a large scale is occurring at the moment in the wealthy industrialised nations. This is leading to an unparalleled shift in purchasing power – from young to old.

...on the other hand
molecular biology
offers the potential
for savings in the
health industry



Source: OECD Health Data 1999

Note: Total expenditures on health includes public and private spending.

Thus the share of the national income taken by the 18-35 year olds halved between 1970 and 1995, while the share taken by over-65s doubled. Whereas the average net income of a 70-year old in 1970 was 40% below that of a 30-year old, it is now 20% higher.

A product trend is already clearly recognisable: the rapid increase in the number of older people in the industrialised societies is leading drug manufacturers to target their research efforts increasingly in the direction of means of combating aging, which will keep older people active longer and therefore significantly reduce the cost of their care. The proximate goals in this respect will be the battle against age-related conditions of the brain (Alzheimer's, strokes, age-related depression, inter alia), age-related cataracts, loss of hearing and respiratory conditions.

Reduction of costs
by combating age-
related diseases

IV. The economic exploitation of the gene: on the way to a new economic age

Genes are the stock market shares of biological progress. Market forces have led to the patenting of genes or genetically engineered tissues, organs and organisms, as well as the procedures which are used in their transformation. The patenting of genetic resources creates the framework for a new economic age, which will be distinguished by the coexistence and cooperation of many small, specialised start-up companies and large globally active biotechnology corporations. The marketing of the gene will, in particular, particularly drive three processes: it will make the right to

the genetic raw material one of the most central political and economic controversies of the new century. It will utterly transform the nature of agriculture. And it will establish biotechnology as an indispensable factor in a both productive and resource-efficient food production.

Rise in the market
value of genetic
ressources

Patenting of genetic resources

The earth's gene pool will attain increasing commercial value in the coming years. The more the global market uses technologies which are based on genetics for the manufacturing of products and materials, the more the value of genetically interesting plants, animals will rise. Human populations will not escape this phenomena, as the decision of the Icelandic parliament to sell the exclusive rights for research on the population's genetic code to a Swiss pharmaceutical concern for 200 million dollars in February 1999 shows.

The marketing of genetic resources will become a central political and economic source of conflict principally because the great majority of the desirable genes are to be found in the rich diversity of the tropical regions, in Asia, Africa and Latin America. Plants from the rain forests are especially interesting, because they may contain compounds which can be exploited for new drugs.

Conflicts regarding
rights of
ownership will
increase

The struggle for genetic resources has already begun and has occupied international organisations like the UN's FAO for more than 10 years. This heralds a new north-south conflict for the next decade, which will however be fought along old lines: the countries of the southern hemisphere accuse multinational concerns of practising bioimperialism and exploiting their national heritage – indigenous

ressources as well as centuries-old orally transmitted knowledge of the importance of this natural heritage – without appropriate compensation. The pharmaceutical, chemical, agro-industrial or biotechnology multinationals of the north maintain against this that the market value will only be realised when they have processed, modified and purified the genetic material. Patent protection is from the point of view of the companies essential, if they are going to risk devoting financial resources and years of research, in order to bring new products to the market. A firm who does not patent, so goes the justification, will lose out in competition with other firms.

The economic exploitation of genetic resources holds the danger of a new North-South conflict

The fact is that none of the international efforts to resolve this situation – for example the Biodiversity Convention in 1992 and the various follow-up conferences (most recently in Cartagena, Colombia, in February 1999) – have been able to sort out any of the disputes at issue. Apart from a series of issues, which are especially concerned with the issue of biological security, open questions include:

The existing international agreements lag behind the technical developments

- to what extent the patenting of human cell lines leads to private companies holding ownership rights on human life and what consequences this may hold,
- what rules should govern the import and export of genetic resources or genetically modified products (e.g., blood, cell lines of microbes and plants, skeletal sections, fossil finds). Among other issues, the relationship of the trade rules of the WTO to the clauses of the Biodiversity Convention and other international

An international trade regulation system is required for genetic resources

environmental treaties remains unclear,

- whether guidelines for licensing contracts should be drawn up which would offer financial compensation to the source regions for the genetic resources and simultaneously provide protection for affected species and ecological communities.

Sharing the profits
from the sale of
genetic resources
with the source
regions

When genetic knowledge on a large scale arising from the decoding of the human genome becomes available for patenting, we will see conflicts developing which the public will take notice of, conflicts which up to now have been almost entirely the province of lawyers and lobbying groups. They will widen into a dispute fought at the heart of society, where economic arguments, value-systems and culturally influenced standards will clash with one another. This conflict about the rights to genetic resources has the potential to develop the same impact globally as the debate on human rights in the second half of the last century.

The patenting of human
DNA will become a
human rights issue

Agriculture as hi-tech producer

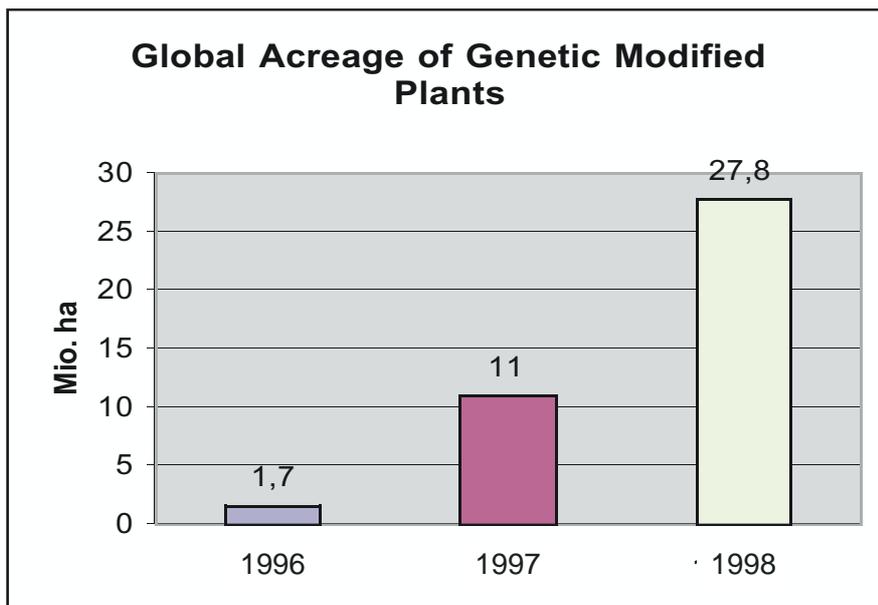
Biotechnology will fundamentally alter the profile of agribusiness. Soil, natural resources and labour as the characteristic limiting factors of agriculture are rapidly losing importance. Agriculture is increasingly becoming a hi-tech producer – capital intensive and supported by laboratory research.

The capital intensity
of agriculture will
increase further with
progress in gene
technology

It is already true today that animal husbandry can not function without this work in the laboratories. In-vitro fertilisation and embryo transfer are "state of the art" and have already cleared the way for the

application of these technologies in the near future. The ability to intervene precisely in chromosomes will probably be available for use within the next ten years, enabling us to tailor the performance and qualities of cattle and pigs. Animals with new functions will be produced: sheep, goats, cattle, who produce the ingredients for pharmaceuticals in their milk; or pigs which provide hearts, livers and kidneys whose cells have been so altered that the human immune system accepts them as being "native". Besides the economic and medical benefits, however, care must be taken during the application of gene technology to animal husbandry that the dignity of animal life is also respected.

Potential applications in animal husbandry raise ethical questions



Source: James Clive, Global Review of Commercialized Transgenic Crops, 1998 New York

In the absence of exact data, China is not considered in this graph.

In crop husbandry the intervention of genetic engineering will achieve the recombination of individual traits in order to strengthen the resistance against viruses, pest insects, salt, frost and drought and to guide the composition of nutrients. The use of genetic engineering

Gene technology has the potential to force sustainable production structures in agriculture

will not be confined to the altering of crop plants which will raise the yield from the fields. There will also be more synthesised products, which will be produced in labs and processed in factories, thereby replacing the standard cultivation methods.

Acreage of Genetically Modified Plants by Country

	1996 (Mio. ha)	1997 (Mio. ha)	1998 (Mio. ha)	Percentage (1998, %)
USA	1,5	8,1	20,5	74
Argentina	0,1	1,4	4,3	15
Canada	0,1	1,3	2,8	10
Australia	<0,1	0,1	0,1	1
Mexico	<0,1	<0,1	0,1	1
Spain			<0,1	<1
France			<0,1	<1
South Africa			<0,1	<1

Source: James Clive, Global Review of Commercialized Transgenic Crops, 1998 New York

Note: China is not considered in this graph, due to inexact data. Rough estimates suggest that the crop area in China accounted for by genetically modified plants in 1998 was c. 100,000 ha.

The agrarian structure of the future will be heavily influenced by corporations which integrate the various different parts of the production process, e.g., the development and production of fodder, seeds, pesticides or fertilisers, into their product palette. The borders between farmers, seed developers, fertiliser firms or food processing factories will then begin to blur. In the age of globalisation life science corporations, agro-concerns, food retailers and international trading houses – just as in other areas (banking/insurance, telecommunications/media) – will begin to move towards forming joint ventures. Alliances will crystallise, which will cover the whole spectrum from

Increasing integration
of corporate structures
in the food and
agricultural industry

research cooperation for the decoding and patenting of plant and animal genomes to seed and harvest as far as production and sales of foodstuffs.

The hi-tech transformation of agriculture will come to pass as a globally applicable pattern in every modern industrialised society in this new century, even if there are significant differences between current developments in Europe and North America. For example, in the 1999 in the USA more than half of the soya and more than a third of the maize harvest was accounted for by genetically engineered seed. In Canada and Argentina one can also speak of an alliance between the large-scale agro-enterprises and the biotechnology industry. In the face of this the European governments, agricultural organisations, retail chains and consumers are at the moment reacting overwhelmingly to reject the application of gene technology in agriculture. A similar picture is to be seen in some Asian countries, e.g., Japan. Indeed American consumers are beginning to regard genetically manipulated foodstuffs with suspicion. The current mixture of unqualified support, reservations, distrust and sitting on the fence is however merely a temporary phenomenon. Narrow international economic inter-dependence will result in the various market structures and levels of regulation converging. Improved knowledge and awareness of the opportunities and avoidance of environmental and health risks will lead in the medium term to a sinking of the range of prejudices – especially the emotional ones – which green genetic technology is faced with at the moment, or at least to a more rational and differentiating point of view which will

Large differences in the extent and regulation of biotechnical applications in agriculture

International competition will lead to a harmonisation of market structures and regulatory regimes

cause legal obstacles eventually to fall.

Although often brandished by the critics of biotechnology, the question as to what extent the dominance of biotechnological agribusiness uproots farmers from their land, is of minor importance in the European industrial nations. Smaller units play an ever smaller role, although they will survive in a niche function due to their importance for the countryside. Asia presents a different picture. In some countries of this region, it is quite conceivable that biotechnology will interfere with traditional cultural and social structures; namely where corporations succeed more and more in producing things which belong to the traditional range of cash crops, and therefore to the local economic basis, or perhaps when it proves possible to make substitute cheaper laboratory-produced substances. Thus, in contrast to North America and Europe, the loss of agricultural jobs must be calculated as a factor for social unrest. The rural family and the village may be of declining importance in the West, but in many parts of Asia they still stand for an important degree of social stability and continuity.

Indispensable, but inadequate: biotechnology and genetics as an element in the war against world hunger

The cultivable areas available worldwide can hardly be extended any more. Especially for this reason biotechnology will develop to an indispensable element in the food production process. Fundamental problems of global nutrition will not however be solved by biotechnology alone. In the future the main challenges to securing adequate nutrition will still be linked to social and structural policies.

Biotechnology will alter the social and economic structures of rural areas

Only by combining gene technology and politically-guided distributive measures will it be possible to attack the global nutrition problem effectively

Among other factors, it is a matter of facilitating the access to food in the poorest regions, while at the same time improving the health services and strengthening the role of women in terms of care for mothers and children, as the World Nutrition Summit in Rome in 1996 correctly emphasised.

In the last ten years c. 240 billion tonnes of soil (which is equivalent to more than half of the total tillage area of the USA) has been lost through overfertilisation, deforestation, erosion, inappropriate irrigation methods and extravagant application of herbicides. Industrialisation and the growth of urban areas also contribute to the destruction of arable areas. The extension of agricultural areas is only a temporary solution. Sooner or later, there will not be any more land that is suitable for cultivation. In a global context at best parts of Brazil, Colombia, Venezuela and African states south of the Sahara still have potential to be converted to additional arable land. This would, however, have a disproportionate and destructive impact on the biological diversity of these regions.

Therefore the necessary growth in production will have to be achieved through more intensive exploitation of existing cultivated areas. Modern biotechnology offer the potential for this intensification. Advances in the genetic manipulation of crops like maize, rice and wheat will make it possible to increase the yields from the existing fields and in a more environmentally friendly way than hitherto possible. An adequate level of production can be guaranteed in this way. The difficulties named above, distribution above all, will however remain.

The growing world population demands increased agricultural productivity

Apart from some cooperative projects in the development aid and scientific research domains, there still remains no convincing strategy as to how biotechnology can be put to work for the countries which suffer most from hunger and malnutrition, particularly the countries of Southeast Asia and Sub-Saharan Africa. Most of the crops which have been genetically manipulated up to now have been intended for the agricultural systems of the capital-rich, industrialised states. This is where the markets are for a biotech-supported agriculture. In only a few cases are the life science corporations examining the classical staple crops of developing countries such as sweet potato or cassava (manioc), the basic source of nourishment for 500 million people in Africa, South America and southern India. If biotechnology are ultimately also recruited in the fight against world hunger, its advantages must also be directed to the countries who cannot afford either these technologies or their own research efforts.

Up to now the application of modern biotechnology has been confined to the industrialised nations

Green biotechnology must also adapt to the needs of those in the areas most threatened by hunger

**V. Reprogramming the human animal:
how the changeability of humanity
forces value-based decisions**

Genetic technology facilitates changes to human nature in areas which up to now were considered to be impossible to manipulate. Humanity will be confronted with a decision which, for Edward O. Wilson, the founder of sociobiology, constitutes the "most sensitive" question, before which it has ever stood: To what extent will existing generations alter the gene pool of coming generations and thereby themselves determine the development of human evolution? This

question could divide broad sections of the human race into two camps of conflicting convictions: the people who support rebuilding the human constitution would be opposed by all those who would reject this step. The moral underpinning of the technically doable and the striving for the fulfilment of personal wishes are the driving forces on the way there.

Germ line therapy is the beginning of tackling the biological architecture of the generations to come

The modern industrialised societies will, at different rates and with different nuances, adapt themselves to the technical-medical changeability of humans. There will also be a small number of countries, who with regard to particular issues – Germany, for example, in the field of embryonic research – will proceed in a more restrictive manner than others and decide to follow a separate path. The existing differences become clear when one looks at the debate provoked by the American philosopher Francis Fukuyama and the controversy sparked off by Peter Sloterdijk in Germany concerning changing the basic genetic material. Whereas the discourse in the USA about the patterns of motivation and social impact of genetic technology has been conducted so far in a tone of rationality and taboo-free space, the philosophical schools of thought in Europe have thrown themselves into a bitter "Kulturkampf" about the ethics of genetic engineering.

Side-by-side with biological evolution is the cultural and knowledge-based evolution of human life

However, international bans or wide-ranging moratoria on issues such as cloning and germ line therapy will never come to pass. There are two decisive reasons for this, which become apparent when one looks at the political-ethical debate in the USA – the country which meets the redesign of humans with a great degree of openness and whose

attitude to biotechnology will have a substantial influence on the way chosen into the future.

- The faster knowledge strides ahead and the more sophisticated technologies become, the more difficult it will be to set boundaries on what the biological sciences are capable of doing, but should not do. That is the core of the argument which has dominated the debate in the USA for some time and has led to the situation at the current state of the technology, where American molecular geneticists have refused to restrict their research efforts, especially in the area of germ line therapy. They argue from the basis of the enormous medical potential of this therapy, whereby genetic intervention normally does not just affect the treated individual, but will also be inherited by their descendants. Its therapeutic potential would consist of the ability to deliberately manipulate the sexual germ cells, in order for example to eliminate family-inherited diseases or to achieve a natural immunity against infectious diseases like malaria or tuberculosis. When one day the risks and side effects of this therapy have been researched through painstaking preliminary research and can be avoided, then this would provide a moral backing for the technically doable. Arthur Caplan, founding president of the American Association of Bioethics, therefore calls the possibility of once and for all correcting at the source inherited conditions like spina bifida, anencephaly, haemophilia, muscular dystrophy or Huntingdon's chorea a blessing, " which makes this germ line therapy a moral obligation". The message

The speed of progress
handicaps political
regulation efforts

which this statement is based on marks the only probable concrete and practical aid to decision-making, with which bioethical discussion can support societal decision-making in the future: a farewell to taboos, focusing instead on the concrete, i.e., the examination of each case on its merits based on precisely defined premises and indications.

A farewell to
indiscriminate taboos

- The advances to date in the fields combining reproductive medicine and intervention in the genome backed up by the evident continual rate of progress will lead to a variety of methods of creating progeny in different ways. Parents and individuals will deploy their financial means to ensure that their children have the best chances for a healthy and successful life. The claim to the right to individual happiness, as is especially evident in the western industrial states, will be large enough to allow a market for genetic improvement to develop, which will help itself to the appropriate advances in science.

For the USA the molecular geneticist Lee Silver estimates that already by 2005 half a million babies will be brought into the world through various genetically supported procedures of in-vitro fertilisation (IVF). The insistence on an ethical argument, namely that of the inalienable right of the individual to make autonomous decisions over his own body and that of his descendants, without interference from state, church or society, plays the principal role here. Provided that the path to genetically corrected humans can be medically and technically justified and supported – against what law would parents offend, if

Conflict between
governmental regulation
and personal freedom

they contrived to give their progeny every available advantage, by providing him with the genes in the cradle which would prevent the occurrence of asthma or obesity, or the tendency towards heart ailments or diabetes?

The wish to give one's own next generation the best possible of what is available is morally impossible to condemn as a single case. Modern societies will therefore have great difficulty in denying the procreators an equal say about the genetic equipping of their children. On a wider scale however, the individual claim to happiness conceals a certain element of social dynamite. The intervention in the genome may lead to a social polarisation for coming generations: a gulf between those who can afford to provide their children with advantages in life through genetic manipulation and those who will remain excluded from these possibilities. The substance of these scenarios of genetically privileged and genetic have-nots will only apply – at least as far as the prosperous industrial societies are concerned – for an interim period. It will be weakened as soon as genome manipulation becomes financially accessible for broad swathes of the population. The real, the more deep-lying antagonism, which might lead to a fundamental drifting apart of different camps of humanity, would be that between those who applaud the redesign of human beings and those who do not want what is possible – whether it's from religious motives, cultural conventions or in a romanticised wallowing in the laws of nature.

Human beings take
responsibility for their
own evolution

Further literature, documents and Internet links on the subject of genetic and biotechnology:

The portal "Biotechnology" maintained by the research group Global Future (www.aventis-forum.uni-muenchen.de) offers a selection of important documents and internet links on the issues dealt with here as well as additional literature recommendations in English and German.