







Trendanalysis Biotechnology 2004

Trends in biotechnology and their possible significance for society

Joint memorandum from: Committee for Animal Biotechnology (Dutch acronym: CBD), Central Committee on Research Involving Human Subjects (Dutch acronym: CCMO), The Netherlands Commission on Genetic Modification (Dutch acronym: COGEM)

CBD **CCMO** **COGEM**

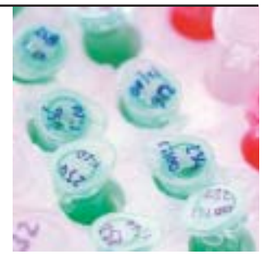
Colophon

Joint memorandum from: Committee for Animal Biotechnology (Dutch acronym: CBD), Central Committee on Research Involving Human Subjects (Dutch acronym: CCMO), The Netherlands Commission on Genetic Modification (Dutch acronym: COGEM)

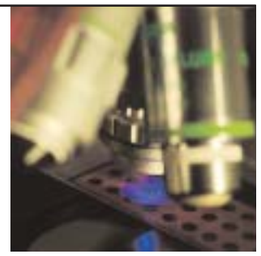
december 2004

graphic design: Avant la lettre, Utrecht
photography: Ivar Pel

Contents



Summary



IVF CHILD WITH SPARE PARTS

The British gynaecologist Rainsbury hopes to create artificial IVF twins by splitting embryos. Only one of these genetically identical twins will be allowed to enter the world as a normal person, the other will be kept as an embryo in the deep-freeze. Then if the child needs a tissue or organ transplant during the course of its life, it might be possible to obtain this via the stem cells of his or her frozen twin embryo. With this, Rainsbury, who already provides parents with a girl or a boy to order, hopes to meet the wishes of parents and future parents. [Volkskrant, 15 June 2004]

In this joint analysis, the Committee for Animal Biotechnology (Dutch acronym: CBD), the Central Committee on Research Involving Human Subjects (Dutch acronym: CCMO) and the Netherlands Commission on Genetic Modification (Dutch acronym: COGEM) present biotechnological trends and the opportunities, possibilities and moral aspects associated with these. The trend analysis was produced at the request of the State Secretary for the Dutch Ministry of Housing, Spatial Planning and the Environment (Dutch acronym: VROM) and his colleagues from the Dutch Ministry of Agriculture, Nature and Food Quality (Dutch acronym: LNV) and the Dutch Ministry of Health, Welfare and Sports (Dutch acronym: VWS). The analysis was coordinated by a steering committee, formed by the three committee chairs under the leadership of the chair of COGEM. Some twenty trends were noted, eight of which were considered to be a priority by the committees in view of the influence these are expected to exert on Dutch society.

The following trends and associated options are expected to have the greatest significance for Dutch society:

- **Uncertainty about the future due to improved genetic tests for disease diagnosis in which there is not a one-to-one relationship between the presence of a gene and the onset of a disease for the persons involved;**
- **Less scope for national policy to prevent the import of GMOs and to guarantee the coexistence of GM and non-GM agriculture, due to the globalisation of science and the economy;**
- **Biotechnology-related developments in other regions of the world can only be influenced by means of proactive policy and international dialogue;**
- **Differences of opinion between proponents and opponents of the use of embryonic stem cells growing, as more knowledge about the clinical feasibility of new stem cell therapies becomes available;**
- **Unknown ecological risks resulting from the deliberate introduction of GMOs into the field to control pests and diseases and protect local animal species;**
- **Threats posed to food safety by the cultivation of pharma crops;**
- **Transparency and openness of government being challenged, due to the increasingly harsher actions from opponents of licensed experiments with GMOs;**
- **Increasing demand for the screening of IVF embryos for a range of serious conditions.**

Many developments in biotechnology are aimed at improving the quality of life and raising the results from agriculture and industrial production. The range of possibilities available within medical diagnostics is set to multiply, due to the increasing detail with which genetic predisposition can be unravelled. This will lead to an expanding demand for genetic diagnostics to screen human embryos obtained by means of in-vitro fertilisation (IVF) for serious genetic disorders. The options for parents to select other desired characteristics will remain very limited. An improved insight into the likelihood of developing diseases later in life as a consequence of genetically-determined characteristics, may result in an uncertain future for the individuals concerned. Further, an improved genetic diagnosis that can accurately predict whether a serious genetic disorder will develop later in life, could result in tensions with respect to the insurability of these diseases. The deliberate introduction of genetically modified organisms (GMOs) into the environment to control pests and diseases is a development expected in the poorer regions of the world. However, it may lead to unknown environmental risks in other parts of the world. The emergence of pharma crops, plants producing drugs, requires a careful consideration of the ecological risks and the integrity of food with respect to the consequences for public health.

The rapid development of biotechnology, a consequence of genomic research, has also resulted in social and ethical dilemma's. With the help of stem cells a cure for diabetes, arthritis or Parkinson's disease seems at hand, although these high expectations are not shared by all. However stem cell therapy is also controversial. Growing knowledge about the clinical feasibility of new stem cell therapies may result in greater differences of opinion between its proponents and opponents. In many cases, the future clinical possibilities and the societal justification of using stem cells in various developmental stages will become the subject of political decision-making.

Globalisation will increasingly influence policymaking with respect to biotechnology. A whole range of developments and products, which at present are considered to be less desirable from a Dutch or European perspective, will nevertheless reach and affect the Netherlands. Examples are the import of GMOs, such as fish, and the products derived from these. Moreover it affects the possibilities for the coexistence of GM and non-GM agriculture. Proactive policymaking and an ongoing dialogue with other regions of the world are important, if a country wants to avoid being continually confronted with surprises from other parts of the world and an increasing pressure to comply with these. Another controversial issue is whether information should continue to be made public to the same extent, now that the opponents of biotechnology are adopting more radical standpoints. After the democratic decision-making process has been completed, opponents can simply carry out destructive actions, aided by the publicly available information about the location of field trials.

As this trend analysis had to be compiled within a short space of time, only a limited amount of attention could be paid to possible changes in values. However, this subject will be duly addressed in the next biennial trend analysis.

1 | Reason, approach, nature of the result

At the end of January 2004, the State Secretary for VROM on behalf of his colleagues from VWS and LNV requested the Committee for Animal Biotechnology (Dutch acronym: CBD), the Central Committee on Research Involving Human Subjects (Dutch acronym: CCMO) and the Netherlands Commission on Genetic Modification (Dutch acronym: COGEM) to jointly compile a trend analysis of biotechnological developments for the House of Representatives of the States General (Dutch Parliament). The letter from the State Secretary stated that: *"the aim of this trend analysis is to inform politicians about major new biotechnological developments and applications in the Netherlands and further afield, the trends which can be recognised in this, the associated chances and possibilities that can be realised and the moral aspects related to these. The analysis will have a greater value if it also devotes attention to the stumbling blocks and dilemmas which arise from the assessment of biotechnology"*. Further, the State Secretary mentioned that in consultation with the House of Representatives of the States General it has been decided that the trend analysis should be compiled once every two years. He requested the committees to complete a first analysis before the summer of 2004.

Following the request from State Secretary Pieter van Geel from VROM, the three committees developed an action plan for producing this analysis. An effective form of cooperation between the three committees was set up. This consisted of a steering committee of the three chairs, under the leadership of the chair of COGEM and a workgroup of the three secretaries that reported to this steering committee. COGEM was requested to coordinate this. The composition of both groups is stated in the appendix.

The analysis was started by itemising the relevant trends, in so far as these were known to the members of the three committees. After this, a list was made of experts to be consulted in the Netherlands and further afield. A questionnaire for the interviews to be held was also compiled. On the basis of this, eleven experts in the Netherlands were interviewed by the COGEM secretariat and ten prominent experts in biotechnology from abroad were interviewed by the externally-commissioned consultancy Schuttelaar & Partners. The results from these inventories are detailed in the two background studies that are included in a separate appendix to this trend analysis. The study from the COGEM secretariat also contains data from the literature. Both reports were subsequently presented to the three committees in a joint workshop held on 8 June 2004.

The report from the COGEM secretariat was structured according to the classification red, green and white biotechnology. These categories denote the medical, agricultural and industrial applications of biotechnology respectively. In the report from Schuttelaar & Partners, a classification based on the nature of the genetically modified organisms was used. This was a deliberate choice, so as to ensure a complete coverage of the extensive field of biotechnology. It was decided that this summary report should concentrate on the perspectives relevant to social embedding.

In the trend analysis some twenty subjects were identified which might lead to new or renewed public debate. During the workshop, workgroups explored these subjects in greater detail in order to compile an overview of their possible societal consequences without the intention of proposing desirable solutions for these. The primary objective was to identify those trends (and their consequences) that might result in new and existing moral questions coming into play. Subsequently a draft report was written which made use of the underlying reports and the criticism of these. This draft was separately discussed within the three committees as well as in a final steering committee meeting of the chairs of CBD, CCMO and COGEM.

As a first trend analysis had to be compiled before the summer of 2004, a quick and therefore provisional inventory had to be made. In the next, in principle biennial, trend analysis a more detailed and balanced analysis will be made of changes in values that might occur. Questions that could be considered, for example, are threatened changes in the healthy image of milk, the intrinsic value of animals and the integrity of farm property. Nevertheless, the three committees consider that this present report provides usable outcomes for both government and parliament.

2 | The context of the question

As the committees started their work by questioning individual experts on their impressions in the area of new trends, the accent was mainly on developments occurring within their biotechnological expertise. During the joint workshop it became apparent that the context and social embedding of the trends monitored had only been briefly discussed. This gives the impression that certain technological developments are unavoidable and irreversible.

However, biotechnology develops within the context of a specific 'ensemble of technology and society'. This context can change over the course of time. Within this context, more options are available than those provided by a single paradigm such as the free-market economy. Developments in biotechnology which are strongly steered by the interests of high-tech countries, can lead to a fatalistic attitude. Of course, if the social embedding of technology is ignored then the widespread occurrence of developments would seem unavoidable, even if these are considered to be undesirable within a region. This leads to a scenario in which biotechnological development cannot be stopped or guided. However, technology has its own underlying social code (script), which has evolved from its social embedding. Consequently, the possibilities for directing biotechnology towards socially desirable innovations which satisfy the principles of sustainable development can be overlooked. In the public debate about the moral aspects of biotechnological trends, there needs to be an awareness of this possible constriction of the context. This trend analysis will to a certain extent also be influenced by the aforementioned paradigm of free-market thinking and large-scale technological solutions.

Furthermore, consideration needs to be given to the worldwide differences in culture and religion where biotechnology is being developed. This aspect and the fact that arguments mostly stem from the currently dominant paradigm of the free-market economy, should be considered in greater detail in a later trend analysis. Such an analysis could help to improve the national governments' ability to cope with global pluriformity.

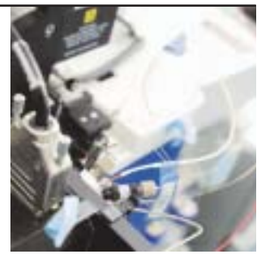
The many themes in this report have been organised using a 'layered grouping'. In this approach, a broad subject is further detailed in specific subsidiary subjects.

Three perspectives can be distinguished for the key questions concerning the social embedding of biotechnology:

- Societal functions of biotechnology;
- Developments reflecting the nature of biotechnology;
- Societal trends that influence the context of the debate.

These three perspectives will be described in more detail in the following chapters. In addition to this, details of the trends will be used to formulate an expectation of the direction each trend could take in society and an expectation of the possible vehemence of the public debate. Of course this has a subjective character determined by current knowledge and the judgement of the committee members, who form a limited group within society. The arguments which the committees think could play a role in the public debate are briefly detailed so that the Dutch Government and Parliament can more easily form their own opinion about the need for policy measures and the possible nature of these.

3 | Biotechnological trends aimed at realising societal objectives



PIG PIDDLE

Scientists have recently managed to successfully transplant a kidney from a genetically modified pig to a baboon. By switching off a gene in the pig, it took three times longer than the normal 30 days before the pig's kidney was rejected. The switched-off gene codes for specific sugar molecules in the cell surface of the kidney. The immune system of apes and humans immediately recognises intruders from these molecules and triggers the immune response. Although this is only the start, it is another step closer to xenotransplantation and the end of the long waiting times for organ transplants. [Transplantation 75, 2003, Barth et al.]

Biotechnology is used for an increasingly broad range of societal objectives. Two cornerstones in this area are developments related to the quality of life (facilitating human health in the broadest sense) and to the furthering of economic productivity. In addition to this, applications that provide environmental benefits are becoming more visible. Applications are also being developed in other categories of life, such as sporting performances (people and animals), and pets. Applications in the area of defence can be used against society if these fall into the hands of terrorists.

3.1 Quality of life, an area with considerable expectations

The quality of life function has already led to a wide range of results, each of which might give rise to public dilemmas.

Control of infectious diseases

Infectious diseases such as malaria and sleeping sickness are transmitted to humans by vectors such as mosquitoes and flies. Genetically modified insects or viruses are being developed for deliberate release into the environment to replace or strongly reduce the disease-transmitting population. The ecological consequences of this have not yet been fully investigated.
This form of disease control is expected to make large inroads in Third World countries and these countries are expected to be prepared to take such ecological risks, in view of the considerable gains that can be realised in the area of human health.

There is a trend towards the deliberate release of genetically modified organisms into the environment, which can replace or strongly reduce populations that transmit infectious diseases such as malaria. It is vitally important that the ecological risks are carefully weighed up against the benefits for public health.

Further, vaccines are being developed against AIDS and other dangerous exotic viruses such as the Ebola virus, Marburg virus and the recently epidemic infectious disease SARS. The majority of genetically modified vaccines being developed are still in the preclinical phase, but in the meantime, three genetically modified vaccines for animals have been approved for the European market.

Treatment of chronic illnesses

A wide range of developments are taking place with respect to the control of chronic illnesses such as cancer, diabetes and brain diseases, for example Parkinson's disease. These developments concern vaccines, gene therapy, xenotransplantation, the use of probiotics in food and the use of stem cells.

Vaccines

Genetically modified (GM) vaccines for chronic illnesses and cancer are also being tested in clinical studies, for example a vaccine against prostate cancer. Whereas vaccines were initially made from inactivated pathogens, the current vaccines are often crippled viruses which carry a specific antigen. Therefore, these modern vaccines are more specific and cause fewer side effects.

Gene therapy

Initially, gene therapy was directed towards simple, monogenetically determined, inherited disorders such as haemophilia, cystic fibrosis and congenital immunodeficiencies. Such diseases are fairly rare and are termed orphan diseases. In the past, considerable expectations were aroused with respect to the cure of many diseases, including chronic diseases. These expectations have not been realised, although positive developments in this area can be reported. At present applications are being developed for more complex inherited conditions such as cardiovascular diseases, diabetes and cancer. However, it is not very likely that large-scale applications can be realised in the near future. As a consequence of this the pharmaceutical industry has too few economic incentives to further develop such applications. Therefore, the development of gene therapy applications for both complex chronic diseases and orphan diseases will continue to be strongly dependent on research in academic centres.

Xenotransplantation

Organ transplantation – for example, the heart or the kidneys – from animals to humans with chronic diseases is prohibited in the Netherlands, but elsewhere the developments are continuing. With the help of genetic modification, researchers are trying to 'humanise' animal organs such as kidneys so as to reduce the number of transplant rejections. It is expected that such transplantable animal organs for human patients will be offered on the Dutch market in the distant future. Another application is the ripening of human egg cells in animals, which in the distant future might be used as a treatment for women following a successful anti-tumour therapy.

In the distant future a supply of animal organs could become available that can be successfully transplanted in human patients, as a result of genetic modification and other processes. This will present the government with the question as to whether the moratorium on xenotransplantation should continue to apply in all cases.

Probiotics in food

Microorganisms, such as bacteria and yeasts, are increasingly being used in foodstuffs, such as dairy products, in order to promote health. They are also being used for therapeutic purposes. These microorganisms are referred to as probiotics. They might, for example, play a future role in eliminating lactose intolerance, reducing cholesterol and reducing the risk of intestinal cancer. The genetic modification of microorganisms in probiotics is also starting to gain ground in clinical applications, for example with respect to the control of Crohn's disease, the combating of tooth decay and the prevention of obesity.

Stem cells

Stem cells are cells which have not yet specialised. There are two types of stem cells: embryonic and somatic (adult). Embryonic stem cells can still form all of the tissues in the adult organism. According to current insights, adult stem cells can only differentiate into a limited number of cell types and tissues. There is considerable interest in the medical use of stem cells because these can be used to make new tissues and organs for tissue and organ transplantation. They are also important for the repair of tissues that have been damaged. Embryonic and adult stem cells appear to offer possibilities for curing diseases (such as Parkinson's disease or arthritis) or for repairing, for example, a damaged heart following a heart infarct. They could also offer possibilities for the treatment of autoimmune diseases such as diabetes.
The genetic modification of embryonic stem cells might become a new form of gene therapy. The use of genetically modified adults stem cells has already been investigated for some time. In the laboratory, adult stem cells originating from a patient can be provided with an extra gene or a defective gene can be repaired, after which the modified stem cells are returned to the patient. This technique could, for example, cure congenital blood diseases and osteoporosis. Several successes with genetically modified stem cells have already been achieved in laboratory animals.
Research with embryonic stem cells is still in its infancy and evokes ethical questions that will be further considered in section 4.2.

Functional foods

The developments described above may lead to new possibilities for elderly people to enjoy a high quality of life up until a very advanced age. Other developments in biotechnology might well make further contributions to this. For example, white

GENE THERAPY KEEPS ADULTEROUS PARTNER UNDER CONTROL

The insertion of a gene can change adulterous male voles into faithful partners in next to no time. The gene stimulates the production of the hormone vasopressin. When the gene was inserted into the naturally polygamous male meadow voles, these became monogamous. According to the American researchers, the study shows that gene therapy can be used to make adulterous animal species, and perhaps even humans, faithful. [Nature 429, 2004, Lim et al.]

PENSIONABLE AGE INCREASED FROM 65 TO 400 YEARS

By using a combination of gene therapy and hormone treatment, scientists have successfully increased the lifespan of the roundworm Ceanorhabdites elegans by a factor six. Were this also possible in humans then our average lifespan would be increased to more than 400 years. In the worm, the gene for the production and use of insulin was weakened. An insulin treatment and the removal of the worm's reproductive organs ensured that the animal's lifespan was increased from 18-20 days to 2-3 months. [Science 302, 2003, Arantes-Oliveira N et al.]

biotechnology is providing possibilities for the cheap production of vitamins, amino acids and flavourings by using genetically modified microorganisms. In the future, green biotechnology might also make it possible to offer such products in the form of nutraceuticals or functional foods. The industry is still somewhat cautious with respect to introducing these products in the food supply, due to European consumers' low acceptation of genetically modified organisms and the products made from these. Should this change at a later stage then a rapidly growing supply of food supplements can be expected.

Tailor-made medicines

The pharmaceutical industry is developing increasingly more specific medicines for groups of patients, a development which is denoted by the terms personalised medicine or pharmacogenetics. Pharmacogenetics studies, amongst other things, the role of the genetic predisposition in the processing of substances, including medicines, in the body. Furthermore, the increasing knowledge about the genetic basis of a disease and its biology will lead to more specific medicines. The final goal is to specifically treat individual patients on the basis of their genetic background. At present, all of the large pharmaceutical companies are collecting data on DNA, blood and tissue samples from patients, in the hope of gaining more insight into the response of patients to medicines in relation to their genetic background. It is therefore important that a carefully considered regulation is introduced to govern the collection of human material for future use. The main advantages of pharmacogenetics are that it will prevent existing medicines from being administered at dosages that are too high, which results in extra hospital admissions, and that the medicines administered will work better. However, an associated problem is how the knowledge acquired about the genetic predisposition of patients for future diseases should be handled. This will be further considered under the next heading.

The trend towards tailor-made medicines is expected to make headway in the near future. As a result of this, for some medicines the market per medicine will decrease and the price will increase. Yet for other medicines the market can increase.

As well as the better use of existing bulk medicines, certain tailor-made medicines will be developed. In some, but not all, cases this will lead to more expensive medicines. This will require adjustments to the reimbursement system for healthcare costs.

Predisposition

Increasing knowledge about the human genome is making it easier to diagnose certain genetic conditions or to detect a predisposition for certain diseases at an earlier stage. The knowledge that a disease might develop at a later stage in life means that the distinction between ill and healthy is becoming increasingly blurred. The diagnosis mostly concerns a risk estimate and with this it is not certain that the disease will actually become manifest. In some cases it can have implications for the insurability of the persons concerned. For example, this is the case for Huntington's disease and myotonic dystrophy where insurance companies are allowed to require that a person in an affected family has to be tested for the presence of the gene concerned. It is conceivable that in the future this possibility will be extended to other serious genetic diseases for which having the disease gene is a significant predictor for developing the disease.

As a result of more being known about the genetic contribution to serious diseases and future health problems, new and further tensions might arise in the insurability and the communal solidarity of policyholders.

Data about predisposition are becoming available in increasingly greater detail. In the case of large predictive values for serious inherited diseases, this can result in tensions in the insurability of diseases and the permissibility of exclusion by insurance companies.

Preimplantation genetic testing

Preimplantation genetic testing is a technique that combines genetic testing with reproductive technology. Prenatal diagnosis is added to an in-vitro fertilisation (IVF) treatment at a very early stage. This method was originally developed to prevent parents receiving a child with a serious disorder. With the release of genetic data it is, however, conceivable that selection will not be limited to genetic abnormalities but that parents will also select a number of other desirable characteristics such as the sex of the child. However far-reaching selection, for example at the level of intelligence or athletic ability, is not possible in humans.

The ability to perform preimplantation genetic testing can eliminate serious disorders. The options available to parents for selecting other desirable characteristics of the embryo are very limited.

Hedonism

Some people expect that biotechnology will be used to satisfy human hedonistic wishes, for example influencing human beauty characteristics or existing adult characteristics in the desired direction, such as hair colour, eye colour, etc. Despite many reports about the subject in the press, the actual possibilities for working on the genetic enhancement of humans are limited. This is therefore not expected to lead to ethical dilemmas in the Netherlands in the foreseeable future. As previously stated, this subject will be considered further in chapter 4.

Sport

Applications of gene doping in humans are not expected to be effective for the time being and will therefore not be used to enhance sport performances (for example, by means of a stronger muscle development) in the near future. Possible gene doping will first of all be used in sports with animals, such as racing horses in the United States. In addition to substances routinely tested in studies, substances can also be brought onto the market from illegal laboratories. It is expected that gene doping will be difficult to control, especially if the body's own proteins are used. The debate about gene doping will cover similar arguments to the present doping debate.

Gene doping in humans is not yet effective and it is not expected that gene doping will be used by sportspersons in the near future.

Nutrition

Although nutrition is an important part of the quality of life, improving foodstuffs with a view to a better taste, a better appearance and a healthier composition is not a biotechnological trend at present. Due to the chance of the public rejecting the product, companies do not want to run the risk of a pointless and prolonged development that can easily take 10 years. Therefore, in general, the preference is to improve the product using conventional methods.

3.2. The significance of biotechnology for the economy

Increasing agricultural productivity

Biotechnology has gained a firm foothold in the agricultural sector. Outside of Europe there has been a strong increase in

LIQUD WHITE STEEL

Aeroplanes, racing cars and bullet-proof vests made from spider's silk. This is the future goal of researchers from the Canadian company Nexus biotechnology. They make transgenic goats that produce spider's silk, also called biosteel, in their milk. Spider's silk is stronger, more flexible and lighter than steal. So why not a spider farm? Spiders are antisocial and therefore they cannot be kept together in large numbers. As to the choice for goats, the company replies that their special BELE® goats breed more quickly and lactate earlier than other dairy animals, such as cows. [nexiabiotech.com]

MALARIA MOSQUITO SAVES HUMAN LIVES

Scientists are busy changing the genetic material of mosquitoes so that these can no longer transmit the malaria parasite. Good results have already been obtained for malaria in rats. A successful follow-up to this with human malaria parasites would only seem to be a question of time. Replacing the harmful mosquitoes with these transgenic mosquitoes should put an end to the spread of malaria. Although malaria control has already been taking place for decades, malaria is still gaining ground and each year millions of people die from it. With the deployment of transgenic mosquitoes, the researchers hope to have found a new weapon in the fight against malaria. [Nature 417, 2002, Lycett & Kafatos]

the acreage of genetically modified crops (GM) grown. Characteristics such as herbicide tolerance and insect resistance can provide farmers with considerable advantages in growing their crop and in making it possible to further intensify the production. In the present context, genetic modification seems to be inextricably linked with further increasing the technological level of agriculture. This enhancement is aimed at crops grown worldwide and at scaling-up of production and processing. Due to the dismissive attitude of European citizens, the cultivation of these crops in Europe, and therefore in the Netherlands, will lag far behind the rest of the world. Introducing the cultivation of GM crops to Europe will therefore not provide the European agricultural sector with any economic advantage for the time being. However, biotechnological applications other than genetic modification, such as marker-assisted selection, will play an increasingly greater role in the Dutch agricultural sector.

Improved product characteristics

The characteristics incorporated into the current generation of GM crops are mostly of agronomic interest, such as herbicide tolerance and insect resistance. In the near future there will be a shift towards the so-called output characteristics. These are characteristics with direct advantages for the processing industry or the consumer. These could be quality characteristics but also other modifications which facilitate the processing of the product. It is expected that this will give a further impulse to the cultivation of GM crops.

Functional foods

Proponents of genetic modification have high expectations of GM crops with health- promoting components, the so-called functional foods. These could provide the consumer with a direct benefit and this might change the consumer's acceptance of genetically modified food. A much-cited example is golden rice which can help to eliminate vitamin A deficiency. It is doubtful whether these developments will make considerable advances in the near future. At present the health-stimulating effect of many of the substances being investigated is often still ambiguous. Substances for which a health-promoting effect has conclusively been demonstrated, such as vitamins and amino acids, can also easily be added to food in a traditional manner.

Stress tolerances and accumulation of new characteristics

The incorporation of stress tolerances against, for example cold, drought or salt could be one way of improving the world's food supplies in the future. Silting and desertification are two of the most important threats to the global agricultural acreage. Crops provided with such stress tolerances can be cultivated on soils which were previously unsuitable for agricultural activities. However, there are concerns as to whether the ecological risks of incorporating such characteristics can be accurately estimated with the knowledge currently available. Also the trend towards accumulating several genes or characteristics in one transgenic crop and the possible synergistic effects between these genes, has led to some ecologists expressing concerns. However with respect to this it should be noted that in traditional breeding, considerable experience has been acquired with the combination of various characteristics.

Pharma crops

Research into the production of medicines in plants (biopharming) has reached an advanced stage, especially in the United States. Researchers and companies involved claim that there are considerable economic advantages and state that the production in plants is safer than the production in microbial or animal systems such as cell lines. If this manner of drug production is successful, it could provide considerable possibilities for the production and use of new medicines against certain diseases. However, there are also objections to biopharming. The food chain could become infected, either through the mixing of products or due to outcrossing with normal food and forage crops. Separating supply chains and making responsible choices with respect to the type of plant in which the medicine is produced, for example non-food crops, are generally seen as being the minimum conditions required to limit these risks. In addition to this, consumer groups completely reject biopharming and the food industry also has considerable reservations about this subject.

Pharma crops will shortly debut on the world market even if there is no support for this within Europe. The production of medicines in this manner could have considerable advantages for future patients. The dangers of the food chain being contaminated through human food or animal feed are real possibilities. Food safety and the risk of social unrest play a role in this issue.

Risks of managing mammalian plagues

In some countries the introduction of exotic animal species has led to animal plagues that are difficult to control, such as rabbits and mice in Australia which damage harvests and cause a public nuisance. These animals could be controlled with the help of genetically modified viruses that have an enhanced effectiveness. However, in other parts of the world efforts are being made to spread living GM vaccines to protect, sometimes the same, animals against diseases. For example, in Spain people want to protect the wild rabbit populations this way. If this development continues then the GM viruses introduced will eventually spread throughout the world and then they could lead to unintended effects elsewhere. In the current international agreements it has been established that countries must carry out an environmental risk analysis prior to releasing GMOs into the environment (Biosafety protocol). However, other countries are not being consulted in the decision-making process and neither can they raise objections to it. This might lead to specific regional conditions, outside the country where the introduction takes place, being neglected. Over and above this, the introduction of a GMO to control animal plagues can lead to countries throwing up trade barriers in an attempt to counteract the unwanted spread of the GMO concerned. International agreements will be needed in this area.

The use of GMOs in a local ecosystem will occur more frequently and might often lead to unintended and undesirable consequences elsewhere. The current international agreements are not sufficient to overcome or regulate these consequences.

Enhancing the productivity of animal husbandry

The genetic modification of animals in the Netherlands is prohibited unless it involves a considerable public benefit. In other parts of the world the genetic modification of animals continues, for example for production purposes. Efforts are being undertaken to improve quality characteristics, to enhance disease resistance and to increase production. Ultimately, these products (meat, dairy products, etc) will be submitted for market authorisation in the Netherlands. EU legislation does not seem to provide any room to refuse such products on ethical grounds. This will be considered further in chapter 5.1.

Improved production characteristics

Research is continually being carried out to improve production characteristics, such as the fatty acid composition of the meat of cows, and to make the product healthier for the consumer. For example, an altered fatty acid composition might reduce the chances of Alzheimer's disease or lower the blood pressure.

More efficient production

Animals that grow quicker and convert food more efficiently can be created by incorporating genes which code for growth hormones. Transgenic fish, such as salmon and tilapias, with

EFFECT OF TOXIC GAS KNOCKED OUT

You no longer need to fear a toxic gas attack. The American company Genencor International is working on the production of enzyme that can break down the toxic gas Sarin. Sarin is mainly known, and became infamous, as a result of the nerve gas attack in the Tokyo underground in 1995. The enzymes are produced by genetically modified microorganisms and large surfaces can be treated by incorporating these enzymes into foams and sprays. You never know, in the future as well as fire extinguishers and sprinkler installations you might even encounter 'Sarin extinguishers' on underground stations in the future. [Genetic Engineering News 24, 2003, Kerr E.]

EDIBLE HAMBURGER BOX

Not just the bread but also the plastic bag it is in, made from natural materials? The American company Cargill DOW LLC is using biotechnological techniques to obtain fibres from crops such as grain, which are comparable to the synthetic fibres obtained from petroleum. However, the use of these bioplastics is not limited to just packaging materials. What should one make of bottles or shirts made from 'natural synthetic' materials? According to the manufacturer these are a perfect combination; a material made from a natural product, yet with the advantages of a synthetic material. [www.cargilldow.com]

an enhanced growth rate have already been produced, as have mammals (sheep) with an extra growth hormone gene.

Preventing major animal diseases

Efforts are underway in various countries to introduce resistances against animal diseases into farm animals. In many cases, the disease resistance incorporated is targeted towards the health of the animal. However, sometimes it is also aimed at preventing diseases in humans, for example BSE in cows or salmonella in chicken. Genetic modifications to combat animal diseases are an application from which the animal directly benefits. This brings up the question as to whether transgenesis could be regarded as ethically acceptable in such cases. In the case of a BSE resistant animal, the question arises as to whether the integrity of the animal and/or the protection of humans outweigh the relatively very small chance of acquiring Creutzfeldt-Jacob disease.

In the near future, products obtained from genetically modified animals that are currently considered to be unethical, will be submitted for market authorisation in the Netherlands. Some of these modifications would seem to benefit the animal, whereas others clearly provide a benefit to the consumer. The question will arise as to whether such imports must be banned or whether the intended import ban can be selectively lifted.

Providing enzymes to catalyse processes

The production processes in which biotechnology is the most integrated are those within white or industrial biotechnology. Genetically modified microorganisms are used, amongst other things, to manufacture enzymes. The application of biotechnology in industrial production offers considerable economic and environmental advantages. Therefore the use of GMOs in this sector is expected to increase in the future. The new EU legislation in the area of traceability and labelling might, however, lead to a reversal in the use of enzymes in food. Whether the addition of enzymes produced by GMOs will result in these food products being labelled as GMO remains unclear. If a decision is made in this direction then a large number of products will have to be labelled as GMO. Suppliers and consumers might then avoid these products with the consequence that enzyme producers will revert to traditional production methods.

Supplying raw materials for the chemical industry

Biotechnological innovations in biochemistry are targeted towards, amongst other things, the replacement of traditional chemical processes by process stages using biocatalysts (enzymes) and the replacement of fossil raw materials by renewable biological materials, with a particular emphasis on plant-based material. The rate at which this development will proceed is determined by many factors, including the availability and price of fossil raw materials. In the longer term, bioplastics made from, for example, glucose seem to have a highly-promising future. At present such biotechnologically produced products only compete with plastics and fibres made from oil in exceptional cases. Therefore the replacement of bulk products made from oil is unlikely in the short term. A lot of research is being carried out into the decomposition of cellulose from plant waste into glucose, so that the price of this can be reduced.

3.3. Intended environmental benefits

Biotechnology and genetic modification are often associated with environmental risks. These frequently concern safety risks related to the use of genetically modified organisms in agricultural production systems where physical confinement is not possible. However, biotechnology can also be used to reduce the environmental burden of large-scale production processes. Genetically modified plants can make a contribution to reducing the use of pesticides in crops that result in a lot of pollution. Further, the use of biocatalysts and renewable, biological raw materials can contribute to a reduction in the environmental burden of industrial production processes.

Cleaner industrial processes

Some products that were previously produced using traditional chemical processes are now made using biocatalysts. Biocatalysts allow processes to take place at lower temperatures in aqueous solutions. This results in energy savings and a reduction in the use of organic solvents. A second advantage of biocatalysts is their specificity, as a result of which there are far fewer effluents. The latter is particularly important within the fine chemicals industry. As polluting processes, such as the manufacture of textiles and tanning, have been relocated to developing countries, biotechnology can also contribute to the processes in these countries becoming cleaner. It is expected that in the future, the further enhancement of biotechnological process stages will replace traditional chemical processes. How quickly this transition takes place will depend on the costs involved. The development of a new process is expensive and time-consuming and the investments required in production facilities are high. Producers will only switch to other production processes once there is a proven cost advantage.

In developing countries more specific biotechnological applications will be aimed for, as a result of which the EU could also be put under pressure to provide sufficient room for the import of such applications.

Crop protection

The Dutch public sees GM crops as a possible environmental threat. Yet GM crops can also contribute to a reduction in the use of pesticides in agriculture. Cotton production is associated with considerable environmental pollution. With the use of insect-resistant varieties, the use of insecticides in this crop can be strongly reduced, as has been demonstrated in Australia for example. Insect resistance in maize can also contribute to the control of the corn root worm. This insect is a notifiable quarantine pest that is spreading throughout Europe and is now controlled by the aerial spraying of soil insecticides.

3.4. The indulgence industry opens up

Up until now, the applications of biotechnology have mainly been focused on industrial and agricultural production processes and medical care. Now that biotechnology is becoming more established and integrated within these sectors, its applications will also surface in other areas. One such sector in which biotechnology is expected to play a role is the 'indulgence industry'.

Animals with a focus on indulgence-specific characteristics

Thanks to genetic modification it is possible to produce animals with characteristics that have no direct benefit other than providing people with pleasure. The now notorious 'glow fish' is an example of this. An increasing number of these applications will emerge in the future, such as genes incorporated into racing horses to improve their speed (a form of gene doping). Another example is transgenic pets that cannot cause any allergic reaction. Besides genetic modification, applications such as

CAT WITH SEVERAL LIVES

"Clone your cat now". With such advertisements Americans are being persuaded to clone their favourite pets, for a mere 50,000 dollars. At the start of 2002, Texan scientists reported in Nature advanced online publication (Taoyoung et al.) that they had successfully cloned a cat. This cat was aptly named CC (Carbon Copy). The Californian company Genetic Savings & Clone, founded in 2000, financed the research and is responsible for the advertisement. If the owner is unhappy about the result, this is not a problem, as Genetic Savings & Clone operates a not-satisfied-money-back guarantee. [news.national-geographic.com]

the cloning of animals will also increase. An American company is currently advertising with the slogan 'clone your cat'. The first cloned cat has already been born.

An increasing number of applications of genetic modification aimed at indulgence will be introduced onto the world market. This will generate a debate about the possibilities to curb these developments elsewhere and raise the question as to how the import and domestic use of these organisms can be effectively regulated.

3.5. More extensive measures needed to guarantee safety

The attacks of 11 September 2001 and the anthrax letters sent shortly after this in America have heightened the anxiety for bioterrorism. With this, biotechnology has become a hot issue. There is anxiety for the possible dual use of biotechnological research, for both legitimate objectives as well as for the development of biological weapons. Further, the anxiety for bioterrorism has led to a strengthening of research into vaccines and methods for detecting pathogens. However, the majority of experts are of the opinion that the current knowledge about pathogens is more than enough to produce biological weapons and that biotechnology will probably not make a significant contribution to bioterrorism.

Preventing abuse by terrorists

The anxiety for the dual use of scientific findings has led to a call for measures, especially in the United States. Editors of leading scientific journals have called for a control system to prevent the publication of sensitive information. Much new research into pathogens that has been initiated within the framework of controlling bioterrorism is considered to be secret, and it is questionable whether the results of this will become accessible to the public. The call for measures will not only remain limited to the United States. Science is a global undertaking and measures can only be effective if other countries agree to these. Therefore the United States will exert pressure on other countries to take similar measures. The Netherlands will also have to adopt a position with respect to the measures it finds useful and can agree to.

As there is an increasing danger of knowledge of potential interest for bioterrorism being abused, careful consideration should be given to the question as to which scientific data should be published and which not. This will once again lead to a debate about the dividing line between scientific freedom, an effective control mechanism and national security.

4 | Public questions about trends linked to the nature of biotechnology

In the previous chapter a number of biotechnological developments or trends with their social and moral implications were described, which stem from the objectives set for biotechnology by society. However, science itself also sometimes leads to developments, with their own moral and social implications. These are not the consequence of societal objectives, but arise from the direction and the methods of the scientific development itself. The aim of this chapter is to describe the most important trends which are an intrinsic part of the development of biotechnology.

4.1. Genomics has an enormous potential

At present genomics research is the driving force behind developments in biotechnology. The gene sequences of an increasing number of organisms are being elucidated. This large-scale research into the composition of genomes as well as the function of genes and their products, is generating a lot of knowledge that can be used in all areas of biotechnology. As well as genes for the modification of plants and animals, genetic markers are also becoming available which can be used in breeding processes. Sometimes, as a result of this, alternatives for genetic modification arise. Genomics forms a significant impulse for the development of production methods in white biotechnology. However, genomics is only in the early stages of its development. Just a fraction of the information that could possibly be gathered is known. Also the research into the function of genes and the role of gene products in metabolism is in its infancy. In 2003, 148 new organisms and 1.2 million as yet unknown genes were detected in a bucket of seawater by using new analytical techniques. Countless unknown organisms and genes have yet to be characterised.

4.2. Stem cells generate high expectations

Stem cell research will make considerable advances over the next few years. However, the applications from this research have remained limited up until now. This could give the impression that scientists are promising more than they can deliver. Just like xenotransplantation, stem cell research is subject to ethical questions. Stem cells with the most potential are isolated from the aborted embryos that remain after an in-vitro fertilisation treatment (the so-called surplus embryos). However, these embryonic stem cells are also subject to more public controversy than adult stem cells. At present it is not yet clear which type of stem cells (embryonic or adult) will provide the most important possibilities for clinical application. This question can only be answered by thorough research and data acquisition. Furthermore, embryonic stem cells are also the first step in therapeutic cloning, a technique which prevents the rejection of transplanted cells that originate from stem cells. The questions that arise in relation to this technique are, for example, whether parts of the human body may be replaced and whether the application justifies the intervention. And in the case of animals, concepts such as the integrity and value of the animal also play a role. However, if animal species threatened with extinction are eventually cloned then opponents of such methods might end up supporting these.

The justification for using stem cells and genetically modified stem cells from humans and animals in various stages of development will always be subject to criticism, due to the increasing range of possible applications. This debate might diminish if major and more widely valued breakthroughs are achieved.

CLEAN GM CROPS

The insertion of antibiotic resistance genes for the selection of genetically modified crops will be superfluous in the future. This statement was issued by the potato concern AVEBE in a press release following a publication in Nature biotechnology [www.nature.com/nature-biotechnology]. In cooperation with Wageningen University and Research Centre, AVEBE has developed a reliable and efficient method with which the use of genetic selection markers is no longer necessary. The presence of antibiotic resistance genes in genetically modified plants has led to a lot of disquiet among citizens and environmental organisations. [Press release AVEBE, 10 March 2003]

4.3. The use of laboratory animals is increasing

RNA interference (RNAi) is one of the most interesting scientific discoveries of recent years. This discovery provides an analysis method for investigating the function of genes. Genomics research and the RNAi technique might lead to a marked increase in the use of laboratory animals. The function of genes is investigated in animal systems by reducing their expression with the help of RNAi technology. This provides unique possibilities to investigate the function of specific genes in growth and development, as well as in diseases. In particular, this technique provides important possibilities for testing specific therapeutic interventions. As a consequence of this the use of laboratory animals will increase rather than decrease. There will also be a correspondingly strong increase in information obtained from this laboratory animal research.

The fact that the use of laboratory animals might increase instead of further decreasing could rekindle the debate about their use. Yet on the other hand, the importance of experimental animal research in the development of new therapies will increase and this might also lead to a greater public acceptance of the use of laboratory animals.

4.4. Detection and classification will become more complex

Scientific advances will make it possible to produce transgenic plants which are not easy to recognise as such. The current generation of transgenic plants often contain an antibiotic-resistance gene, which is used as a selection marker during the transformation process. Objections to the use of these genes have led to alternative, markerless systems being developed. At present regulatory signals from other species are still used to prompt the gene to express itself at a high level in the plant. However, it is also possible to use promoter genes within the species of plant concerned. The insertion of a foreign gene into a genome is a random process and is therefore easy to recognise. However, methods are being investigated to insert genes in a specific manner. As soon as this becomes possible, the insertion will no longer be recognisable as such.

If genetic modification becomes undetectable then this intervention will be increasingly hidden from the current possibilities for control. Policymakers will need to find other pretexts in order to steer developments in the desired direction, such as regulating research institutes and researchers instead of their actions.

It is expected that as a result of the current developments within genomics an increasing number of crop-specific or species-specific genes will become available. These types of genes will be used to improve quality characteristics or to acquire resistance to pathogens (e.g. Phytophthora in potato), by using genetic modification to insert these genes into the plants concerned. This means that new GMOs will be produced in which only sequences from the same species have been inserted. Although these transgenic plants will have been produced by means of genetic modification, they will not contain any transgenic sequences. In effect they will not differ from traditional breeding products. In the short term the question will arise as to whether the current legislation is appropriate for these GMOs and whether this type of GMO should be classified differently.

The use of genetic modification to produce organisms with sequences from their own species raises the question as to whether the existing rules need to be modified to allow for this.

5 | Trends in the public context which affect the debate about biotechnological developments

An analysis of possible changes in biotechnology cannot ignore changes in society. Far from being static, society is in a constant sate of flux. Changing insights and emotions among the public have been reflected in developments in biotechnology. Ethics is also a dynamic process in which convictions are subject to change. Public acceptance is one of the guiding forces during the implementation of scientific discoveries. With this it must not be forgotten that the Netherlands and Europe are not an island. They can only protect themselves from developments in the rest of the world to a limited extent and are even less capable of effectively influencing developments elsewhere.

5.1. Globalisation advances further

The increasing globalisation also affects the developments in biotechnology. Whereas earlier scientific research mostly took place in Western Europe and the United States, at present groundbreaking research is also taking place in many other countries. Asian countries in particular are making considerable progress. In these countries biotechnology has been placed high on the agenda and considerable investments are being made in these techniques. According to many, Asian countries such as Japan, South Korea and China have already surpassed Europe in this area or will do so shortly. This means that developments will increasingly take place outside of Europe. This has economic consequences because these countries are rapidly developing a biotechnology industry which competes with that of Europe and the United States. This also means that there will be less national options to guide the developments.
Eventually, thinking in terms of national interests will play less of a role in biotechnology issues. It is expected that the general interests of the global community will become more dominant. However, in the short term tensions will arise, such as an increased presence of products on the national market that have been produced elsewhere and in a manner which the country concerned finds undesirable. However, Europe can only protect its markets to a limited extent. This might, for example, generate tensions with respect to the desire of some people to be able to maintain GMO-free areas in agriculture.

As a result of globalisation, the scope within national policy to keep out undesirable developments is decreasing. It is becoming increasingly difficult to influence nationally undesirable developments and the pressure to allow GM products produced elsewhere is increasing.

Outside of Europe a gradual increase in the cultivation of GM crops is taking place. Moreover, developing countries will increasingly be open for applications that provide considerable national advantages. These countries will also exert increasing pressure on the EU to throw up fewer barriers against GM products. At the same time it is in their interest to retain the ownership of their own indigenous crops.

There will be a marked increase in the cultivation of genetically modified crops outside of Europe. Characteristics that provide advantages for the consumer and the processing industry will be incorporated. Questions such as coexistence and the role of the government in this will become more pressing.

5.2. Dealing with regional differences in acceptation

Throughout the world there are considerable differences in the public acceptance of biotechnological applications. These differences are in part due to cultural and religious views. The question arises as to how this should be dealt with. Globali-

EXTINCT TASMANIAN TIGER BACK TO LIFE

The Australian Museum is making frantic attempts to resurrect the Tasmanian tiger. The last specimen was captured in 1933 and died in a zoo in 1936. Researchers from the museum have successfully isolated DNA of a good quality from a pup preserved in alcohol. A suitable surrogate mother is being sought. The researchers are optimistic and they think that in 2010, they will be able to show the first pup to a generation which has had to make do with a black-and-white photo. [www.austmus.gov.au]

EATING RICE PREVENTS MEASLES

Being vaccinated against measles after eating a rice-flour porridge. Australian scientists are working on an edible form of the measles vaccine. The researchers have already successfully produced a vaccine in tobacco plants. Experiments in mice have demonstrated that the vaccine works and the researchers have now started to test the vaccine in primates. The next step is to produce the vaccine in rice. Each year, measles kills one million children in developing countries. It is impossible to transport the vaccine in a cooled state to some regions and there is also a lack of trained medical personnel. [www.med.monash.edu/microbiology]

sation requires new forms of international agreements and a reconsideration of the national position. The current international agreements about biotechnology focus on biosafety. Perhaps efforts should also be made to reach agreements about ethical boundaries that must be complied with throughout the world. Compromises will need to be made in order to reach global agreements. This could also lead to the Netherlands being forced to examine and reconsider its viewpoints.

Biotechnological developments that are contrary to the Dutch vision will continue to take place elsewhere. One response to this could be to develop a proactive strategy to influence developments in other countries as much as possible in the direction preferred by the Netherlands, for example by starting a dialogue with national governments and other parties at an early stage in order to reach collective standpoints, which can also be upheld in relation to the WTO.

5.3. Consequences of the government's decreasing role

In contrast to other countries, the Dutch government has chosen to adopt a modest role with respect to stimulating biotechnological innovation. Research centres were made independent at the very moment that commercial enterprises were starting to transfer their activities elsewhere due to an anticipative or curtailing government policy. As a result of this agricultural research has found itself in a difficult position. The expenditure for R&D in the Netherlands is less than the average of the OECD and EU member states. In 2001 (last measuring point), the number of R&D working years invested by companies in the area of biotechnology was less than in 1999.

As a consequence of the government's decreasing contribution, companies face more uncertainties, developments are taking place more slowly, researchers sometimes create expectations that are too high in order to gain new resources, and innovation is taking place more quickly in other countries such as Japan, the United States and other EU countries such as Belgium. Due to this trend the Dutch government could come under pressure to focus on limited areas of innovation and to reflect on the effect of the detailed legislation.

At present, biotechnological innovation in the Netherlands lags behind developments in other countries. This could force the Dutch government to reconsider its policy with respect to innovation and legislation.

5.4 The changing nature of the debate

For a long time the public debate about genetic modification in the Netherlands and Europe has been dominated by the rejection of GM agriculture and GM food by consumers. This has affected developments in, but also outside of, Europe. As a market, Europe clearly has an influence on international developments. However, the public debate around biotechnology seems to be slowly changing in terms of its direction and intensity. Changes in public acceptance could have considerable consequences for developments within biotechnology.

Habituation

The debate around biotechnology, stirred up by NGOs such as Greenpeace, has been going on for years and the media and general public seem to be getting tired of it. The standpoints are mostly known. Moreover, up until now no large scandals have occurred with respect to biotechnology. During the 25 years in which genetic modification has been taking place in many laboratories, not a single incident has been reported anywhere in the world in which an 'accident' that posed a serious risk for humans or animals occurred. In this respect naturally-occurring organisms pose a considerably greater threat (e.g. SARS and certain types of influenza). It is important to realise this whenever genetic modification and gene technology are discussed as isolated issues.

Habituation is another factor. Biotechnological applications are gaining a foothold in everyday life. An increasing number of medicines have a biotechnological nature and detergents contain components produced by GMOs. As the public increasingly comes into contact with more GMO products – sometimes scarcely recognisable as such or with a clear benefit such as medicines – the perceived risk can become less and the acceptance can grow so that the debate gradually subsides.

The support for specific applications

The support for specific biotechnological applications can quickly increase if there are clear benefits for the citizen. The market introduction of genetically modified cotton proceeds apace, but without much debate in cotton-producing countries because the advantages for the population there were experienced as evident. Cotton growing is extremely polluting for the environment and GM cotton considerably reduces the use of insecticides. The advantages of biotechnological applications in the medical sector are not controversial and in the white biotechnology sector there is no discussion about the environmental benefits. In the agricultural and animal husbandry sectors, applications with an advantage for the consumer or the processing industry are expected to appear in the near future.

Harsher actions expected from opponents

A possible growing public acceptance of genetic modification does not mean that the number of protest actions will decrease. Indeed it is expected that these actions will actually become more radical. A smaller group of opponents will carry out increasingly harsher actions as their grip on the developments seems to be decreasing. They oppose genetic modification as a matter of principle because it is perceived as a threat to their core values. This group does not appear to be prepared to make compromises. Their actions will increasingly focus on sabotaging the developments as opposed to just acquiring public attention for their standpoints. This development has already taken place to a certain extent. During the last series of actions against field experiments in the Netherlands, the acts of sabotage were no longer claimed or reported to the press.

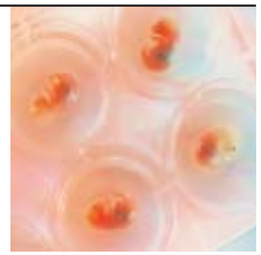
It is expected that the public acceptance of biotechnological applications which are still controversial at present will eventually increase. This could be associated with more radical actions by small groups of conscientious objectors. The government will be confronted with the question as to how to deal with these uncompromising opponents.

The Government Information (Public Access) Act is under pressure

The locations where field experiments are carried out are made public. Field experiments with GM crops are nearly always destroyed in the Netherlands and the rest of Europe. The destruction of field experiments has not only led to frustrations among researchers, research institutes and companies, but also to considerable damage. This is one of the reasons why companies have transferred their activities to other countries. Calls are being made for the location of field experiments to be kept secret or to only provide a more general area indication, such as the municipality in which the experiments are taking place. The dilemma associated with this is that the public nature of government is being weighed up against the damage suffered by third parties (research institutes and companies) and against the possible damage to the Dutch economy due to companies transferring their activities elsewhere or stopping these.

The problems with respect to the destruction of field experiments will give rise to the question as to whether the public nature of government weighs up against the damage suffered as a result of protesters' actions.

6 | Urgent issues and possible future controversies in the public debate



The considerable scepticism within the Netherlands and Europe with respect to biotechnology is striking. This scepticism concerns the possible use of applications as well as expectations about their feasibility. This is not only reflected in a lower degree of public acceptance, but also in a certain gloominess which researchers and industry emanate compared to their American or Asian colleagues. The gloominess among researchers and industry is partly due to what they see as a failing government policy with respect to innovation and a rational and integrated national legislation with respect to biotechnology. Research is increasingly taking place outside of the Netherlands and companies are rapidly transferring part of their research to other countries.

Yet a shift in the public acceptance of biotechnology can still be expected. As more habituation occurs and more products with a clear advantage for the consumer and citizen appear, the public acceptance is expected to increase. This process can be considerably accelerated if an application with a generally recognised use or advantage for large groups in society comes onto the market, such as a health-promoting or healing effect. It is, however, equally possible that a serious incident will take place, as a result of which a large resistance towards biotechnological applications will occur.

An increase in the public acceptance will strangely enough not result in a decrease in the actions and resistance towards genetic modification. There is the risk that small groups will switch to far-reaching sabotage actions, similar to the actions of animal rights activists in the United Kingdom. As these groups are not interested in a dialogue or in reaching compromises, the government will have to consider how it is going to deal with these groups. Ignoring them will no longer be possible or desirable if these actions become more radical. In view of the elusive nature of these groups, society is likely to respond with secrecy and a harsher stance. As a result of this, democratic principles, such as the public nature of government, could be threatened.

In the previous chapters some twenty themes have been identified which score highly for the public debate. In the opinion of the committees, the following themes have priority in relation to this, due to their influence on society and the expected intensity of the public debate:

- Diagnostics, where 'carrying' certain genes plays an important role in the onset of a serious disease, in relation to confidentiality of the data and the insurability for certain diseases.
- Consideration of the influence of globalisation on the role of national policy making, such as that with respect to:
  - imports of genetically modified organisms (e.g. fish) and the products derived from these;
  - possibilities for coexistence in agriculture and;
  - possibilities for influencing international developments.
- Discussion about the uses of embryonic stem cells in society.
- Ecological risks of deliberately introducing genetically modified organisms into the environment to control animal plagues or to protect animal species from diseases.
- Pharma crops and the safety and integrity of food.
- The Government Information (Public Access) Act in light of the abuse of information about licences for field experiments by more radical action groups.
- Due consideration will need to be given to the use of genetic tests, which on the one hand will make it possible to screen for serious conditions and on the other to select desirable human characteristics during the preimplantation of embryos.

Appendix

Composition of the steering committee and workgroup

Steering committee

- Prof dr J van der Meer (acting chair CCMO), member
- Prof dr E Schroten (chair CBD), member
- Dr ir F van der Wilk (secretary COGEM), secretary
- Prof dr ir B C J Zoeteman (chair COGEM), chair and also contact for the workgroup

Workgroup

- Dr M J H Kenter (secretary CCMO), member
- Drs mr H Lommers (secretary CBD) member
- Dr ir F van der Wilk (secretary COGEM), coordinator