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Genes for your food – Food for your genes

Societal issues and dilemmas in food genomics

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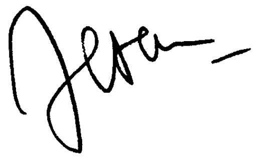
Foreword

Genomics is a new domain of research which developed on the back of the fact that complete DNA information (the genome) of micro-organisms, animals, plants and human beings was becoming more widely and easily available. Genomics covers the mapping of the genome and the study of how hereditary characteristics translate into cell functioning and eventually the functioning of the entire organism. Governments and companies around the world are investing heavily in genomics research. The Dutch government, for instance, intends to invest some € 190 million over the four year period 2003-2006. The Netherlands Genomics Initiative was called into existence to wisely exploit these resources to build up a ‘top level knowledge infrastructure’.

Both the government and the Lower House thereby expressed their political wish that proper consideration be given to all social issues and concerns in this early stage of genomics research. Previous experience with (a lack of) social acceptance of biotechnology, especially genetically modified crops, emphasised this need. So, within the programme, the Netherlands Genomics Initiative has reserved the substantial amount of 20 million euro for research into social aspects and communication. To determine which specific activities are needed, a list of the social issues to be studied, discussed and communicated should be drawn up. To this end the Rathenau Institute listed the likely social questions in the areas of agriculture, food processing and nutrition.

One or more applications are to be expected in all links of the food chain. Genomics on the production side of the food chain concerns, for example, the mapping of the genome of food crops, agricultural animals or important industrial enzymes. On the consumption side it is, inter alia, about knowledge of the relationship between individuals’ genetic backgrounds and their need for nutrition. The Rathenau Institute uses the term ‘food genomics’ to refer to the specific application of genomics to research questions in the wide field of agriculture, food and nutrition.

In this collection of essays we seek to find applications of this technology and the different social contexts in which this is and will be taking place. In this way we will be able to reflect on the social impacts of food genomics on food production and food consumption. To this end social scientists have written five essays in which societal issues concerning food genomics are investigated and evaluated: from the viewpoint of the social-economic organisation of both production and consumption of food; on world food security; the wishes and concerns of citizens and consumers and the use of animals. The essays were discussed at the working conference *Genes for your food – Food for your genes* (*Genen voor je eten – Eten voor je genen*) by a broad spectrum of interested parties. A report was made of each discussion that is presented after each of the essays concerned. As conclusion there is an overview of many societal aspects of food genomics that could be used as overture to further research and discussion.



Mr.drs. Jan Staman
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Introduction

Rinie van Est & Lucien Hanssen

Genomics is a new area of research in which both governments and industry will be investing huge sums over coming time. Genomics seeks explanations of biological processes based on information from DNA (genome), from RNA (transcriptome), from proteins (proteome) and from metabolites (metabolome) together. The specific application of genomics in research in agriculture, foodstuffs and nutrition is called *food genomics*.

Definition of food genomics

In this publication genomics refers to genomics in a broad sense thus covering the entire research field aimed at mapping DNA (genomics in a narrow sense), and DNA expression into RNA (transcriptomics), proteins (proteomics) and molecular processes in the cells of organisms (metabolomics).

Genomics techniques are being used to study numerous agricultural, food and nutrition issues. The Rathenau Institute uses the generic term food genomics to cover that entire research field. It thus includes, for example, the study of the genetic make-up of plants or animals (agri or agrogenomics), and the study of the effects of nutrition on our health (nutrigenomics).

Genomics is explicitly distinct from genetic modification. In the latter the hereditary material (genome) of micro-organisms, plants or animals is changed. Both genomics and genetic modification are key concepts in modern biology and biotechnology.

Thinking as to the possible societal implications of food genomics is still in its infancy. At this time, policymakers and scientists from public and private research institutions especially are setting the direction of genomics research with agendas being strongly related to the ambitions of the various research groups. But experience with developments in biotechnology and food production has shown that it is critically important at an early stage of development to take account of the concerns and desires of society as a whole. Researchers expect that the social implications of the results of food genomics research will be intrusive – especially in the positive sense. But it is also important to gain insight into the way other parties in our society assess the societal implications of food genomics. For example, how do farmers, consumers and other interested parties see these developments and their consequences for society? What effects do they want and not want to see, and why?

Project Towards a Societal Agenda for Food Genomics

In order to contribute to understanding of the social and moral aspects that play or will play a role in food genomics research, 2002 saw the Rathenau Institute initiate a number of investigative and reflective activities in the project Towards a Societal Agenda for Food Genomics. At least two publications resulted from these activities: this collection of essays and the report *Food genomics research in the Netherlands. Possible products and societal issues.* (*Voedingsgenomicsonderzoek in Nederland. Mogelijke producten en maatschappelijke aspecten*) by Enzing and Van der Giessen (2003).

The latter study is carried out by TNO-STB and gives an overview of the applications of food genomics (see box on page 15). The social meaning of food genomics is naturally closely associated with its applications. The report serves as a basis for consideration of the societal aspects of food genomics. A summary of this report can be found in Appendix 1.

Prior to publication of these documents the Rathenau Institute organised two key meetings: the experts meeting, *Food Genomics* (*Voedingsgenomics*) held in Utrecht on 31 January 2002, and the working conference *Genes for your food – Food for your genes* (*Genen voor je eten – Eten voor je genen*) held in The Hague on 5 June 2002. These meetings were the first structured attempts to broaden the discussion regarding possible societal aspects of food genomics, both as far as arguments and those involved were concerned.

The concept for the content of the five essays in this collection were discussed at the experts' meeting. Scientists and technologists involved in food genomics research were confronted with analyses and insights from social scientists, and vice versa (see report in Appendix 2). The insights gained contributed to the essays and also further highlighted the contours of the Towards a social agenda for food genomics project.

During the working conference *Genes for your food – Food for your genes*, a broad group of those involved discussed topics deserving of social and political attention. The meeting was attended by policy-makers, scientists, people from industry and members of social organisations (see Appendix 3). They discussed the essays at the workshops. Participants were also asked to suggest three societal topics they considered most important for further discussion.

The essays thus represent the publication *Genes for your food – Food for your genes*. This collection is intended to give a summation of possibly relevant issues and questions, and also highlight and clarify the social context and social dynamics that hide, sometimes unseen, in the background. The various authors focus on the question as to how far social desires and concerns that can be distilled from ongoing discussions on for example, transgenic crops, functional foods, feeding patterns, sustainability and use of animals, are relevant for food genomics.

In these essays, social scientists seek to understand the social and moral aspects of food genomics research to be able to initiate dialogue. The essays deal with (a) the socio-economic organisation of production, (b) food consumption, (c) global sustainable food security, (d) desires and concerns of citizens and consumers and (e) the use of animals. Together, the essays provide a survey of the impact of food genomics on the entire food chain, with attention being given to both the production and consumption sides. The authors have nominated existing and new societal issues and questions by handling their themes from both a cultural-historical and a socio-economic context. The central question in each essay is whether the application of genomics research is in line with existing social and cultural developments. Or do they instead offer new perspectives?

At the end of each essay is a report of the discussion that took place during the working conference. The closing chapter gives an overview of societal issues and dilemmas surrounding food genomics. This overview will serve as starting point for further research and discussion.

Further elucidation of essays

In the first essay Guido Ruivenkamp places genomics research in the context of the increasing industrialisation of agriculture. He describes how the application of new technology and biotechnology have radically changed the nature of food chains, the interplay of power and the basic principles of players within the chain. For example, primary agriculture for the production of sowing seed and the use of artificial fertilisers and pesticides have become more dependent on *life sciences* and agrochemical companies. Ruivenkamp examines whether genomics research is associated with such developments and whether this study offers new opportunities, for example, for restoration of the autonomy of the farmer.

Themes	***Topics***	***Author(s)***
Socio-economic organisation of food production	Increasing the science content of the production process Power of life-sciences multinationals Uncoupling agricultural and food products	Guido Ruivenkamp (WUR)
Towards global sustainable food security?	Global food provision Sustainability. Intellectual property rights	Bart Gremmen (WUR)
Use of animals	New forms of animal use Use of laboratory animals Animal health	Lino Paula (UL)
Socio-economic organisation of food consumption	Feeding patterns Symbolic significance of food Medicalisation and genetisation	Hub Zwart (KUN)
Desires and concerns of citizens and consumers	Gap between producer and consumer Consumer faith in government and industry Risk perceptions of consumers	Hedwig te Molder (WUR) Jan Gutteling (UT)

In Chapter 2 Bart Gremmen studies the contribution that food genomics research can provide to sustainable food production and better world distribution of food. Is food genomics research essential for feeding the growing world population? Does food genomics lead to sustainable agriculture? Are third-world countries benefiting from the knowledge coming from this research?

In Chapter 3 Lino Paula describes the possible effect of food genomics on the use of animals. Modern biotechnology has led to new forms of instrumental animal use. Paula asks himself, inter alia, whether genomics research, that will provide new knowledge for optimising the breeding of farm animals, will open the door further towards a more instrumental approach to these animals. Will fundamental knowledge of the genetic make-up of animals and man also influence how we look at these animals? At the same time, attention is given to the impact of functional food on the use of laboratory animals. Does genomics research lead to an increase or decrease in the use of laboratory animals?

In Chapter 4 Hub Zwart examines the influence of genomics research on the socio-economic organisation of food consumption. In order to interpret current developments in the area of consumption, he takes a look at the past. He describes the birth of the modern consumer for whom food is more than the consumption of nutrients. It is the consumption of symbols, or of creating significance. Using a number of current examples, such as Golden Rice, Zwart illustrates the impact that genomics has on the social and moral dimensions of food consumption.

In the last essay, in Chapter 5, Hedwig te Molder and Jan Gutteling analyse the pros and cons of citizens being involved in technological and scientific developments. These authors base their thinking on experiences in organised social debates, such as the public debate 'Food and Genes' (*Eten en Genen*) organised in 2001 to survey the attitude of the Dutch public in relation to genetically modified foods. Te Molder and Gutteling make a number of recommendations regarding communication to the public on food genomics issues. They also look at the role that genomics researchers themselves can fulfil in the social debate.

Finally, Chapter 6 offers a summary of the social and moral issues and dilemmas for food genomics that deserve social and certainly political attention. The summary is based on the analyses in the essays and the results of the working conference.

Applications of food genomics

In this box, applications of food genomics are examined: in the area of vegetable and animal starting materials (agrogenomics); the processing of raw materials into food (food genomics)*; and the consumption of food* (nutrigenomics). *These three areas together cover the entire chain. The descriptions below are mainly derived from the publication* Food genomics research in the Netherlands. Possible products and social aspects *(original title:* Voedingsgenomicsonderzoek in Nederland. Mogelijke producten en maatschappelijke aspecten) *(Enzing & Van der Giessen, 2003); a summary of this report can be found in Appendix 1.*

Agrogenomics

Agrogenomics is especially concerned with genomics research for the production of plant and animal starting materials. When the genetic make-up of agricultural crops and animals is mapped, new options arise to increase yields, decrease losses during storage and transport, and optimise processing procedures. These aims can be achieved by refinement of characteristics such as vitality, life-span and disease-resistance, and also drought, cold and salt tolerance or resistance to metals. For example, a potato with resistance to potato blight (phytophtora), a cold-tolerant salmon or a tomato that can be stored for a longer time.

In addition as a result of genomics research, transgenic plants and animals can be made with completely new characteristics. Thus plants and animals can be enriched with (micro)nutrients that have a positive effect on human health. For instance, imagine vitamin-A rice or cows that can provide cholesterol-lowering milk. Further-

more, genomics creates the possibility for non-food *applications for plants and animals – for instance, medicines or high-value materials. If it concerns characteristics that occur in nature in the same sort, then no genetic modification is required for improvement or breeding. In that case, by making use of knowledge and methods of analysis from genomics research via selective crossing* (marker-assisted breeding) *and breeding programs, the required genetic changes can be achieved. However, because the same sort of animal often does not have the required genetic characteristics, the uses of genomics without the use of genetic modification are limited within the farming sector.*

Food genomics

In food genomics, the techniques of genomics are used for improving the processing of raw materials into foodstuffs via for instance fermentation processes. An important part of our food is made via fermentation processes, for example, micro-organisms (yeasts, bacteria and fungi) used in the production of beer, wine, cheese and yoghurt take care of the necessary transformation processes. Genomics techniques have increased our knowledge of the mechanisms of these micro-organisms and from this we can optimise the 'production' process within *the micro-organism. This means using as little energy and food resources as possible and producing as little waste as possible.*

At the same time, more additives and food ingredients are being produced by micro-organisms, for example, aroma and taste substances, preservatives and also materials that are essential for our health, so-called biologically active substances, such as vitamins, essential fatty acids or antioxidants. Nutrition companies are continually screening all types of bacteria, yeasts and fungi that are assumed to be safe for the production of foodstuffs. In this way they hope to find micro-organisms that can make particular food ingredients more efficiently than currently. Genomics can greatly improve the quality of these selection and optimisation processes. The food industry is currently diligently searching for new biologically active substances. When a bioactive material is presented as a pill (pharmaceutical), it is called a neutraceutical*. When it is added to an available nutritional product, then we talk about a* functional food*.*

Industrial food production nowadays uses genetically modified micro-organisms in many ways. In contrast to the use of gene technology in the farming sector, the use of genetic modification in industry has led to little social unrest. This is firstly because the micro-organisms carry out the transformations in closed systems, so that the consumer does not experience the risk for the environ-

ment and workers to be significant. Secondly, the altered micro-organisms are themselves no longer present in the food product. It is expected that mainly on the basis of the new insights from genomics research, this production method for additives will increase greatly in the future. This development influences the place of agriculture in the food production chain, and also the sustainability of production processes and the possibility of making new functional foodstuffs.

Nutrigenomics

An important area in genomics research is the relationship between nutrition and health. This concerns for example research into the effects of food ingredients (nutrients) on health, or into individual genetic differences between people and their effect on nutrition and diet. The combination of genomics and nutrition science is called nutrigenomics*. Nutrigenomics research is expected firstly to provide more insight into the mechanism of action of food components in the body. This could give the necessary foundation for the health claims of existing and new enriched foodstuffs. It then also contributes to the development of completely new types of high-value foodstuffs that are linked to the individual genetic profile of the consumer. Nutrigenomics research can in addition help to explain the different reactions of people to food based on inherited characteristics that are often caused by small chromosomal differences. It can also help to understand better the effects of environmental factors such as food on genetic activity. The research also contributes to food safety: with this knowledge, new biomarkers can be developed to evaluate the safety and quality of food throughout the entire chain.*

1 Genomics and food production – the social choices

Guido Ruivenkamp

1.1 Introduction

Many scientists think positively about the potential applications of genomics research in the agrofood sector. Thus it is claimed that more knowledge of the plant genome will lead to higher yields because the times for sowing, fertilising and harvesting can be more accurately defined. The same goes for knowledge about resistance to diseases or pests, and crop cultivation in salt-containing or dry soils. Genomics may also influence the processing of agricultural products into foodstuffs. For instance, increased knowledge of micro-organisms may make the transformation of agricultural products into food more efficient and environmentally friendly. Finally an increasing differentiation in food consumption may be achieved because new possibilities exist for the development of 'custom-made' nutritional products, those tuned to the specific health requirements of individual consumers.
It is expected that, all-in-all, food genomics research will mean choices that will serve many social applications.

This essay examines the possibilities and problems caused by social choices in food genomics research. The central argument is that genomics research takes place between two different models of agricultural development and food production.

Firstly, within the model of industrialised agriculture in global agro-industrial production chains, by which genomics research is linked to the historical development of the externalisation of agricultural science research. By this we understand the systematic and continuing reorganisation of agriculture towards the image being designed in and by the agricultural sciences. The concept of externalisation also refers to changing agriculture from the *outside*.

Secondly, within the model of region-specific diversity in agriculture, by which genomics research is associated with strategies to facilitate changes from *within* the farming sector and to link them to local specific, endogenous developments. This includes biological farming, agriculture aimed at the preparation of regional products, etc. (Jongerden & Ruivenkamp 1996). Endogenous development endeavours to link up with current, region-specific innovation processes characterised by accurate tuning to local knowledge about local sources.

The position of food genomics research within the two models implies also that the interaction of social and technical elements of food genomics research can take various forms. The central question is which specific form the integration of social science and pure science can take. For example, sustainability has different meanings within the model of industrialised agriculture and in the model of diversity in agriculture. Setting up genomics research according to the one model or the other can make a lot of difference. This essay examines the choice of developing genomics from the perspective of both models.

The composition of the essay is as follows: the second section proposes that the scientific-technological complex known as genomics did not occur spontaneously but has been the result of long historical development in agricultural research and technology. As such it must be understood in its interrelationships with historical developments in global food or agro-industrial production chains. It is argued that genomics research is an example of the externalisation of agricultural research, giving further form to this and must be understood in the context of the social organisation of agro-industrial production chains.

In the third section it is proposed that these historical developments in the agro-industrial production chains are being reinforced and changed by developments in biotechnology. The concept *dialectical change* is introduced, which emphasises that genomics research is related to ‘industrialised farming in transition’.

These reorganisations are characterised by socio-economic shifts in the ‘farming and food production landscape’ (Appadurai 1992) and are also related to the action perspective of those involved in the food chain. This changes the identity of farmers, companies and scientists (Ruivenkamp 2002). Thus it is no longer appropriate to describe for example sowing seed companies and enzyme companies exclusively as single economic units. Due to the direct influence of their new products on the programming of agricultural production these companies also attain greater political identity. The identity of scientists also changes because, for example, the difference between fundamental and applied research is becoming more vague.

Which way food genomics research goes will be determined more and more by the new identities of the various actors involved in the agro-industrial production chain and especially by processes that form the identity of food genomics researchers.

In the fourth section, the creation of the identity of these scientists is examined. This essay proposes that it is precisely the scientists researching genomics who will themselves be more often confronted with a specific social conflict. Scientific research is increasingly often influencing farming practice. At the same time, it is less clear what specific contribution an individual researcher can provide to a particular social change. The complex social organisation of the research means the scientist is more often alienated from the social dimensions of it, yet the social impact of the work increases. We thus conclude that the possibilities for social choice with regards to food genomics research will primarily be determined by the social context within which this research takes place. This context is characterised by the following two areas of tension:

- the interrelationship of food genomics research with historical developments and reorganisation processes of industrialising agriculture (sections 1.2 and 1.3);
- the fact research is organised in a complex, opaque and alienating way yet at the same time is fulfilling an ever more important social role (section 1.4).

These two areas of tension will determine the way in which social and technical elements will interact within food genomics research. Of great influence here will be whether scientists prove themselves capable of gaining greater grasp of the social significance of their work and whether they are prepared to break through the current unidimensional association of food genomics research with industrialising agriculture.

Therefore the end of this essay describes how food genomics research can be linked with endogenous development pathways. Because of the current historical context of food genomics research alternative developments are marginalised. We thus make a plea that such alternative developments should actually receive more public support.

1.2 The historical development towards industrialisation of agriculture

According to Goodman and colleagues (1987) the industrialisation of agriculture took place via two long-running historical processes, summarised by the terms *appropriation* and *substitution*.

Appropriation refers to the gradual take-over of the controllable biological activities from farming practice by external institutions, especially industry. For instance crop seed production, originally performed on the farm, is now more often contracted out to external research organisations and thereafter appropriated by life-science companies. These are engaged in sowing seed production, improvement, diagnostics and the production of foods and dietary products, medicines and such like.

A classic example from the working domain of life-science companies is the development of hybrid maize varieties that have put the maize producer out of the loop in the creation of maize varieties. Another example of the appropriation of a farm process took place around the management of soil fertility. Originally the farmer did this himself via crop rotation, etc., but now soil fertility is primarily managed by the use of artificial fertilisers supplied by agrochemical companies (Jongerden & Ruivenkamp 1996).

Substitution refers to the historical development by which the agrarian origin of food sources are gradually being replaced by products of industrial-biochemical methodology. This development undermines the direct line between agriculture and food production. Farm products are being reduced to semi-manufactured industrial goods that can in time themselves be replaced by synthetic industrial products. This development started with the replacement of butter (made from milk) by margarine (made from vegetable oils). A more recent example was the replacement of beet and cane sugar by maize fructose syrup and synthetic sweeteners such as aspartame (Ruivenkamp 1986).

1.2.1 Food genomics research within agro-industrial production chains

These two developments – appropriation and substitution – imply that farmers are losing control of a number of activities and especially that they must pursue new working relationships with agricultural research institutions and companies. In this way the farming sector is now becoming more a part of an agro-industrial production chain. In this chain, four process phases can be differentiated:

1. production of *input* for agriculture, such as seeds and artificial fertilisers;
2. actual agricultural production;
3. processing of agricultural products into foodstuffs;
4. distribution of these foodstuffs to the consumer.

Because of this, agriculture is becoming less of an independent sector. Many activities that farmers originally performed themselves, such as improving and cross-breeding varieties, upgrading soil fertility and storing outgoing material are being taken over by external institutions (e.g., gene banks, improvement and agro-chemical companies etc). This has created new working relationships between the farmers and the producers and suppliers of these new products. The farmer is becoming ever more integrated into the international organisation of the agro-industrial production chain. The specific way in which this is happening involves the fact that technological developments impinging on the first, third and fourth phases of the chain are now having an ever increasing influence on agriculture itself.

The relationship between the development of agricultural technology and the occurrence of new working relationships should not be seen as just one-way traffic. There is a sort of two-way influence at work. The new technology is influencing the way in which agriculture is being integrated into agro-industrial production chains. The characteristic working relationships between the various involved parties of the agro-industrial production chains is influencing the development of modern agricultural technology and the way in which research is performed.

New agricultural technology such as biotechnology and genomics were thus primarily designed from the working relationships existing in the agro-industrial production chain. Essential characteristics of these working relationships include :

- increasing concentration of economic power in multinational companies in all phases of the food chain;
- increasing standardisation and regimentation of agriculture via the use of a limited number of high-yield varieties;
- change in character of the agricultural product from end product to semi-manufactured product.

The social organisation of global food chains has worked its way through into the specific development of agro-industrial biotechnology (Ruivenkamp 1989). The extension of agro-industrial biotechnology has involved development of food genomics research. Considering the two-way influence of technology and social developments, the first proposal is:

> *Characteristic working relationships of the agro-industrial production chain are mirrored and given further form in genomics research.*

Actually, this general proposal means genomics research giving further shape to the historic development:

- of an increasing presence of science and externalisation of agricultural science research (Van der Ploeg 1992) – as a characteristic for the working relationship between scientist and farmer within the agro-industrial production chain. This implies that genomics research carries with it the fact that the role of scientists and farmers is now more and more determined by this specific practice of externalised scientific agricultural research;

- towards increasing standardisation and regimentation of agriculture – characteristic of the working relationship between the sowing seed company and the farmer. This implies that food genomics research will support the new role of sowing seed companies as key players;
- towards a quality change in the agricultural product that will be looked on as more of a biochemical (functional) semi-manufactured product – characteristic for the specific working relationship between foodstuffs companies and farmers. This implies that genomics research will reinforce foodstuffs production as an assembly of biochemical, functional food components;
- towards an increasing multinationalisation of food production and increasing patenting of crucial scientific products.

The interlinking of food genomics research with existing working relationships in the agro-industrial production chains is not unavoidable, it can be changed. In particular by the players involved themselves. They may criticise the necessity of placing genomics research as an extension of historic development, even more so because biotechnological developments lead to processes of change, which are characteristic of 'industrialising agriculture in transition'. This implies that genomics research can also be influenced by just these processes of change of an 'industrialising agriculture in transition' and that the interaction of social and technical relationships can achieve another form.

1.3 Genomics research interlinked with industrialising agriculture in transition

In this section the concept of *dialectical change* is introduced. Concrete examples are: 'the straw that breaks the camel's back' or the boiling of water to form steam. In other words, the concept of a quantitative increase of a development due to which at a certain moment a qualitatively new situation exists, a point of sudden change. The script of food genomics research is not only determined by the 'history' or the characteristic historical development in the agro-industrial production chain but also by the qualitative changes that occur in the social organisation of the chain. The introduction of biotechnological developments in the agro-industrial production chain brings with it the fact that the two characteristic developments of appropriation and substitution can change the contents qualitatively by quantitative expansion. In this way genomics research can stand somewhat apart from the historical developments of appropriation and substitution and become more interlinked with the qualitatively new characteristics of an industrialising agriculture in transition.

In this section the qualitative change in the organisation of the agro-industrial production chain is described via three specific separation processes. In this way it is demonstrated that another coalition of social and technical elements in food genomics research could occur by interlinking genomics research with these new characteristics of an industrialising agriculture in transition.

The separation of agriculture and natural surroundings

Biotechnology is connected to the developments of appropriation and substitution, and has reinforced these developments to the point a qualitative change in the social organisation of the agro-industrial production chain occurs (Ruivenkamp 1989). An explanation follows that shows that the quantitative expansion of the 'appropriation possibilities' has led to the fact that 'appropriation' itself has changed into remote management over the 'appropriatable' and controllable biological activities. This expansion of industrial appropriation of controllable biological activities has taken place especially as a result of the uncoupling of agriculture from its natural environment. (Van der Ploeg 1992). Scientific plant improvement reinforced by biotechnological developments has provided an important contribution to that uncoupling process.

Plant improvement

The genetic structure of a plant is primarily formed during evolution by the interaction of the plant with its natural environment. Natural selection has enabled plants themselves to internalise the requirements for good growth from their environment into their genetic programme. For this reason some plants grow well in a cool climate and others in a warm climate. Attempts have been made by traditional improvement and cross-breeding techniques to shift the limits of these narrow relationships between plant growth and their natural surroundings. Thus during the Green Revolution attempts were made to bring other information into the genetic programme, especially for the purpose of higher yields. Bringing in these economically important characteristics often occurred at the cost of the internalised characteristics that actually gave the plant its natural protection. The plant did indeed provide higher yields but required greater outside protection in order to survive.

Improvement techniques have therefore on the one hand 'freed' the agricultural varieties of the limiting characteristics of their natural surroundings but at the same time have made them dependent on other techniques or characteristics. It is important to realise that such strategies for survival were not born into the genetic structure of the new varieties in the first instance. They were added 'from the outside' in the form of agrochemical pesticides and artificial fertilisers, etc. Instead of the interaction between plant and environment, a triangular relationship developed between plant, chemicals and environment.

This contextual change – called 'biochemicalisation' of agriculture (Ruivenkamp, 1989) – is a part of today's agro-industrial biotechnology (as shown by the development of herbicide-resistant crops) and is being further expanded. Thus crops have been developed with an inbuilt resistance to insect pests, diseases, or the ability to bind nitrogen, a higher food value and that can be gradually cultivated in colder, warmer, wetter or drier regions. All these different types of crops are similar in that they have been developed within the 'biochemicalisation' model. In other words, within the dualistic development of, on the one side, freeing crops of their relationship with their own surroundings and, on the other side, making them dependent on externalised agricultural research. This does not mean that in the end all crops will be cultivated in greenhouses – 'free from the cold ground' – where the climate is regulated. More likely there will be an increasing differentiation of types of cultivation in the various regions. But still with the same basic characteristic that the relationships between crops and the environment is more and more being determined by scientific information brought into the sowing seed.

As a result of further development of various plant biotechnology techniques, such as tissue culture, cell fusion and R-DNA techniques, man will intervene ever more efficiently in the genetic structure of a crop. This quantitative expansion of the possibilities of changing the genetic structure of crops leads to the next specific qualitative changes in the social organisation of the agro-industrial production chain, that can also be included within food genomics research.

1.3.1 New aspects in remote management of industrialising agriculture

The working relationship between sowing seed companies and farmers is no longer such that business has appropriated for itself the production of sowing seed. The phenomenon of increased spread of new varieties also means greater spread of a specific form of agriculture is even more important. This is illustrated by the increase in the cultivation of transgenic crops 30-fold in a period of only six years. Despite many protests, worldwide cultivation of transgenic crops increased from 1.7 million hectares in 1996 to 52.6 million hectares in 2001, which was especially due to the introduction of only one new characteristic (herbicide tolerance) on 77% of the transgenic area (40.6 million hectares), according to James (2001).

The expansion of the possibilities of changing the genetic structure of a crop means that where, when and in what way the agricultural product will be sown and harvested, and how the agricultural product will have to be processed industrially will be determined more and more by scientific research. Management of the agricultural production system is now falling more into the hands of private and public research institutions that develop and distribute the new knowledge-intensive inputs. The farming production system will also become more (often) remotely managed via the use of these new knowledge-intensive inputs. In this way there will be a redistribution of political influence and decision-making power. It will no longer be primarily the policy-makers in the ministries or the farmers themselves, but the researchers working in complex, non-transparent networks who, via the development of new varieties, will provide new contributions to the way in which the agricultural production system operates. Via the distribution of their knowledge-intensive inputs they will exercise remote management over farming production. These new inputs are called '*politicising*' products (Ruivenkamp 1989) – products that require specific processing and intervention via their specific, *material,* characteristics. The redistribution of political influence on programming agricultural production is thus happening in the context of the combined development of decreasing influence of policy-makers on the production process (often the term 'liberalisation' is used) and the increasing influence of the new inputs. This shifts the 'political system' into the organisation of the production chain.

A second change is that the new social order is progressing via further globalisation of the 'miracle seeds for development', and also especially by segmentation into regionally differentiated agricultural production systems. The same patented techniques and products can be used to develop different types of agricultural products, such as herbicide-resistant, disease-resistant, pest-resistant, better nitrogen-binding crops, and crops with a higher food value. Dependent on the politico-economic climate in the region a life-sciences company may for example develop disease-resistant crops for the north and herbicide-resistant crops for the south.

That same company could thus gain interest in various regional developments and separate food chains that both contribute to maximising returns on investment in the patented techniques. This means that regions and location-specific production systems will no longer derive their identity from the availability of their own (alternative) production system. Rather the degree of political autonomy of a region will be determined by the possibility of creating space for another material interpretation of the knowledge-intensive inputs. Genomics research can thereby play both an inhibiting and a facilitating role. Considering the current social attitudes it is probable that genomics research will (seek to) position itself within the extension of the above-mentioned reorganisation processes, which leads to the second proposal:

The separation of agriculture and the natural surroundings mirrors genomics research and is thereby further reinforced.

Development of genomics research within the above-mentioned changes in the organisation of the agro-industrial production chain implies that genomics research is linked to and leads to reinforcing of:

- the dualistic development in crop improvement both to release them from their internalised and limiting environmental factors and to make the crops more dependent on the know-how brought in by scientists;
- the development to make it more efficient to intervene in the genetic structure of crops. Considering the interrelationship of genomics research with social reorganisation of the food chain, this increase in efficiency will take place within the context of the shift of decision-making power regarding agricultural production in the direction of research centres. This implies that genomics research itself will gain a more 'politicised' content;
- the development towards remote management of agricultural production by increasing segmentation of regionally different agricultural systems. Thus genomics research will be associated with social pressures for developing new crops in certain regions without making use of gene manipulation methods. However, at the same time in other regions genomics research will be used via more directed gene technology intervention for the development of highly productive crops or crops with an altered food value;
- the development towards increased patenting and privatisation of techniques and products that are used for different sorts of crops and for different regional production systems.

The mutual influence of social developments and food genomics research is not limited to what happens in the development of new agricultural varieties but is also influenced by the changes occurring in the processing of agricultural products into foodstuffs.

1.3.2 The division between agricultural and food products

The historical development of gradual and partial replacement (substitution) of farming practice by an industrial and synthetic approach to food production has been greatly stimulated by upscaling, increasing scientific content and international homogenisation of regional processing methods. The agriculture sector has changed into more a sub-sector of the international food industry. Furthermore, the agricultural product is now changing more from a specific raw material (e.g., cane sugar) for a specific regional food product (sugar) into a general input (carbohydrate source) for the preparation of food components (glucose and fructose), assembled at the international level.

Biotechnology supports this breakthrough of the direct line between agricultural and food product through two processes:

1. development of new enzymatic techniques for obtaining food components from an ever increasing range of agricultural crops;
2. possibilities for producing these components by micro-organisms in the factory.

Because of improvements and applications of enzyme technology and microbiological production of food components, the food product is becoming more detached from its specific agricultural origins. This separation is taking place via a gradual transition from the 'historical' process of substitution to the mutual exchangeability of farming and biochemical raw materials during the preparation of foodstuffs. The growth of exchange and exchangeability of different farming and biochemical sources for food production has led to the fact that the old basic principle – food is processing of a specific agricultural product – has been broken down and that food products are now more separated from the agricultural product than ever in the past (Ruivenkamp 1989). Food genomics research developed in the separation process will also be strongly affected by the following quantitative changes in the processing of agricultural products into foodstuffs.

New aspects in the processing of agricultural products

The separation of agriculture and food products also means increasing flexibility in the character and flow of farming raw materials to the processing industry. Industrial consumers of, for example, sugar, such as soft drinks companies, no longer need to select either cane or beet but can obtain their sugar input (glucose and fructose) from many different carbohydrate sources, e.g., maize.

Beyond even this increased level of freedom in sourcing, development of enzyme technology and microbiological production of food components make it possible to broaden foodstuffs production even over the limits of the basic nutrients. For instance, carbohydrate sources can be converted into glucose via enzymes and then further via microorganisms into proteins and/or amino acids. In the opposite direction, by an industrial method, sucrose replacements are produced based on amino acids (e.g., aspartame). Thus different carbohydrate sources are made exchangeable (e.g., maize fructose and cane sugar as source of sweetness) and also the separation line between for example carbohydrate and protein can be forgotten. The flexible supply of raw materials to the companies that assemble foodstuffs components is thus expanded and intensified. This quantitative expansion in obtaining food components from various farming and biochemical raw materials has led to a qualitative new situation (*dialectical change*), that is known under the term *mutual exchangeability* for farming and biochemical raw materials.

The interaction of social and technical elements in food genomics research can especially be reinforced by developments towards increasing exchangeability of raw materials in the agro-industrial production chain.

A second consequence of the increasing separation between agricultural and food products is that the possibilities for regional food provision are increased because the foodstuffs or their components can be assembled from various farming and biochemical raw materials. At the same time an increasing competition can occur between the various regional methods (social forms of organisation) of producing the corresponding basic nutrients.

These two developments together – the increasing possibilities for production of components at the regional level plus more intensive competition between the regional extraction and production methods, carries with it the fact that for apparently independent regional production systems there will be increasing dependence on scientific research in the biochemical industry. Genomics research interrelated to these developments will therefore exercise an ever increasing influence on regional developments.

A third consequence of the separation process is that the research institutions and companies that have the know-how and the production capacity to bring to the market protein, carbohydrate and fat-degrading enzymes will be important players in the reorganisation of production in many countries. Thus successes in enzyme production have been decisive in for example the use of other agricultural crops for different food products in a particular region (e.g. the use of maize as source of sweetness). The development of new enzymes can also change the international flow of trade in agricultural crops (such as has been shown by the use of maize-fructose in the USA) and this can influence the price levels of various agricultural crops. The importance of enzyme technology lies in the intrinsic political character of creating reorganisations in the third phase of the food chain. Enzymes can be looked on as 'politicising' products (Ruivenkamp 1989), because they make an important contribution to the flexibilisation of raw materials transport to the food processing industry and thereby induce reorganisations in the agro-industrial production chain. Research institutions and companies that develop these catalysts can therefore be looked on as crucial political players.

A fourth consequence of the separation of agricultural and food product is that a drastic change in the social organisation of the food chain occurs, in which even the validity of the term 'chain' may disappear.

As the basic principle of food production – namely that food products are processed agricultural products – is broken down, the foodstuffs industry becomes more freed from the intrinsic food quality of the agricultural product and becomes less dependent on the processing of agricultural products and their derivatives. At the same time the food industry now becomes more integrated and even dependent on the developments in the biochemical industry. The politico-economic power in the third phase of the food chain shifts therefore towards areas that appear mainly to lie outside the food chain, such as enzyme production and microbiological production of food components. This implies that the events in the food chain will be understood less well from analysis of the food chain and will be better understood from analysis of the position of, for example, the biochemical industry.

The development of food genomics research within these reorganisation processes in the production of food components of an industrialising agriculture in transition leads to the third proposal about food genomics research:

> *The separation of agricultural and food products is included within and reinforced by food genomics research.*

This proposal implies that genomics research is linked to and will lead to reinforcement of:
- developments towards improving the biocatalysing functions of industrially important micro-organisms, by which the flexibilisation of the regional production systems of food components will increase. Food genomics research gains thereby direct politico-economic content;
- developments towards more intensive competition between different regional production systems for producing food components based on regional raw materials;
- conflicting development of regional independence in the production of food components combined with increasing dependence on scientific and technological research networks;
- the trend that the developments in production of food components are determined now more often outside the food chain. This means that for example agricultural economists must broaden their outlook via analysis of chain management and also look into the developments in for example the biochemical industry and the coalition of social and technical elements in genomics research.

Genomics research can all-in-all make an important contribution in supporting a transition towards a new food production system in which a number of foodstuffs, such as fats, proteins, sugars, etc., are produced, then functional components (vitamins and minerals) and taste and colouring substances are added and finally the whole package of constituents is supplied to the consumer in the traditional form of food in attractive and promising packaging. The packaging is often the only direct link between a product's image and its farm origin. Packaging creates the illusion that, for example, a chocolate biscuit contains mainly cocoa and that strawberry jam consists mainly of strawberries. The costs for production of these images (advertisements, etc.) and for production on demand are often larger that the direct production costs for the product itself. It is then striking to realise that people almost never take account of these changes and still talk about 'supply and demand', and the 'individual consumer and producer' without redefining these terms within the new 'economics of signs & space' (Lash & Urry 1994).

The transition from production of foodstuffs made from specific agricultural products towards production of food components assembled from a wide range of agricultural and biochemical raw materials makes a new production system possible in which the separation between agricultural and food products is converted into a third separation process, namely the separation of the agricultural product from its intrinsic nutritional quality.

1.3.3 The separation of the agricultural product from its intrinsic nutritional quality

For further development in breaking through the direct link between agricultural and food products the assembled food components can also be further separated from their intrinsic nutritional qualities. Due to this separation, the opportunity exists to associate the assembled food components to new symbolic and/or quality characteristics of the product as desired. Thus the assembled food components could be put on the market and sold thanks to their supposed contribution to all sorts of beauty and sporting images. At the same time more checks must be made (and paid for) in order to avoid 'contamination of products' and to gain insight into how far the assembled products can actually provide the claimed contributions. For example, the undesired presence of excess nandrolone in vitamin preparations recently caused doping problems in football circles.

Genomics research within this context could lead to developing 'healthy' (industrial) food components 'custom-made for the individual consumer'. The interrelationship of genomics research with this third separation process in the agro-industrial production chain implies the fourth proposal:

> *The separation of the agricultural product from its intrinsic nutritional quality mirrors itself in genomics research and thereby gains further form.*

This proposal means that genomics research can create new possibilities for stimulation of the consumption of assembled food components, that comply with criteria for the sporting and healthy image of the individual consumer. As intrinsic food qualities in the agro-industrial production process become more separated from the agricultural and food products themselves then genomics research can orient itself more towards the reinforcing of a new industrial appropriation of the 'custom-made' development of (healthy) food components for the individual consumer.

1.4 Social conflicts within genomics research: uncoupling of social significance from scientific research

Four general proposals have been made regarding the different forms of interaction between social and technical elements in genomics research. Which form this interaction actually takes will become clear in the future. Genomics researchers will play an important role but this section shows that there is little reason for optimism. In fact it is just these researchers who will be confronted with a specific social conflict in their research: while they work towards 'politicising' products, their view of the social significance of their work becomes ever more limited because they must operate within very complex and fluid networks.

For example: enzyme research takes place within an international production system characterised by an increasing concentration within few companies and the use of a limited number of enzymes from a few microbiological sources. This concentrated production system is actually managed via numerous cooperatives between a growing range of producing and scientific institutions. In other words, enzymes are developed within a concentrated, decentralised production system based on complex and flexible networks of cooperatives between companies and public and private research institutions in the various phases of enzyme production. Due to this specific organisation of enzyme development and production, enzyme producers lose their grip on and insight into the production process while the end-products of their work, the enzymes, cause large social changes in global food production. This social conflict in enzyme research appears to be characteristic for enzyme production itself and also for the development of all 'politicising' products of biotechnology development. The same developments in concentrated and non-transparent cooperatives are found more clearly perhaps in the sowing seed sector around the development of new improvement techniques.

The complex and fluid cooperatives within the production chain of biotechnology products and techniques carry with them the fact that the traditional dividing lines between fundamental and applied research become blurred. Study of the complex enzymatic processes in plants (e.g., ACC-synthase and ACC-oxidase) can on the one hand be looked on as fundamental research while on the other hand just these research activities can be crucial, for example, in influencing the ripening processes of vegetables and fruit. These research activities can actually be of great importance for the food multinationals which explains why they are working so hard at patenting the most important scientific developments in this area.

Thus fundamental scientific activities around the collection, selection, isolation and introduction of genetic information into crops is becoming more commercialised and closely linked to the economic interests of the *genetics supply industry*.

The non-transparent nature of the research networks and the increasing commercialisation of all types of scientific sub-sectors carry with them the fact that the dividing lines between public and private research are becoming more vague. It is becoming more problematic to base the difference between public and private research on a difference in location where the research takes place and/or on the source of financing, whether government or private. These aspects are becoming less important for showing the proposed differences in content of the research itself.

Furthermore more results and products flow both from public to private research institutions and vice versa, together within the complex and non-transparent research networks of life-science companies. Companies that in addition have the financial strength to purchase the most successful results from public research. In addition public institutions are now more often performing research from a reference base initiated from the use of knowledge-intensive inputs. Thus the global distribution of ‘high-yield’ varieties and the use of artificial fertilisers and pesticides has led to the fact that public research institutions follow the research paradigm of industrialised agriculture. Which variety and which crop are cultivated in a region is more often determined by ‘technical considerations’: what crop can be grown together with what, given the use of this material?

The pressure to be associated with particular developments in industrialised agriculture can be so strong that public research institutions carry out the same sort of research as private institutions but without being approached by industry. Because of this, public institutions may be inclined to solve agri problems for example the current rotation system in a (bio)technocratic way.

The next socially conflicting development is thus taking place in scientific research. On the one hand there is increasing complexity of the social organisation of research. This is based on fluid networks around all sorts of sub-sectors that are becoming larger and more numerous and on a smooth flow of information from public to private, and from fundamental to applied institutions and vice versa. Because of this the individual researcher has little or no insight into their contribution to the development of a specific end-product or into the social dimensions of that product. On the other hand this scientific work is now characterised more by its contribution to the development of 'politicising' products, such as specific sowing seed (e.g., glyphosate-resistant crops) and industrially important micro-organisms (e.g., *Aspergillus niger*, *Saccharomyces cerevisiae,* etc.).

It is expected that researchers 'as people' will remain fully involved in their sub-sector of research and therefore indirectly in reorganisation in the production system. Thus in scientific research, increasing integration often takes place of working hours and free time, of work and hobbies, and of production and education. This personal involvement in the sub-sector of research implies that we can talk about an expansion and intensification of working hours for the producers (the enzyme researchers, plant improvers, employees in fundamental research) who produce the 'politicising' products for the food chain. Instead of the 'compulsion of the conveyor belt' as illustrative form of management for workers in the 'Ford-like' development model, within the current development model of food component production, there is 'increasing self-punishment in complete freedom' of researchers who make a crucial contribution to the development of the 'politicising' product without actually themselves being able to find out which specific contribution they make.

The consequence of this specific social organisation of scientific research is that scientists – because of the complex organisation and specific social imbedding of their work – are alienated from the social significance of their work. In addition, the transition to the new production system of industrialising agriculture-in-transition described above can also take place quickly and quietly. Even the imagination of the possibilities of another research paradigm will be missing. And the critique appears to take on the form of total denial. Social organisations often follow this path of total dismissal, also because they cannot view the perspective of another coalition of social and technical elements in biotechnology and genomics. Proceeding from the interrelationship of genomics research with the above-described complex social organisation of externalised agricultural science research, the fifth proposal can be formulated:

Genomics research mirrors and reinforces the socially conflicting development that individual researchers become alienated from the social significance of their work while that social significance is actually increasing.

The reorganisation described above in scientific research implies that genomics research can lead to reinforcement of:
- mixing of fundamental and applied, and public and private research within the context of the 'politicising' of agricultural and food production;
- uncoupling of the social significance from scientific research.

The interrelationship of genomics research with the characteristics of industrialising agriculture in transition is not something that is actually unavoidable. Other developments can also take place. The social contrasts in the research work described may also stimulate researchers to critically reflect on the uncoupling of the social element from their work. They can attempt to grasp again the social significance of their scientific sub-sector. Or the social contrast in the research can eventually stimulate the researchers to 'sub-politicisation' of the research (Beck 1994) to an attempt to actually get insight into the social significance of their work. This implies that also the following, sixth proposal on genomics research can be formulated:

Genomics research can be a stimulant for reflective activities of researchers to reintegrate a social significance into the various subsectors of their scientific work.

This proposal implies that it is important to examine which possibilities the researchers have – within the current historically specific context – to bring about a new coalition of social and scientific elements within genomics research.

1.4.1 Possibilities for reconstructing food genomics research

Social choices in genomics research can especially be made in the manner of regional integration in global food chains. One possibility is that genomics research is linked to development of an industrialising agriculture-in-transition and reinforces this development towards regionally segmented agricultural production systems (see proposal 2). Food genomics research can also reinforce the development of the apparently autonomous but mutually exchangeable regional production systems of food components (see proposal 3).

In this case a social and scientific coalition occurs within genomics research interrelated to the development of industrialising agriculture and aimed at reinforcing the three separation processes in industrialising agriculture (see sections 1.2 and 1.3). It is social and scientific integration according to the option of development from 'outside' (an exogenous innovation process). A social and scientific coalition that is aimed at further development of regionally differentiated knowledge-intensive inputs (sowing seed and plant protection mechanisms) and at specific biocatalysts for increasing regional autonomy in production of food components or at improving health guarantees in industrial components production.

A second possibility is to interrelate the social and scientific coalition in genomics research with endogenous development pathways. This concerns development 'from within' (Van der Ploeg et al. 1994); an endogenous innovation process based on differentiation of already available local sources and knowledge. A similar social and scientific coalition in genomics research starts from the critical reflection that industrialising agriculture is really falling into a crisis and that it is necessary to go 'beyond modernisation' (Van der Ploeg et al. 1995). A social and scientific coalition that is aimed at freeing food genomics research from its association with the three separation processes of industrialising agriculture and to link genomics research to endogenous innovation processes.

The future of genomics research may thus become more entangled in a new social conflict regarding the use of genomics as exogenous or endogenous innovation instrument. This concerns the question of power over the formation of a social and scientific coalition in food genomics research aimed at bringing to perfection the three separation processes of industrialising agriculture or aimed at facilitating endogenous development processes. In both cases the social and scientific coalition in genomics research will manifest itself especially via a particular manner of integration of regionally specific developments in global production systems. Therefore, my last proposal is:

> *Genomics research mirrors and reinforces the social contrast between an exogenous and an endogenous innovation process that will be especially manifested via various forms of regional integration in global production systems.*

In the sections 1.2 and 1.3 it was shown that regional integration for industrialising agriculture is especially set up from within and 'top-down' and is controlled by global developments in the market. Now we examine in what way the coalition of social and scientific elements in food genomics research can also be formed from an interrelationship with endogenous development pathways.

Possibilities for development of food genomics research within endogenous development pathways

Genomics research aimed at the endogenous innovation power of a region and following and reinforcing the path to further differentiation of regional character must comply with the following conditions :

1. Genomics research must be aimed at bringing together what has been separated off from industrialising agriculture. Genomics research, especially functional genomics, must be used to search for the genes, transcriptomes, proteomes and metabolomes that can contribute to the relationship between agriculture and the natural environment.
2. Genomics research can be used to search for characteristics that can refine the regional crop-rotation system. For example in India research has been performed into the development of dual purpose and early maturing sorghum varieties (Ruivenkamp 2002). This generates extra income, succession crops can be cultivated earlier and less pesticides are required.
3. Genomics research must be used to examine in what way it will contribute to 'decommodification' (changing the character of the product from a commonly available, reasonably priced item to a less broadly available and higher priced specialist product) of sowing seed production. Thus characteristics such as 'apomicticity' can be tracked by which farmers will again be able to grow hybrid varieties on their own farms.
4. Genomics research should be used to search for characteristics of industrially important micro-organisms that make it possible to recreate and reassess the direct line between agricultural and food products at the regional level. From an endogenous point of view more attention should be given to finding micro-organisms and biocatalysts that are capable of reassessing the nutritional qualities of region-specific products.
5. Genomics research should be associated with initiatives for not primarily achieving regional independence at the level of the large-scale food component production but earlier at the level of the development of agricultural crops within region-specific geographical conditions.

These conditions suggest that there are various choices for associating food genomics research with endogenous development pathways and developing specific forms of a social and scientific coalition. Indeed this is not a case for the individual researcher, all the more in that the individual researcher will be functioning more in specific networks. That is why attempts have been made to set up new networks within which it is attempted to place biotechnology and genomics in the extension of endogenous developments. An example of this is the programme *Access to food through tailor-made biotechnologies*, set up by the TAO group [7] in cooperation with partners from India, Kenya, Ghana, Cuba and Brazil.

The influence of these custom-made biotechnology networks on the social discussion on the coalition of social and scientific elements will be especially determined by the degree with which these networks are successful in creating specific (alternative) forms of social and scientific integration in the specific sub-sectors of biotechnology and genomics research.

1.5 Closing remarks

In this essay we looked at food genomics research being primarily interrelated with historical and qualitatively new social developments of the agro-industrial production chain. We emphasised that this interrelationship cannot be seen as inevitable. Firstly because these developments can lead to critically questioning them. Secondly because researchers can be those who – despite the social conflicts in research described – still try to gain more insight into the social significance of their work. There is thus opportunity for making choices on the way that social and scientific elements should interact in food genomics research.

It is even possible to develop an alternative coalition of social and scientific elements in food genomics research. An alternative coalition manifested by freeing genomics research from its unidimensional association with industrialising agriculture and simultaneously interrelating it with initiatives working towards differentiation of regional localities.

Even so, a similar choice for an alternative social and scientific coalition is not simple. Researchers must fight the current unidimensionality of genomics research and at the same time must work out specific choices over the other social and scientific coalition in genomics research. A first step could be setting up new research networks in which researchers gain a view of their possibilities of bringing specific social dimensions into the sub-sectors of their work. Researchers working at the level of the genome, transcriptome, proteome and metabolome will then be capable of making specific choices regarding a social and scientific coalition in these scientific sub-sectors. Choices that will be especially divided with regard to research into various forms of regional innovations. Indeed, that is where social conflict manifests itself between genomics as an exogenous instrument for industrialising agriculture-in-transition or genomics as an endogenous catalyst and facilitator for endogenous developments. The establishment of trans-disciplinary and trans-professional committees could thereby be a second step in increasing the possibilities for social choices in genomics research.

References

Appadurai, A. (1990). 'Disjuncture and difference in the global cultural economy'. In: *Global Culture. Nationalism, globalization and modernity*. Featherstone, M. (ed.). London: Sage Publications.

Beck, U., A. Giddens & S. Lash (1994). *Reflexive modernization. Politics, tradition and aesthetics in the modern social order*. Cambridge: Polity Press.

Cook, R.J. (1998). 'Toward a successful multinational crop plant genome initiative'. In: *Proceedings of The National Academy of Sciences 1998.* On-line at http://www.pnas.org.

Goodman, D., B. Sorj & J. Wilkinson (1987). *From farming to biotechnology. A theory of agro-industrial development.* Oxford: Basil Blackwell Publications.

Integrated Genomics Ltd., Press releases 1999-2001, available on-line at http://www.integratedgenomics.com/press/news2001

James, C. (2001). 'Global review of commercialized transgenic crops: 2001'. New York, Ithaca, *ISAAA Briefs*, no. 24.

Jongerden, J. & G. Ruivenkamp (1996). *Patronen van verscheidenheid.* Wageningen: Wetenschapswinkel Wageningen University.

Kellner, D. (1989). *Critical theory, marxism and modernity*. Cambridge: Polity Press.

Lash, S. & J. Urry (1994). *Economies of signs & space.* London: Sage Publications Inc.

NWO Programme for Genomics, May 2001.

Ommen, B. van (2001). 'Elke eter de juiste hap. In: N&T wetenschapsmagazine, October 2001.

Perelli, A., F. Flematti & G. Ruivenkamp (1984). 'L'agribusiness multinazionale'. In: *La Questione Agraria* 15. Milano: Franco Angeli Editore.

Pistorius, R. & J. van Wijk (1999). *The exploitation of plant genetic information. Political strategies in crop development.* Amsterdam: Print Partners Ipskamp.

Ploeg J.D. van der & Van Dijk G. (eds.) (1995). *Beyond modernization. The impact of endogenous rural development.* Assen: Van Gorcum.

Ploeg, J.D. van der & A. Long (eds.) (1994). *Born from within. Practice and perspectives of endogenous rural development.* Assen: Van Gorcum.

Ploeg, J.D. van der (1987). *De verwetenschappelijking van de landbouwbeoefening* Wageningen, Landbouwuniversiteit. Departement sociale wetenschappen, paper no. 21.

Ploeg, J.D. van der (1991). *Landbouw als mensenwerk. Arbeid en technologie in de agrarische ontwikkeling.* Muiderberg: Dick Coutinho B.V.

Rathenau Institute (2002). 'Expert Meeting on Food genomics'. The Hague: Rathenau Institute.

Ruivenkamp, G. (1989). *De invoering van biotechnologie in de agroindustriele productieketen. De overgang naar een nieuwe arbeidsorganisatie.* Utrecht: Jan van Arkel Publishers.

Ruivenkamp G. (1992). 'Can we avert an oil crisis?' In: *Biotechnology – a hope or a treat?* (ed. I. Ahmed from International Labour Office Geneve). London: The Macmillan Press Ltd.

Ruivenkamp, G. (1998). 'Subpolitiek: Politisering van onderop'. In: E. Lammerts van Bueren et al. (red.). *En toen was er DNA...Wat moeten we ermee.* Zeist: Indigo.

Ruivenkamp, G. (1992). 'Tailor-made versus Industrial Biotechnology'. In: *Prophyta.* Doetinchem: Misset.

Ruivenkamp, G. (2001). *Access to food through tailor-made biotechnologies.* Wageningen: Chair group TAO.

Ruivenkamp, G. & H. Hobbelink (1987). 'Biotechnologie en de Derde Wereld. De ontmaskering van een nieuwe belofte'. In: *Derde Wereld Tijdschrift* 2, Nijmegen.

Sande T. van de., G. Ruivenkamp & S. Malo (1996). 'The socio-political context'. In: J. Bunders, B. Haverkort & W. Hiemstra (eds.). *Biotechnology: Building on farmer's knowledge.* London: Macmillan Education Ltd.

Scholtens, B. (2002). 'Geld voor genen'. In: *de Volkskrant*, 23 March 2002.

Werf, M. van der (2001). 'Voedsel van topkwaliteit'. In: *N&T wetenschapsmagazine,* October 2001.

1.6 Report on workshops on socio-economic organisation of food production

Frank Biesboer

Influence on the research agenda

> *Can genomics research contribute to developments within the dominant industrial-agrarian complex? This question was central to the workshops on the socio-economic organisation of food production.*

Genomics research within the industrial-agrarian complex is mainly aimed at better management of production. Ex-Unilever scientist Verrips had mentioned at an earlier expert meeting that genomics made possible higher production and better quality because for example the time for sowing, adding fertiliser and harvesting can be more accurately established. In his essay, Wageningen researcher Ruivenkamp stated that genomics research promotes the fact that agricultural production, especially in the Third World, will more often become dictated by the international agri-business. By this he meant that primary agriculture would become more dependent on large multinational companies that supply seed and chemical pesticides, and that take up and process the agricultural products.

Research niche

Ruivenkamp would like the social agenda of genomics research to be aimed at promoting genomics research that looks at regional autonomy of food-producing countries or at improvement of regional production systems that are self-supporting. What does this mean for the research agenda? The development of, for example, sowing seed and plant protection mechanisms by which countries producing for the international market can reinforce their own positions in the production chain. And for self-supporting production the better tuning of crops to their natural surroundings, possibilities of growing new varieties on the farm itself or improving the intrinsic nutritional value of regional food products. In short: Ruivenkamp would like genomics and agricultural production in the Third World to be one of the themes of the social agenda.

There were other proposals for a similar 'research niche'. Wageningen researcher Van der Weele wants to put genomics to work for sustainable and animal-friendly food production. Van der Kamp sees possibilities for genomics research for biological agriculture: one can give 'sensor indicators' for quality control and measurement such form that small producers can use these technologies themselves.Verhoog of the Louis Bolk Institute doubted that the reductionistic approach of food genomics will allow it to be combined with the holistic approach of biological agriculture. He explained: "If you have a headache and you take a pain-killer then that is the reductionistic approach. Not because you thereby reduce the pain but because you just take the pain away and do not look for the cause of the pain (e.g., tiredness, stress, etc.). Looking also at all the factors that could cause the pain is the holistic approach."

According to Van Dam-Mieras of the Science Committee for Government Policy (WRR), the central question is: how can you promote the use of the research results by poor countries of the Southern hemisphere? Bertens of the Association of Biotechnology Companies (Niaba), did not see a role in a research niche for biotechnology companies: they do not 'do' genomics, they just make products by using genomics.

Public participation

There were many pleas for the involvement of society in the discussion on research direction and not just to leave this to the institutions with the power and the money. Experience with Bt resistance showed that if you do that, development can lead in the wrong direction, according to social communication advisory consultant Schilpzand. But it is still unclear in what way you can involve the public. According to De Lange of the Dutch Ministry of Agriculture, ordinary citizens find genomics much too complicated to be able to take decisions on it themselves. According to Van der Weele-Minderhoud of the Dutch Association of Countrywomen, farmers cannot overlook the influence of genomics. There is a clear division between those who want to become involved in genomics and those who do not and are working simply to earn a living.

Other societal agenda points

Many other proposals for the societal agenda were submitted. They included:

- The relationship between patent, intellectual property and small producers;
- The consequences of genomics for the other functions of a farm in society, e.g., landscape management, clean water, etc.;
- The significance of development of dietary foods for the production and distribution chain;
- The socio-economic consequences of genomics research.

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2 Towards worldwide sustainable food security?

Bart Gremmen

2.1 Introduction

It seems so normal – every day inhabitants of the rich West eat huge amounts of many different foods. It is available almost everywhere and in numerous tastes and types. But we have been able to take these riches for granted only for the last 50 years. After the Second World War agriculture targeted productivity and efficiency. Large-scale deployment of technology led to decreasing prices and increasing surpluses that occasionally flooded the world's markets and created economic and environmental problems. The central theme of this essay on food security and food genomics is the balance between sustainability and food security.

The situation in the rich West cannot be compared to the poverty of much of the Third World, especially not with countries in Africa and Asia where many live at or below the subsistence level. Although in 2002 poverty was the major cause of hunger, harvest failure and (mis)-organisation of logistics also caused misery. For many decades people from the West have been trying, with varying degrees of success, to increase food production in developing countries by the introduction of new technology. The most important example was the 1960s Green Revolution in India and Asia. The West offered small farmers a combination of new crop types, artificial fertilisers, pesticides and credit. It is still unclear whether this was an overall success. Although richer farmers produced more food this was definitely at the cost of the environment, for example, with raised quantities of pesticides turning up. The position of the poor small farmer was often not improved as they had great difficulty obtaining credit to buy expensive artificial fertilisers or indeed new seed.

After the Green Revolution, genetic modification has been regularly presented as a solution for the world's food problem. A highpoint was 'Golden Rice' which contained vitamin A for fighting eye disease. Now it is the turn of genomics to guarantee food security in the Third World.

Although genomics is still in its infancy, analysis of its general characteristics shows something can still be said as to its chances of improving food security. One conviction is that food genomics will only extend the knowledge gap between the rich West and the poor countries of the Third World. A lot will have to happen to have the results of genomics research in the West directly improve the crops in the Third World.

This essay first examines global sustainable food security. The discussion then addresses the most important general characteristics of food genomics research. The third step is a consideration of whether the Third World can participate in food genomics research on the basis of three conditions. Finally the possibilities for the Third World to benefit from Western research are discussed.

2.2 Global sustainable food security

According to Prof. A. van Tunen, food security is especially a question of quantity and quality. The most recent figures of the Food and Agriculture Organisation (FAO) of the United Nations report that 815 million people in the world were undernourished in 2002 and this was especially a quantitative problem. If nothing is done, the number of chronically undernourished people in the world will increase drastically over the next fifteen years and there will be a shift of the problem to other regions. The sub-Saharan region is the most vulnerable to and indeed affected by starvation, because food output is not keeping pace with population growth. In order to reverse this trend a rapid and sustainable increase in production is essential, and measures will have to be taken to ensure that food is made available to those in need.

Both the countryside and city areas in these countries are affected by food shortages. It is often very difficult to transport food to and in these areas. By 2015 there will be as many as 26 cities in the Third World each with a population of more than ten million; so-called ‘mega-cities’. To provide sufficient food for each of these, six thousand tons of food will be needed daily.

Although, seen quantitatively, most people in the Third World are currently not suffering from starvation, the quality of their food is at best poor. Another problem is that people are increasingly changing to Western eating habits. Presently, inhabitants of countries such as China eat little meat. If they were to suddenly decide *en masse* to eat meat the animals required would cause a huge shortage of plant-based products because so much plant food would be required for feeding the animals. In order to assist the hungry in the future measures need to be taken. On a global scale there are six broad initiatives possible each of which has its own advantages and drawbacks:

1. *Better distribution of existing food resources.* Efficient logistics ensures food is in the right place at the right time and thus tends to avoid it being wasted or thrown away. Discussions on new technological developments often introduces the fact that there is no actual food shortage, but the food is not available at the right place or indeed at the right price. This can give rise to strange situations. India, for example, exports food although many of its population are hungry. Logistics measures have environmental drawbacks. They require more roads to be built, more energy to be generated and products often have a short shelf-life.
2. *Stimulating new eating habits.* If the inhabitants of the Western world were to switch to a low meat diet there would be more plant-based food available for people in the Third World. Preventing countries in the Second World from switching to more Western food habits could also have a positive effect on available quantities. At the same time the quality of vegetable food products in the Second World should be increased because their low quality is the most important reason when prosperity is rising, to switch to meat products.
3. *Put more land into use.* There are many places in the world where land is not being used for agriculture. These are principally nature reserves and so-called marginal areas where low yields would be expected due to poor water supplies and ground quality. Starting to use such areas carries the danger of dramatic ecological effects such as reducing biodiversity and raising environmental pollution.
4. *Use of agronomic solutions that carry with them increases in nutrients and pesticides.* By operating agriculture from current scientific insights a number of possibilities are available for increasing production, such as the use of new pesticides. This is actually a slow process and the necessary conditions (e.g., a high level of provisioning and education) are often not present in the Third World. This option also causes problems with sustainability due to pollution of the environment.
5. *Biological agriculture.* Although this type of agriculture carries with it relatively little in the way of sustainability problems, it yields on average 25% less compared to current agriculture.
6. *Biotechnology.* This includes various possibilities such as genetic modification. On the global scale large and relatively rich developing countries such as China, India and Brazil are leaders in the production of transgenic crops. (The situation is not the same for all countries in the Third World; in the following, emphasis is given to the poorest in the Third World such as sub-Saharan countries). There are heated discussions about the advantages and disadvantages of genetic modification for the environment, for nature and for health. The monopoly position of a few large multinational companies and the high costs of this technology are also disadvantages. Because the science of genomics does not (in itself) involve genetic modifi-

cation (although the two can be combined) less social resistance is to be expected.

The above measures are diverse. The first two have no relationship to increased production, but involve government policy. The past has shown these measures are difficult to realise. This is not true for the third suggestion, but this one does have enormous disadvantages. The last three measures are directed towards improvement of agriculture in which development aid often plays an important role. Each of the above measures would be insufficient on its own to fight future starvation. They all have disadvantages that become apparent in the balance between sustainability and food security. Only an integral and sustainable approach will increase the amount of food in the future.

Sustainability is a social norm that has become an important factor on the international agenda in recent years. During the debate 'Food and Genes', the NGO HIVOS (Humanist Institute for Co-operation with Developing Countries) stated that research performed on behalf of the World Bank showed that there are more than 190 definitions of sustainability. I believe that the definition adopted in the Brundtland Report gets to the central issue:

'Development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs' (WCED 1987, p. 43).

By explicit emphasis on development in this definition, sustainability becomes a dynamic issue that plays an important role in the relationships of the rich West with the Third World. The question is whether genomics can help to improve food security in a sustainable way.

2.3 Global food genomics

Genomics is a collective name for a number of multidisciplinary techniques and can be used to answer new and existing questions or solve particular problems. Without those questions or problems genomics cannot be called a science but just a collection of techniques, according to De Geus of the project bureau Biotechnology of the Netherlands Ministry of Agriculture, Nature Management and Fisheries. According to Van Tunen, University of Amsterdam researcher, plant biotechnology consists of tissue culture techniques, molecular improvement, genetic modification and genomics. His definition of genomics is 'the large scale definition and use of the function and organisation of genes, from man and other animals, micro-organisms and plants at the levels of DNA, RNA, proteins and molecular content' (Van Tunen 2002). Genomics research has been concentrated especially on the human genome and a few small organisms such as the fruit fly. For plants, the main studies are on the plant *Aribidopsis*, better known as mustard seed, a relatively small weed that also occurs in the Netherlands. In the following sections five general characteristics of the social context of genomics research are depicted. (Enriquez Cabot 2001).

International cooperation

The first characteristic is that genomics can be seen as a so-called *global* technology. It is almost impossible for individual states and countries to develop and use this technology separately themselves. International cooperatives and networks are necessary to keep genomics in operation. The costs of for example a super-computer are far above the budget of most countries and companies. Very large long-term investments are needed if a country or company wants to stay involved in genomics.

Data linking

A second characteristic is that genomics consists for a large part of *in-silico* biology, a type of biology that has risen in the last ten years alongside *in-vivo* and *in-vitro* biology. This means that the complete genomes of many types of organisms are being converted into digital form which is then stored in large databanks. These databanks are processed using specially developed software that compares the genomes of organisms. In this way research in the field of biology can spread outside the specific location of the laboratory.

Knowledge-based economy and education

Genomics research is part of the knowledge-based economy and this has major social consequences. A knowledge-based economy needs relatively few employees compared with a production-directed economy. The education system in a knowledge-based economy is organised in a meritocratic or performance-directed way. Education in a knowledge-based economy is the key to the future and must be adjusted for this.

Public-private cooperation

The fourth characteristic is the unusual form of public-private cooperation that exists in genomics research. Considering the influence of fundamental research in genomics is large, industry cannot or does not want to carry the costs for this sort of risky research itself. Universities of international renown have taken the lead in fundamental genomics research. The founders of small genomics companies are mainly researchers in these institutions. After becoming successful such small companies often merge with large multinationals for example in the area of pharmaceuticals. The long development time between discovery and end product also requires large capital-intensive companies and a stable political climate. It sometimes takes more than ten years before a product appears on the market. Patents are the most important means for protecting these interests.

Genetic profiles

The fifth and last characteristic of genomics research is that genetic resources play a major role in research activities, for example they are the starting point for determining the genome of an organism. Conversely genomics can have consequences for genetic resources because for example changes can take place in the taxonomy (the classification of organisms) or by offering the possibilities to 'purify' genetic resources by locating particular pieces of 'foreign' DNA.

Food shortages: plant or animal?

Regarding food the specific quality of genomics lies on the one hand in nutrigenomics and on the other hand in seed improvement. Nutrigenomics is the determination of the unique nutritional requirements of a person based on their genetic background. In the future it will be possible for everyone to establish their own personal diet that is adjusted to their own genetic profile. The objective is to make the chance of contracting a particular disease as low as possible. Industry should then be able to design foodstuffs that can be linked to these diets. The shift from quantity to quality could offer a solution for certain groups in the Third World, but that goes actually a step too far as the problem of starvation is a quantitative one in the first instance. The question is whether and how far genomics can still contribute to solving this problem.

The contribution of genomics to solving the hunger problem is directed especially towards seed improvement with the aim of increasing crop output. Sufficient and regular production of agricultural crops would solve many of the problems. People could also survive by eating animals but this possibility for solving the food shortage is not (yet) part of food security and genomics. There are various reasons for this: meat is an expensive luxury product for the population of many developing countries. Secondly it is not to be expected in the short term that there will be many sorts of new applications of genomics in the area of animal production because this is controversial in many countries. In time we can think about developments in the area of *marker-assisted breeding*, which can deliver new breeds without the need for genetic modification.

Marker-assisted breeding is an option in plant seed improvement for those who do not want to use genetic modification. The question is really whether the Third World can participate in these food genomics developments.

2.4 Conditions for participating in genomics knowledge development

There are three conditions that must be fulfilled in Third World countries if they want to participate in knowledge development in the area of food genomics and seed improvement. These are: infrastructure, access to genetic resources and ownership of knowledge.

2.4.1 Infrastructure

The fact that genomics is a *global* technology offers countries in the Third World some perspective to participate, however small. Companies could benefit from low wages in the Third World but these companies must first build up an infrastructure in those countries. The chances of a Third World country becoming a fully fledged partner in the production of knowledge is small. Developing countries have only limited budgets and possibilities, and genomics is a relatively expensive and complicated technology. New investments are constantly needed when new techniques become available that replace the other then-outdated weaker links. Results will only be achieved in well-equipped laboratories with advanced analysis apparatus, computers and software. Computers that are necessary for processing the explosive growth in genomics research data are simply not present in the Third World. Technological developments are progressing so rapidly that it is easy to be left behind, and it is then not easy to catch up. The Third World cannot keep up the tempo and is shut out, just as in earlier industrial revolutions.

There will also be a ‘brain drain’ (especially to the U.S.A.) of the few people in the Third World who have followed a suitable education in the West. There is limited potential for having well-qualified researchers on hand as in the Third World there is little or no suitable education. Only cheap and simple work (e.g., data processing) can be contracted out to the Third World. The long development time between discovery and product requires a large capital-intensive company and a stable political climate that is in general not present in most developing countries. Thus genomics would not even get off the ground due to the lack of infrastructure. The most important cause is the structural lack of funds in the Third World. Therefore the Third World can only benefit from the results of genomics research in the knowledge-based economy and not in the production of the knowledge itself.

2.4.2 Access to genetic resources

There are many genetic resources, and many of these to be found in the Third World. Such countries will never become rich from them however because Western companies are often able to collect genetic resources from many different countries. Thus it is not so much about ownership or possession. Access to genetic resources plays an especially important role in genomics research by which public accessibility must be guaranteed because otherwise Western companies will gain a monopoly position. Gene banks that have collected and stored the genetic riches will fulfil a key role.

The influence of genomics on biodiversity is potentially great. Considering that from the 250,000 known plants only about 500 are used in agriculture the impact will be seen when people look at the most important crops. During the sixth conference of those involved in the Biodiversity Convention in 2002 the Dutch government made an effort to come to a reasonable arrangement for the use of genetic resources. Internationally more agreements are being reached regarding the use of the most important world food crops, such as in the Convention on Plant Genetic Resources of the FAO.

2.4.3 Ownership of knowledge

Patents in biotechnology are a more important item to keep out competitors than in other economic sectors. The most important reason for this is that there must be time available to be able to earn back the high costs of research and development. Patents are set down in national laws and are internationally recognised and they are therefore dependent on government policy. Governments or organisations that are thus empowered by governments, such as the European Patent Office, grant patent rights to public and private parties. These parties are thus able to stop other parties from making, using or selling a discovery, with exclusive rights usually being valid for 20 years. Enforcement of patent rights is usually in the hands of governments via administrative procedures and via the Law in national legal systems. Although the criteria for being granted a patent (novelty, creativity and utility) are the same throughout the world there are still some differences between national legal systems regarding the interpretation of these criteria. National courts of law need to be decisive in cases of differences in interpretation. A company must also then take out patents in a number of countries, usually first in the U.S.A. as the most lucrative international market.

The most important type of patent is a combination of protection of the composition of the substance (proteins or chemical compounds) and the method of production. Since 1980 in the U.S.A. patents have been granted for living organisms including genes, DNA fragments, methods of making useful genes and methods for making and characterising DNA. The total number of this type of patent is now in the tens of thousands. Obtaining a patent is just the first step in a long route of testing, producing, distributing and marketing.

The current system of intellectual property will change drastically as a result of developments in genomics and will play a crucial role in knowledge development. The emphasis will no longer be on patents for generally active products but on the sort of patent which is called in pharmaceuticals a *blockbuster.* These return much greater yields than they cost to develop. Genomics on the other hand offers the possibility of focusing on specific characteristics and processes. The foundation and financing from the West of so-called clearing houses (institutes that collect information about patents, process the data and make it available for countries that need the information) have been recently more often called the solution for the Third World. This cannot be actually a solution for Third World countries because they have no means to work on follow-up activities (e.g., purchasing a licence).

2.5 Perspectives of Western genomics for the Third World

What prospects does food genomics offer to Third World countries for building up a sustainable food security (Beekman 2001; Jacobs 2001) The crops that will be eligible for food genomics in the short term are especially rice and to a somewhat lesser degree maize and rape seed. The characteristics that will be central for these crops for genomics research are: food quantity (resistance to diseases and pests, and tolerance to salt and drought), food quality (nutritional value, contents of vitamin A and Fe) and medicines (vaccines and *plantibodies*). Food genomics in the West is not directed towards the local varieties in Third World countries but at crops that already play an important role in the economies of Western countries.

Crops are needed in agriculture worldwide that comply with the current requirements of the market and the environment. It is thought that food genomics will be able to contribute to sustainable agriculture. In the first place this will be achieved by research into crop resistance, from which the environment will benefit by a reduction in pesticide use. For this the emphasis lies on classic crops such as potatoes and tomatoes that can serve as models. There could be a reduction in energy use resulting from work in the area of cold resistance. In the future plants could be designed that take up certain dangerous materials from the soil or add certain compounds essential for other plants to the soil. Genomics research could also contribute to a reduction for example in synthetic plastic and polyester use by the development of degradable bio-plastics.

Considering the enormous increase in patent applications and the number of mergers, problems can be expected regarding the monopoly position of some companies. The products could because of this become very expensive and chances of developing crops for increasing sustainability and food security could be missed. The periodical *Intermediair* (2002) has reported that ActionAid, an English development charity for the Third World, submitted a patent application for its 'specially developed' pre-salted French fries. The organisation hopes that it will even go so far that all snack-bar owners who sprinkle their own salt on their French fries will then have to pay money to ActionAid. It is intended to be a demonstration of the fact that biotechnology companies have submitted patent applications on primary foodstuffs to which they have made only very small changes. In this way, proposes ActionAid, all the food in the Third World will eventually be patented. The Texan company Rice Tech for example has been granted patents on hybrids of basmati rice. The Indian government had to go on their knees to the US government to prevent the US patent office from awarding a patent to Rice Tech regarding *all* types of basmati rice. Rice is one of the five crops, alongside wheat, maize, soya and sorghum, that constitutes three-quarters of food in Third World countries. Almost 70% of all patents for modification of these crops are in the hands of just five biotechnology companies, including Dow and Monsanto. The authorities should move towards compulsory licences (a country then compels a licensee with threats that otherwise, thus without a licence, they could make an already patented product), such as happened recently in the U.S.A. with a vaccine against the anthrax bacterium. Companies should also actually be able to maintain their own lower prices for a number of countries.

2.6 Conclusion

Biotechnology and more recently genomics have been regularly presented as the solution to world demand for food. Some find this argument 'pure product promotion', such as the HIVOS during the debate *Food and Genes (Eten en Genen)* of the Terlouw Commission. They believe that food supply over the next 35 years will be actually greater than the demand and that genomics will lead to a decrease in the income of small farmers because new seed will become more expensive. In addition, food prices will decrease further due to increased production.

Third World countries will not benefit from the creation of knowledge in the area of food genomics. They are mainly directed towards the production of raw materials and only a little towards the production of goods. They have not for a long time been part of the knowledge-based economy. Food genomics puts high demands on the knowledge infrastructure of countries and Third World countries do not have this infrastructure and thus also will not be able to catch up. So the knowledge gap between the West and the Third World can only expand. The so-called strategy of *empowerment* (providing countries or groups with knowledge and materials) will not work because the developments follow each other too rapidly. The potential of countries to participate in developments is not available in Third World countries. It is thus not necessary in the framework of development cooperation to set up aid programmes that are aimed at developing food genomics in Third World countries.

It is desirable that genomics research makes an important contribution to feeding the growing world population. Countries in the Third World must be able to benefit from the new possibilities that exist due to the knowledge developed in the West from food genomics research. That can only happen if genomics research in Western countries is directed towards the local crops of the Third World countries. As is the case with some medicines, local crops or 'orphan' crops are not seen as commercially interesting. Western governments must stimulate international research into these crops. This can be for example via tax measures and also by financing specific programmes at universities and by stimulating private-public cooperation. Farmers in Third World countries could eventually get crops that have been adjusted to local conditions and that give a greater yield. The consumers in these countries could then be able to buy food that is safer and healthier. Third World countries could put more emphasis via food on prevention in health care that would eventually be cheaper and simpler. Future foodstuffs with a health-improving effect will actually be too expensive for the Third World. They must be custom-made for individuals or small groups and that is very expensive.

The way towards global sustainable food security must therefore proceed through the local varieties from the Third World, otherwise the Third World countries will only get on their plates the 'crumbs' from production in the West.

References

Beekman, V. (2001). *A green third way? Philosophical reflections on government intervention in non-sustainable lifestyles.* PhD thesis. Wageningen: Wageningen University.

Caulfield, Timothy A. & Bryan William-Jones (eds.) (1999). *The commercialization of genetic research. Ethical, legal and policy issues.* New York: Kluwer Academic/Plenum Publishers.

Enriquez Cabot, J. (2001). *As the future catches you. How genomics & other forces are changing your life, work, health & wealth.* New York: Random House.

'Patatje-met onder patent'. In: *Intermediair* 8 (2002) 38.

World Commission on Environment and Development (WCED, 1987). *Our common future.* Oxford: Oxford University Press.

2.7 Report on workshops on food genomics and global food security

Frank Biesboer

Ensure that poor countries can also have an interest

Can food genomics have significance for the food problems of poor countries? This question especially was discussed in the workshop on food genomics and global food security. The most daring suggestion was to make a demonstration project for one of the poorest countries in the world.

Everyone agrees that there a wide gap yawns between the poor countries and the Western world and that each technological development threatens to widen the gap even more. Suggestions for the social agenda are closely related with various estimates of the possibilities of the poor countries. Gremmen from Wageningen University writes in his essay that the development and application of food genomics in the Third World will remain an illusion until something changes in world politics; the ground lost on many fronts is too great. The development of this new science requires that a country actively participates in modern biotechnology and informatics research. For poor countries that is too high an aim. According to Gremmen poor countries must be able to benefit from the products of food genomics that could be useful. He also believes that improvement of so-called orphan crops is needed. Some people go even further in their gloominess on the role that genomics can play. For example Huizingh from the University of Amsterdam: “What are the critical factors that cause the food problem – wars, transport problems, improvement problems, gender structure, pollution, energy supply, limited production. And what does genomics add to this in order to influence favourably these critical factors”, was his rhetorical question.

Morally unacceptable

Van Thunen of the Swammerdam Institute found this approach too depressing and unacceptable. Countries such as India and China have a large reliable research potential and on some points they are even further ahead than the Netherlands. He finds it morally unacceptable that poor countries are shut out of genomics developments. Van Thunen: “It requires close cooperation between governments and knowledge institutions there and financiers here.” The social agenda should promote the realisation of this. Considering the task of doubling world food production then we need to use every means available.

According to Van Thunen food genomics can also make a contribution to this. The question must be put on the social agenda as to which contribution food genomics can provide for solving the food problem in poor countries.

Despite his scepticism over the role that genomics can play, Huizingh agreed with one suggestion for a social agenda: develop systems by which poor countries can make optimum use of their own biodiversity. Van der Windt of Groningen University saw something in the idea of getting people from the genomics world together with those with development problems: “Just long enough to allow them to come up with agreed proposals.”

Another participant proposed a demonstration project for one of the poorest countries. In this attention would be paid to food genomics and also a broader development agenda: inventive use of food crops as raw materials for other products and development of the local population by education and strengthening the position of women. A multinational company should participate in this project.

Other societal agenda points

A completely different question is what is the significance of increasing prosperity on a world scale for the intake of (animal) proteins and the consequences thereof on the quantity and quality of the food supply? Which food resources are required for this and what role will food genomics play in its development?
Many other suggestions were received in writing regarding the societal agenda. Some of them were:

- stimulate the development of knowledge in countries such as China and India by managed programmes;
- create space for researchers to ‘wander down new pathways’;
- work on drought-resistance for local crops;
- stimulate special education projects in poor countries;
- create food supply programmes for the future ‘mega-cities’.

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3 Genomics and man's attitude to animals: towards a sustainable relationship?

Lino Paula

3.1 Introduction

Animals must be 'delighted' with the increasing societal attention being given to their interests. Both formally in law and government policy and informally at home and on television the word is being spread that 'all animals count' and that we must have a respectful attitude towards animals. Although 'they' cannot make their desires known to us directly, 'we' are convinced that we know which basic interests of animals must in any case be respected.

Our relationship with animals is characterised by an extreme form of schizophrenia. Although we maintain high moral standards, we often keep animals under degrading conditions in practice. Thus we have the bio-industry in which chickens can no longer carry the weight of their own inbred bodies and healthy animals are 'preventively slaughtered' *en masse* because agricultural economics figures show that it is cheaper to kill them than to vaccinate them against disease. In addition we have a scientific 'industry' in which mice are genetically modified on a large scale to make them suitable for the terminal and often painful laboratory animal tests for the benefit of your health. In short, the vast majority of the animals that are directly dependent on our care notice little of our intentions of goodwill, but they do notice a lot of negative things about our actions (Boon 2001, p. 23).

Technology has played a major role in these actions. It made us successful as hunter-gatherers in the distant past. Then it helped us become successful as plant and livestock farmers, and in the near future probably as 'pharmers' (farmers producing pharmaceuticals). A recently developed technological innovation now links our nutrition to our health; it is called *food genomics* and it is bringing together a map of the genes of the plants and animals that we eat and the interaction between this food and our genes. How these interactions influence our health is also specifically called *nutri*genomics.

What significance will these innovations have for our relationship towards other animals? In this essay we discuss the scientific, social and ethical issues surrounding genomics and animal use. The emphasis lies on the shift in animal use as a consequence of genomics research towards nutrition and food products. In addition brief mention is made of the more general significance of genomics for our relationship with animals. Finally in the light of the developments highlighted in this essay, some topics for a social agenda for food genomics and animal use are brought forward.

The term genomics refers in this essay to genomics in a wide sense: the entire research programme (including the methods and techniques that are part of it) that is aimed at mapping DNA (genomics in a narrower sense), and DNA expression into RNA (transcriptomics), proteins (proteomics) and molecular processes in the cells of organisms (metabolomics). Genomics in this broad definition is explicitly distinct from genetic modification, which in animals is also called transgenesis. Genetic modification here means the intended changing of the hereditary material (genome) of organisms using modern techniques. In genetic modification direct changes are made to the DNA of organisms using a cut-and-paste technique. New genes can be introduced or existing genes can be switched off after which the organism gains characteristics that it did not possess naturally. Both genomics and genetic modification are interpreted here as sub-sectors of modern biology and biotechnology. The important link between these terms is explained in the following section.

3.2 Links between genomics, genetic modification and biotechnology

Although genomics research is often presented as something very new, it does not take place within a scientific or social vacuum. The impact that genomics will have on our relationship with animals is associated with developments in society and the life sciences. From a scientific viewpoint, knowledge of the genome of organisms only gains real significance in relation to other techniques that make it possible to intervene in organisms and biological processes and production. With this knowledge, the techniques can indeed be directed to influence living processes at the molecular level. Genetic modification is also one of these techniques (Jansen 2001). Genetic modification is important in genomics research for discovering the function of specific genes via so-called *knockout* experiments. However with the application of genomics knowledge, genetic modification is also an important instrument to alter organisms (and in line with this, their production processes) faster, more specifically and fundamentally. Genomics is in this sense strongly linked to, and a logical consequence of, the already existing knowledge and techniques of modern (molecular) biology and biotechnology.

This link is valid from a scientific viewpoint and also from the area of infrastructure and interested parties. Usually it is the same Western companies that are now dominant in biotechnology and the life sciences together with certain ICT companies such as IBM that are to be found at the forefront of research and development in the area of genomics.

From the scientific, social and infrastructural points of view there is a gradual progression between molecular biology, genomics, biotechnology and genetic modification. Yet genomics probably does mark an important conceptual shift in our technological capacity. An impressive combination of knowledge and techniques exists in genomics that means it is possible for us to 'create' organisms and actively design or redesign biological production processes whether directly integrated with electronic aids or not. This advancing management of life can still be seen as a process of smaller or larger gradual changes such as the design of improved or completely new gelatines from non-animal sources (De Wolf 2002). The ultimate *genomics* approach to life in the conceptual sense is actually to build up an organism or micro-organism entirely *de novo* from a synthesised DNA genome in the laboratory. As a first step towards this, a picture must be built up of which genes are minimally necessary to allow a cell to function normally. This first step was completed several years ago as a Minimal Genome Project (Hutchison III et al. 1999). Two leaders in the genomics world, Clyde Hutchison III and Craig Venter, also want to initiate the second step, the construction of a *de novo* genome. Due to criticism from bio-ethicists and bio-safety experts (and the expected social resistance) they have not so far gone ahead (Rozendaal 2001). Craig Venter has recently announced that he is actually going to initiate this second step.

3.3 The impact of food genomics on animals – research and product development

What significance does this increased knowledge of and power over biological processes now have for our relationship with animals? They can be used for their even further development and to alter them to accord with human interests and specific wishes. This power can indeed also be used to protect against negative influences from man and the environment on animal life. Areas are discussed below in which food genomics could have an important influence on our use of animals. First livestock farming is discussed and then laboratory animal tests that are performed in the framework of food safety.

3.3.1 Genomics in livestock farming/breeding

Modern biotechnology techniques can no longer be ignored in modern livestock farming (Farm Animal Breeding and Society 1999). Artificial insemination with sperm that had been preserved in frozen form is currently the standard method for fertilisation of most animals kept for human consumption. *In vitro* fertilisation, embryo transplantation and embryo division are all applied commercially in livestock farming. In the rapidly developing area of aquaculture (the equivalent of livestock farming but with fish) the technology has permeated even further. For example, in aquaculture the choosing of gender via sperm has been applied on a large scale and enabled the selection of, from a production-technology viewpoint, more attractive female animals. Genetic modification is a much more controversial technique that is rarely applied in the food industry on a commercial basis.

Genomics can give an extra impulse to the use of all these techniques as a clearer idea can be gained as to how the characteristics interesting for production purposes are linked to specific genes or groups of genes. Gene maps have been assembled for this, often on a European level, of the animal species available in livestock farming (FAIP 2000). This so-called gene mapping can then be used on the breeding farm in combination with known indicators in the DNA for the presence of required genes or their varieties; this is called *marker-assisted selection*. Using this knowledge and these techniques, breeding programmes can be made much more efficient, effective and far-reaching towards desired characteristics. It is also possible to influence better complex characteristics, those manifesting only late in the life cycle, or opposing characteristics. Furthermore the mapping of the genetic diversity (or lack of it) of the different varieties can be improved and this can be taken into account during breeding. Thus genomics can be of great significance to the breeding farm.

In addition better knowledge of genotype (and on the same line phenotype) of animals could contribute to better animal medicine and health. In the same way as in human medicine, genomics can make a significant contribution in animal medicine to the development of new vaccines, genetic tests and medicines. It also means that better account can be taken in breeding programmes of the genetic basis of diseases, deficiencies and characteristics that are related to animal welfare (such as stress resistance and disease resistance).

A final application in livestock farming related to genomics is that the origin of products can be traced better using databanks in which the gene passports of animals have been stored. This application can be used for monitoring quality and safety, for example.

The actual impact of genomics on livestock farming is especially dependent eventually on the self-chosen production purposes and evaluation criteria. In recent years lower costs per unit product were the main reason for the introduction of new technologies and production systems in livestock farming. (For an overview of the problematic consequences, see Jonge & Goewie 2000). In addition, to a lesser degree there is also an aim for new product quality and environmental requirements. Animal welfare is in contrast not an important independent criterion, but is especially directed towards the degree to which it contributes to the realisation of the costs, qualities and environmental goals. The aims of specific projects in livestock farming using the most modern biotechnology are up to now especially seen as a progression from the aims of recent years: reduction in production costs, improvement in quality and environmental requirements. It seems reasonable that, under the influence of the trend related to food genomics towards healthy nutrition, relatively more research should be performed towards improvement of the quality of health of animal products. There is actually a lack of specific quantitative summary data on this.

Genomics is also in the context of livestock farming strongly interrelated to existing biotechnology techniques and infrastructure (FAIP 2000, p. 6) and to a certain degree these techniques are also exchangeable. A breeding pathway via the genomics approach can for example be an alternative to genetic modification. The importance of this is that genetic modification of animals is still very controversial, especially when intended for food. The more passive way of having an 'influence' via the knowledge and techniques of genomics will probably lead to less resistance from consumers as it fits better with the 'classic' image of breeding.

In the area of infrastructure, livestock farming is now still characterised by small and medium companies (FAIP 2001). In some sub-sectors livestock farming is already to a large extent the monopoly of a few multinationals; in the poultry sector there are for example only a few multinationals in the world who supply broiler breeding stock (Jonge & Goewie 2000, p. 39). It is expected that under the influence of developed and expensive biotechnology techniques the need for upscaling in research and development will increase further. This phenomenon has already occurred in plant improvement. It can lead to a situation in which a small number of trans-national companies can build up powerful monopoly positions via patenting of knowledge and technology. The U.S.A. already has a technological advantage and a higher investment level in the area of genomics than Europe. Key technology and knowledge on livestock breeding could in time thus become the exclusive property of US companies (FAIP 2000).

A recent specific example of this is the US company MetaMorphix that has mapped a rough copy of the genome of the cow (*Nature* 2000, p. 778). The company has thereby traced thousands of genetic indicators that could provide insight into the relationship between genes and product characteristics. The company has announced that they will keep the genome and the indicators secret and head towards patent applications for genes that are of interest for livestock farming goals. This sort of development can severely inhibit the real possibilities for alternative research and development (R&D) programmes based on an alternative social agenda. There is also already tension between private and public R&D agendas in the area of human genomics. A recent example of 'monopolisation' with possible negative consequences for the social research agenda is the patenting of a breast cancer gene by the US company Myriad Genetics. As a result of this patent researchers or therapists who want to develop tests based on this gene will need to pay a fee to Myriad Genetics.

Significant and conflicting differences exist between countries in the standards and desires for the relationship with animals. It is expected that in a country such as the U.S.A. animal welfare, unless it also has a production interest, individual species behaviour and animal integrity will play a much lesser role in the protection of animal interests than in the Netherlands. At the same time they are working on applications and breeding programmes that would be looked on as undesirable at this time in the Netherlands. Thus a discrepancy could occur between social desires 'here' and actual products developed 'there'. So even without the issue of monopoly, there is also the question of how in a world of free trade we should cope with the import of 'undesirable' products.

Applications of modern biotechnology in livestock farming/breeding

In order to explain what sort of specific projects are applied in modern biotechnology, a number of outstanding examples are mentioned briefly. Projects aimed at reducing costs, improving quality and complying with environmental requirements are discussed in succession.

Reducing costs

In the past in the Netherlands the company Pharming worked on transgenic cows that produced a human version of the protein lactoferrin in their milk (Bijman 1996). Lactoferrin is a protein that has various actions, including the inhibition of mastitis, which is a very common problem in modern milk production, having a negative influence on milk production costs and the welfare of the cows. Due to great social resistance this application did not find its way into livestock farming. Instead cows are treated against mastitis mainly with injections of other antibiotics. Work is still progressing on resistance against mastitis, including via genetic modification (Kerr et al. 2001).

Another project directed towards cost reduction is salmon breeding (Fletcher et al. 2001). Via selective breeding in which the knowledge and techniques of genomics were used salmon types have been bred that grow faster and convert food more efficiently. The same result was also achieved by genetic modification of salmon in which a gene that coded for a growth hormone was introduced into the fish. Almost all of the salmon that is for sale in the supermarkets is currently of the cultivated, non-transgenic variant. The transgenic variant is not yet on the market due to great public resistance. This salmon example shows that there are more technological 'roads leading to Rome' that are appreciated differently by the population. For both salmon variants anyway there are great concerns regarding the ecological risks of these fast-growing salmon being released because they could oust the wild population of salmon and other fish species (WWF-UK 2001).

Improving quality

In addition to decreasing production costs, work is also in progress on improving quality, sometimes even as a double goal. In the past transgenic pigs have been created that grew faster (less cost) and had less fatty meat (better quality). This was actually linked with disastrous health consequences for the animals themselves (Pursel et al. 1989). These so-called Beltsville pigs suffered from stomach *ulcers and broken bones, which led to the project being stopped. Research projects with similar goals are actually in progress in various parts of the world. At Osaka University in Japan for example transgenic pigs have been created containing a gene from spinach that codes for an enzyme that converts fat into linoleic acid. Studies are in progress into what consequences this might have for the welfare of the pigs, and the taste and safety of the meat. Another example of quality improvement is changing the protein and sugar composition of cow's milk such that it is more suitable or nutritionally richer for consumers, for example lactose-poor milk, specially suited for a group of consumers who are not capable of metabolising lactose properly. With this sort of application genomics is important for working out the interactions between metabolic processes and for following the expected and unexpected effects of the changes made.*

Environmental requirements

Pigs are one of the subjects for studies in the area of environmental requirements. Acidification of the environment by phosphates from fertilisers is one of the great problems of livestock farming at this time. Thus a research group from the University of Guelph, Canada, has bred transgenic pigs with a gene that codes for the enzyme phytase. This enzyme facilitates the uptake and metabolism of phosphates, resulting in the pigs' manure containing less phosphate. This environmental improvement can in any case be achieved in a similar way by adding the enzyme phytase (produced from genetically modified bacteria in a socially acceptable closed system) to 'normal' pigs' food.

Projects with similar environmental goals are in progress in aquaculture. Researchers are studying the possibilities of breeding fish on food based on vegetable proteins. At this time carnivorous fish must be fed using fish caught at sea and this has significant consequences for the wild population. Replacing a part of this catch by vegetable food would therefore lead to a big environmental benefit. These projects are also being approached using different routes (with and without genetic modification). All of these routes are strongly linked to modern knowledge and technology in biology and lead to changes in the 'normal' biological nature of the animals.

3.3.2 The hidden suffering behind innovation – laboratory animal tests in the framework of food genomics

Whether we are talking about vegetable or animal food products, all innovations in the food industry are linked to extensive efficacy and safety tests. For these a great many laboratory animal tests must unfortunately still be performed and in this way food genomics just increases the 'demand' for these tests. Genomics will also have another effect on laboratory animal tests: under the influence of food genomics especially nutrigenomics there is a trend towards the medicalisation of food *casu quo* health claims on food products. In comparison to food products, medicines are developed under relatively stricter safety and efficacy requirements and relatively more tests and more taxing laboratory animal tests are required for each medicine product. This medicalisation of food can therefore also specifically lead to the need for more and more severe laboratory animal tests.

In addition the demand for laboratory animal tests is increasing as a result of genomics research in the field of human medicine (*Nature* 2002, p. 785). Genomics also generates many new research issues and research areas and it is expected to be a stimulus for the development of therapies and medicines for specific and thus smaller groups of patients. Researchers expect that just exploratory research into the functions of human genes will use millions of transgenic mice.

However, genomics can itself make a potential contribution to the official national and European authorities endeavours to reduce, replace and refine (the three R's) the use of laboratory animal tests (the Dutch law Wet op de dierproeven and EU guidelines 86/609/EEC). Thus genomics can in some areas contribute to replacing laboratory animal tests with alternatives *in vitro* (experiments in which only cells are required) or even *in silico* (computer simulations). In these, genomics knowledge and techniques are used for DNA chips, micro-arrays and high-throughput screening. These alternatives are often cheaper and faster, which also provides advantages for research. This can have a significant impact on the replacement of laboratory animal tests as shown by the company figures from Charles River, one of the world's largest providers of test animals and animal test supplies. In the last five years the test-animal part of their turnover has decreased from 80% to just 40%; there has been a corresponding increase in the share from alternative tests (Aoki 2002).

Genomics can also lead to a reduction in laboratory animal tests due to improved knowledge of the genotypes of animals and of the interaction between genotype and phenotype. Thus research results can be better extrapolated both quantitatively and qualitatively, which would mean that fewer animals (and/or fewer species) are needed per experiment. In addition improved knowledge in some areas can contribute to the replacement of higher animals by lower animal species; for example, replacing mice by zebra fish in developmental biology research.

Improved knowledge of the interaction between genotype and phenotype makes it possible to predict more accurately the consequences of intervening into the genotypes and phenotypes of animals. This means that undesired and unexpected side-effects can be better prevented or stopped earlier. Genomics can thus contribute to the refining of laboratory animal tests and cause these tests to be less intrusive. For example because of improved knowledge of the interaction between genotype and phenotype, sub-clinical symptoms might be used as models for syndromes. Another example in which genomics together with genetic modification and other modern biotechnology techniques is applied is the *biophotonics imaging* system from the US company Xenogen (www.xenogen.com). Using this system mammals are genetically modified such that their cells emit light when particular metabolic processes take place, for instance those processes connected with diseases. These processes can therefore be followed in living animals without needing to use invasive treatment (operations or dissection).

What the net long-term effects of genomics will be on the use of test animals is at this time difficult to predict and as yet no systematic research has been started into this. What also counts here is that it depends on the technological possibilities, together with the infrastructure possibilities and the social context, which are of equal importance. For small-scale laboratories (also in universities) genomics alternatives are relatively expensive or even out of reach. This is where social agendas can be driven into the corner by technology monopolies. Slow introduction of alternatives can also be the consequence of established commercial interests or ponderous bureaucrats, who are not always eager to replace existing internationally accepted tests with new alternatives.

New forms of animal use due to biotechnology

Completely new forms of animal use will exist under the influence of modern technology in which the knowledge and technology of genomics and also genetic modification will play a role. Because these applications are only indirectly linked to food genomics, we shall only mention here briefly the most obvious new uses: animals as bioreactors, organ donors, clones, pesticides or biosensors.

By using animals as bioreactors the animals produce high-value biological compounds that they do not make themselves in nature.

Thus they are made to produce unusual proteins in their milk, or sometimes in their blood or eggs. The milk or blood is then removed and the compound isolated and purified from it. Until now this has been mainly proteins with a medical mechanism of action, but all sorts of applications can be imagined. A recent example of this is the production of spider-web protein in goat's milk, that can be used for reinforcing military vehicles and for making bullet-proof vests.

When using animals as organ donors it is endeavoured to get pigs altered, by use of genetic modification, etc., so that they can serve as organ donors for people (so-called xenotransplantation). Genomics and genetic modification play important roles in the altering of an animal donor according to the human transplantee.

The cloning of animals has more goals, for instance to generate many identical offspring of unusual animals (for example top quality cows in livestock farming or rare wild animals such as the giant panda). Cloning can also be used to give specific individuals a 'new' life (e.g., a pet that died or extinct animals).

Finally under influence of this new technology, forms of animal use exist that are not actually entirely new but cannot be said to be readily accessible. For example, they are working on introducing transgenic insects as pesticides against agricultural pests or even against malaria. Another example is the use of animals as biosensors. Just as in the past canaries were used in coal mines, other animals are also being used as sensitive measuring instruments for the detection of certain dangerous compounds. For example transgenic fish have been created that give off light when certain pollutants are present in the water.

3.4 The broader impact of food genomics on animal use

A number of areas have been discussed above in which genomics and biotechnology have a direct influence and great significance, in combination with other technological developments and trends, on our relationship with animals. Man in the 21st century has gathered so much knowledge and power over animals that he can shape his relationship with them almost fully according to his own wishes and views. In our modern Western society we are no longer under threat by animals nor do we need them for our survival. All the survival functions that animals traditionally had before us – such as employee, transport means, guard, clothing – are or can be taken over by more efficient instruments and production processes. In the following the question will be discussed as to what level does food genomics make animals unnecessary as a food source.

Scientists and investors expect that because of food genomics both producers and consumers will direct their attention further towards the influence of food on our health. This no longer only concerns general population-wide nutrition and advice based on epidemiological studies. Nutrigenomics exposes the relationship between genes, nutrition and health. Therefore the optimal diet can be established for each individual based on their genetic background. Already there are various *functional foods* for sale in supermarkets that are greedily taken by the consumer, e.g., Yakult and Benecol. Individual gene passports have been mentioned as one of the future possibilities (Korthals 2001). In the supermarket the consumer passes this passport through a scanner and can thus read which food products are associated best with his own genetic profile. This is not just science fiction as can be seen from a recent controversial example from England: the Body Shop were selling a genetic test without the intervention of a medical doctor (Meek 2002). This test analyses the DNA of the client for a few genetic factors and then provides personal nutritional advice.

With this shift towards health, foodstuffs from animal origins fall under a new evaluation framework which has been determined by the various health scandals and dangers surrounding animal food, that have frightened the consumer over recent years: BSE, antibiotics, hormones, *Salmonella*, *E. coli* and dioxins in meat products. The 'normal' characteristics of animal food that do not promote health (such as a relatively high fat content) will thereby become more central issues. An important argument for many consumers regarding not giving up the eating of meat despite all this, is the lack of a complete alternative, with respect to both health and taste. A meat-free diet in the past had the risk for health that relatively little or just 'one-sided' soya protein was consumed. Therefore a shortage of some essential amino acids occurred (see: Position of the American Dietetic Association 1997). With a meat-free diet a shortage can also occur in the body of certain vitamins, such as B12 (Herbert 1988). A meat-free diet could also be looked on as a source of pain. New technology such as genomics and biotechnology are a way out from such problems. Various industrial and university research groups are busy developing both healthy and tasty meat substitutes (Van Kasteren 2001). In the past this has already led to products with a high level of technical quality, such as *textured vegetable protein* (TVP) from Unilever. For various reasons TVP was not a commercial success. However, using the experience and with the technology developed from TVP, products are now coming on the market that will find their way to consumers. One example is the mycoprotein product Quorn.

This new technology brings in this sometimes indirect way the consumer closer towards complete alternatives to meat. There are more considerations than health and taste that play a role in the evaluation of these alternatives with other important evaluation criteria being costs, the environment and animal health. For a small but growing group of consumers, the vegetarians and vegans, the last two criteria are the decisive ones. Vegetarians have principle ethical objections against eating animals, while vegans are against eating meat also on environmental grounds.

Compared with current intensive livestock farming the non-animal alternatives score substantially better on the criteria of the environment and animal welfare. These alternatives convert energy and raw materials more efficiently into food products and are not plagued by excess fertilisers or animal welfare problems. Non-animal alternatives are expected to score better regarding costs due to fewer required inputs. The differences in costs will actually depend on the scale of production and the level at which indirect and hidden costs are included. Thus the last foot-and-mouth disease crisis made it painfully clear that, in the economic considerations not to vaccinate, all sorts of indirect and hidden financial costs were not included, such as loss of turnover in tourism and catering, recreation and the costs of a massive police presence, not to mention the indirect and hidden social costs.

Genomics knowledge and our image of animals

Practical technological applications and also theoretical knowledge that result from genomics are of significance for our relationship with animals. Scientific knowledge already exercises by itself a not-to-be-underestimated influence on our images of man and animals. Darwin's evolution theory regarding the origin and behaviour of species is thereby the starting point of a long historic trend. In this, scientific attention for the biological relationship between man and animals leads to a still greater pressure on current cultural and philosophical thoughts over our relationship with animals. The former so deeply felt religious and fundamental differences between man and animals are thereby becoming exchanged for attention to the gradual similarities with them.

An interesting aspect of genomics is that Darwin's ideas on the differences and especially the similarities between the various animal species have now been substantiated at the molecular-genetic level. It becomes clear that the classic morphological genealogy classification into species partially crosses over and sometimes blurs the old dividing lines between species. An example of this, close to home, is the far-reaching genetic similarity between man *and chimpanzee. The chimp and human genome differ by only about 1% from each other and just a fraction of that difference codes actually for genes. Speaking on the genetic-evolutionary level chimpanzees are therefore related to man more closely than they are to the other primates such as the orang-utan (Enard et al. 2002). Such new knowledge over far-reaching biological relationships also renews attention for philosophical questions about the cultural and moral relationships between man and other animals.*

3.5 Social and ethical context of food genomics

The possibilities offered by food genomics for research and product development have been discussed in the preceding sections. The consequences, either direct or not really intended or aimed for, of food genomics on our use of animals as food sources was also examined. These possibilities should eventually be able to 'prove' themselves in a social context. A number of trends in society in our relationship with other animals appears to be important. In the following section the public attitude surrounding food and the use of animals, government policy and the ethical discussion regarding our relationship with other animals are examined successively.

Attitude of the general public regarding food and the use of animals

In recent years various public research studies and social debates have shown that the general public is concerned about the safety of their food and are sceptical regarding 'unnatural' foods (INRA 2001; European Coordination Office SA/NV and Rathenau Institute 2002). In addition there are concerns about the welfare of the animals: the general public is frankly negative about genetic modification of animals for food applications (SWOKA 1998). As an exception when animals are the issue, it is not so much safety arguments that are central in the area of health and safety but moral arguments that determine whether biotechnology is accepted. The producers of animal foods have also rejected genetic modification up to now because consumers did not accept it and because of the costs. Cloning for example has not appeared to be sufficiently interesting for livestock farming until now due to the relatively high costs (Liinamo & Neeteson 2001). The specific attitude of the general public towards genomics has not yet been adequately studied. Even less is known about whether the general public makes a distinction between the application of knowledge about genomics via traditional methods and techniques (e.g., traditional breeding and husbandry) and the new genomics methods and techniques that only indirectly intervene in the genome (including via *marker-assisted selection*).

Developments in government policy

The government considers it of great importance, economically and otherwise, that the Netherlands takes a leading position in the area of genomics (parliamentary document Kennisinfrastructuur genomics no. 1). Therefore they are stimulating via various funds and promotion measures for the realisation of an infrastructure for genomics research in the Netherlands. In addition they have emphasised the importance of an explicit research programme into the social aspects of genomics research that has been started via NWO in the meantime. This is not an excessive luxury for the animals. After all, the Dutch government does recognise the 'intrinsic value' of animals (parliamentary documents Rijksoverheid en Dierenbescherming nos. 1 and 2). In this way they are showing that they consider that animals are morally relevant and that they deserve legal protection for the sake of their own interests.

The government maintains a so-called 'no, unless' policy regarding the relationship with animals. In this policy, treatment on animals is forbidden unless this treatment complies with legal requirements and previous permission has been granted. This applies both to livestock farming and to experiments on animals, including those within biotechnology (The Dutch laws Gezondheids- en welzijnswet voor dieren, Besluit biotechnologie bij Dieren, Wet op de dierproeven). This policy does not forbid genomics research, including non-genetic modification, as such. It does mean that the government puts limits on the research goals and the use of techniques. This definitely applies to genomics research directed towards livestock farming, such as for example has clearly been shown in the recently published policy document 'Animal Welfare' from the Ministry of Agriculture, Nature Management and Fisheries (Policy Document *Dierenwelzijn* 2002). In this policy document the Ministry maintains that animal welfare and respect for individual species behaviour of animals must be the core of man's relationship with all farm animals and pets. Within 10 to 20 years livestock farming in the Netherlands must be reorganised into a sustainable form. This does not mean that the animals must be altered to fit in with the cheaper production systems but that the production systems be re-designed in such a way that they answer the requirements of the animals.

As starting points for the welfare requirements of animals the so-called 'five freedoms for animals' apply:

- Freedom from thirst, hunger and incorrect feeding;
- physical and physiological inconvenience;

- pain, injury and disease;
- fear and chronic stress;
- and freedom to show their own individual species behaviour.

This trend towards respect for animal welfare and individual species behaviour has already been introduced into animal experiments. In addition in this context the aim towards alternatives (the three R's: reduction, replacement and refining of the use of laboratory animals) is of great importance. Specifically in the context of biotechnology animal experiments, respect for the integrity of the animals is one of the evaluation criteria (Paula 2001). This integrity refers in part to the individual species behaviour and also to the animal's wholeness and physical and physiological condition. Considering all these conditions it is thus a question of whether the government will give permission, for example, for genetic modification of animals for food applications.

Developments in the ethical discussion on our relationship with animals

The moral evaluation frameworks for the practices relevant to food genomics, livestock farming and laboratory animal research are both in development and not completely similar to each other. This is apparent when the conditions and limits that are maintained in these areas are examined. Except for the problems that this itself provides, the already existing legal frameworks and classifications may no longer be sufficient for the evaluation of animal use for food genomics. As already described genomics blurs further the distinction between genetic modification and other modern biotechnology techniques. Without genetic modification we can also interfere with animals and specifically alter and redesign them, although the genomics route will in fact take longer. As biotechnology has already shown earlier, it should become more obvious that the interests of animals go further than just the welfare and health of the individual animal. Respect for their individual species behaviour and integrity play a role here. In addition medicalisation of food could result in the fact that the evaluation of the use of animals in livestock farming shifts towards testing frameworks that are applied to laboratory animal use.

These developments can only be consistently analysed if a broad integrated view is taken of both transgenic and non-transgenic applications and techniques in livestock farming and food genomics. The 'broader' interests of animals must be furthermore placed and 'operationalised' in the dynamic, future-directed context of animal breeding and technology development. This will also include the evolution of the characteristics and interests of animals. Apart from the evolution around our own moral thinking, in the drastically changed livestock farming of the future other physical bottlenecks will be apparent. It is important for an evaluation framework for food genomics and livestock farming, and for technology and animal use in general that similar future-directed effects are explicitly taken into account. The evaluation framework could thereby also clearly indicate the desired route. The new policy document *Dierenwelzijn* gives a foundation for this as it expresses clearly the intention of altering the accommodation of animals for their benefit and not vice versa. Animals must be allowed to show their own individual species behaviour.

Towards a broader normative evaluation framework for animal use?

The existing and proposed legal evaluation frameworks for animal use are intended to guarantee animal welfare and individual species behaviour as pre-conditions. In the context of livestock farming sustainability has also become an important pre-condition. These three conditions appear to offer a broad, integrating and guiding evaluation framework. However, in practice there will still be many situations that will require clarification. In specific cases the three conditions will for example not all point in the same direction. Group accommodation and somewhat more space for showing the individual species behaviour of social animals can for example lead to a natural pecking order. Individual animals low in the pecking order can suffer due to this.

It is even more important to acknowledge that the separate criteria can be understood and added to in substantially different ways. A choice can be made to define these criteria such that they gain a measurable scientific content. The criterion of animal welfare can be defined for example as the absence of certain concentrations of stress hormones in the blood. Likewise sustainability can be defined as the complete closure of the physical material flows and recycling. On the other hand we can also choose for a more qualitative, ethical definition of these terms. Animal welfare can for example be defined as 'being able to lead a good and rich animal life in which the individual species behaviour can be shown'. Sustainability can be defined as 'provisioning within the existing possibilities of the current generation without bringing into danger the possibilities for future generations' (WCED 1987).

Especially in formal policy-level evaluation frameworks, such criteria in practice can often be given a more quantitative, scientific content and the ethical dimension disappears into the background (Paula 2001; Stafleu et al. 1996). Because of this they often no longer appropriately comply with the ethical concepts of society and the very reasons why these similar criteria were included in the formal frameworks. It is therefore important to define beforehand, for policy-level evaluation frameworks, the final goals and intentions that these terms and/or criteria try to accomplish.

In particular the ethical interpretation of the condition 'sustainability' must in that case be further worked out in the context of animal use. Sustainability also recognises an anthropocentric interpretation which means a guarantee of the interests of the future generations of *people*. A similar interpretation appears to do little justice to the recognition of the moral self-respect of animals. In this anthropocentric interpretation sustainability will be coming continually in conflict with conditions of animal welfare and individual species behaviour. An exclusive anthropocentric view on sustainability now leads to scenarios such as the 'pigs flat': not fixed to the ground, high technology and high intensive husbandry of pigs on an industrial area on which all inputs and outputs can be directly exchanged with and processed by other companies present (Sterrenberg & Rutten 2001).

It appears doubtful whether in a similar scenario the conditions for individual species behaviour and animal welfare could be guaranteed. A more fundamental problem is that there appears to be a *contradictio in terminis* with respect for the intrinsic value of animals expressed in a similar instrumental way. The ethical intention behind this respect also threatens to get lost. It therefore appears morally more consistent to give the specific interests of future generations of animals explicitly a place in the interpretation of the term sustainability. In a similar interpretation then it must be explicitly weighed up how our choices will influence the possibilities for future generations of wild and domestic animals. For example a more emphatic look must be taken at how our choices will influence the 'fitness' and the habitats of domestic, wild or natural populations of animals. They need the 'fitness' and habitats in order to maintain themselves reasonably independently and to evolve.

If a similar broad evaluation framework is consistently used, it can result in the fact that some of the non-transgenic technologies and practices used nowadays would be evaluated as undesirable. Very invasive or manipulative techniques such as *in vitro embryo production*, *in vitro embryo transfer* and hormonal treatments might then be completely banned. Such a framework does not stand in the way of technological renewal as such. New applications and technologies that come out of genomics research that could be used to help serve animals should thereby be properly evaluated as desirable. More passive techniques such as *gene mapping* and *marker-assisted selection* could thereby perhaps find a large-scale entry.

3.6 Themes for a societal agenda

In this essay the scientific, social and moral contexts surrounding food genomics are globally described. The question is: what is the significance of this for a societal agenda for food genomics? As so often with technological developments there also is a control dilemma here. Now, so early in the development pathway for food genomics, social alteration of these technological developments is still easily possible but the developments themselves and their consequences, moral and otherwise, and feasibility are difficult to estimate. If we actually wait until the consequences of a particular development pathway have become clearer then this pathway, due to a physical and financial infrastructure that exists in the meantime, has again become much more difficult to alter. A careful attitude concerning a social agenda for food genomics appears already to be actually possible. It can happen as a result of social desires and values that can be recognised in ongoing discussions regarding livestock farming, animal use and biotechnology and that are relevant for a fruitful social embedding of animal food genomics. A number of general points about that, as discussed earlier in this essay, will be briefly explained below.

Image formation and societal acceptance

We have described above the fact that food genomics is also embedded in an industrial-technology-biotechnology complex. In addition genomics is embedded in a government policy that has stimulation of the development of genomics as its primary goal. This could have an important influence on social image formation. It could very well lead to public mistrust regarding this technoscience complex that is not, considering its alliance with the government, completely controlled by or responsible to society. The image that can exist is that this complex only has responsibility to the market and the shareholders of a private, commercial agenda. This image formation has strongly influenced the discussion around biotechnology (Sterrenberg & Rutten 2001).

Considering the association of food genomics with biotechnology it is probable that food genomics will be brought into association with biotechnology and genetic modification. The fact that some interested parties would prefer not to highlight the scientific and infrastructural association between genomics and biotechnology can be explained from the controversial ring that terms such as biotechnology and genetic modification (and also some biotechnology companies as such) have gained in the *social* discussion.

It can be seen that at the moment some interested parties are trying to put their product (from biotechnology) under a different name (genomics) in order to put it on the market. Indeed this can be more productive than the attempt to wipe away the possibly unjustified, but nonetheless enduring negative image formed about food biotechnology. However there is still the question of whether the distinction desired by some or the re-labelling of genomics and genetic modification are socially achievable. As mentioned earlier these fields of study from a scientific or infrastructural viewpoint are connected with each other as two branches from the same common stem of biotechnology. It is expected that the companies and institutes involved will eventually meet the same social organisations and issues for the application of genomics knowledge and expertise. Apart from the feasibility of an already forced uncoupling of the social discussion about genomics and this context, there is the question of whether such an uncoupling is at all desirable. It brings with it after all the danger that the 'social' lessons learnt from the introduction of various biotechnology applications will not be used for the introduction of new genomics applications (even if they do not use genetic modification).

The need for early clarification and social dialogue

The specific applications and initiatives that are visible to the public also have an impact on image formation of the influence of food genomics on animal use. Food genomics also does not score well in this.
At this time there are few specific and visible (media) initiatives to comply with animal food genomics with much uttered social and policy desires. One of the few projects that are directed towards this is the European research network SEFABAR (Sustainable European Farm Animal Breeding And Reproduction) (Liinamo & Neeteson, 2001). This network is aimed at sustainable, economically feasible and socially acceptable breeding scenarios for farm animals. It is especially directed at professionals in livestock farming and will not report on its findings externally until 2003. The network was formed by representatives from more than 40 scientific and industrial organisations involved in the breeding of animals and they also work together with social scientists and ethicists.

The initiatives and consequences visible to the public, such as cultivated salmon, various transgenic applications and new laboratory animal tests are conversely usually even in conflict with these desires. It seems unlikely at this time that the general public will spontaneously associate food genomics with social or policy-level goals, such as animal welfare, respect for individual species behaviour, animal integrity and sustainability. The development and acceptance of applications that do answer these social needs will also be influenced by the general image formation around animal genomics. As already described above the perspectives of animal welfare and individual species behaviour in livestock farming can be improved by better knowledge of the animal genome (leading to better breeding programmes and veterinary medicine) and new possibilities could exist for alternatives to laboratory animal tests.

Both for the sake of social image formation and also the various directions that can be taken with animal genomics, it appears that for a social agenda it is especially important that it aims at early clarification and influence on the goals for which genomics will be used *in practice*. On the one hand this limits the risk of investing in knowledge and infrastructure that cannot be well marketed but does lead to a new infrastructure of vested interests that can only be bent with great effort. On the other hand this limits the risk that desired innovations fail due to negative image formation around food genomics.

Towards a broader evaluation framework

It is proposed that socially responsible embedding of food genomics profits from earlier clarification and influencing of the use of animals for food genomics. This assumes the availability of a useful social evaluation framework. In the Netherlands there is a 'no, unless' policy agenda regarding animals. This policy agenda has the important consequence that the accent in the social evaluation framework for food genomics and animal use remains on animal welfare and individual species behaviour. At this time the evaluation frameworks established by the authorities and the general public for food genomics practices, livestock farming and laboratory animal tests are not yet completely identical and/or clear. The establishment of a broad and consistent evaluation framework in which animal welfare, individual species behaviour and sustainability are pre-conditions deserves further attention.

New freedom of choice for a 'no, unless' agenda

This essay argues that under the influence of genomics and other technologies the necessity to use animals for fundamental human survival requirements disappears. Due to this an unknown new freedom of choice exists in our relationship with animals. The consequence is that for all of these choices social responsibility can be taken. The freedom of choice that exists goes beyond the choices already made, respect for animal welfare and individual species behaviour. The use of animals for food applications becomes an explicit choice that can be put on the social agenda. In this, except for considerations from the viewpoint of animal welfare, principle animal ethical considerations (such as if there are realistic alternatives is it then justified that we as intelligent beings kill cows for food?) and environmental considerations (is there in a world that is over-full still place for large-scale practices for relatively non-sustainable food production?) will play a role.

Towards alternatives for laboratory animal tests

At the beginning of 2002, the Dutch parliament decided to reserve € 900,000 for research into the genomics programme aimed at alternatives for laboratory animal tests (Policy document Beleidsnota biotechnologie, no. 17). This put this topic clearly visible on the social agenda. A first step for this research for alternatives was the identification of existing genomics techniques that can contribute to the further implementation of the 3 R's. In addition it is important that substantial research should be performed into the active development and implementation of new methods and techniques in genomics that contribute to the 3 R's. This leads after all to a social win-win situation: both the development of an infrastructure for genomics and the implementation of the 3 R's. Similar alternative research in the area of genomics can be very beneficial both socially and economically. This has been proved by various young US companies such as In Vitro Technologies and BD Gentest, who have specialised with commercial success in the development of innovative *in vitro* alternatives.

Avoiding commercial 'monopolisation' of knowledge

Too great 'monopolisation' of knowledge and technology by private organisations can stand in the way of the possibilities of a social agenda for animal use with food genomics in various ways. Guaranteeing the retention of sufficient possibilities and freedom of choice for society deserves further attention.

References

Aoki, N. (2002). 'Evolving away from animal tests'. In: *Boston Globe*, 27/02/2002.

Beleidsnota biotechnologie, no. 17 (motion by Terpstra c.s.). Tweede Kamer 2001-2002, 27 428.

Beleidsnota dierenwelzijn (2002). Den Haag: Ministerie van Landbouw, Natuur en Visserij.

Besluit biotechnologie bij dieren (1996). In: *Staatsblad van het Koninkrijk der Nederlanden*, no. 5.

Bijman, W.J. (1996). 'Application of biotechnology to livestock production'. In: M. Fransman et al. *The biotechnology revolution?* Oxford: Blackwell Publishers, pp. 241-251.

Biotechnologie. HII 2001-2002, Tweede Kamer 46.

Boon, D. 'Mens en dier: gezworen vijanden'. *Justitiële verkenningen* 9 (2001) 01, pp. 23-32.

Enard, W. et al. (2002). 'Intra- and interspecific variation in primate gene expression patterns'. In: *Science,* vol. 296, pp. 340-343.

European Co-ordination Office SA/NV and Commissie Biotechnologie en voedsel (2002). *Eten en Genen* – Eindrapport). Den Haag: Commissie Biotechnologie en voedsel.

FAIP (2000). *The Future of Genomics in Farm Animals.* Oosterbeek: FAIP.

FAIP (2001) 'Reproduction and selection of farm animals'. htttp://www.faip.dk/info.htm.

Farm Animal Breeding and Society (1999). *The future developments in farm animal breeding and reproduction and their ethical , legal and consumer implications*, pp. 111-115. Oosterbeek: AnNe Publishers.

Fletcher, G.L. et al. (2001). 'Transgenic salmon: potentials and hurdles'. In: J.P. Toutant & E. Balazs (eds.). *Molecular farming. Proceedings of the OECD workshop held in La Grande Motte (France), September 3-6, 2000.* Paris: INRA Editions, pp. 57-65.

Gezondheids- en welzijnswet voor dieren (1992). In: *Staatsblad van het Koninkrijk der Nederlanden*, no. 585.

Herbert, V. (1988). ‘Vitamin B12: Plant sources, requirements, an assay’. *American Journal for Clinical Nutrition*, vol. 48, pp. 852-858.

Hutchison III, C.A. et al. (1999). ‘Global transposon mutagenesis and a minimal mycoplasma genome’. *Science* 286, pp. 2165-2169.

INRA Europe (2001). *Eurobarometer 55.2*. Brussels: INRA (Europe).

Institute of Medicine, Food and Nutrition Board (1998). *Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B-6, Folate, Vitamin B-12, Pantothenic Acid, Biotin, and Choline*. Washington DC: National Academy Press.

Jansen, L. (2001). *Genomics. Over de noodzaak van genetische modificatie*. The Hague: Rathenau Institute (internal document).

Jonge, F.H. de & Goewie, E.A. (2000). *In het belang van het dier*. Assen: Van Gorkum & Comp.

Kasteren, J. van (2001). ‘Ander eiwit’. In: *Natuur & Techniek wetenschapsmagazine*, no. 9, pp. 43-47.

Kennisinfrastructuur Genomics no. 1. Tweede Kamer 2000-2001, 27 866.

Kerr, D.E. et al. ‘Losostaphin expression in mammary glands confers protection against staphylococcal infection in transgenic mice’. In: *Nature Biotechnology* 19 (2001) 1, pp. 66-70.

Korthals, M. (2001). *Tussen Voeding en gezondheid (preadvies 2001 NBVe)*. Utrecht: NVBe.

Liinamo, A.E. & A.M. Neeteson (2001). Sustainable breeding for farm animals. Overview of ongoing research and business efforts in Europe. *Preprints 3rd EurSafe Congress,* Florence 3 - 5 October 2001, pp. 465-466. Milan: A&O.

Liinamo, A.E. & A.M. Neeteson (2001). Sustainable breeding for Farm animals. Overview of ongoing research and business efforts in Europe. *52nd Annual meeting of the EAAP,* Budapest 26-29 August 2001.

Meek, J. (2002). ‘Public “misled by gene test hype”’. In: *The Guardian* 12/03/2002.

Nature (2002) vol. 417, p. 778.

Nature (2002) vol. 417, p. 785.

Paula, L. (2001). *Biotechnologie bij dieren ethisch getoetst?* Den Haag: Rathenau Instituut.

Position of the American Dietetic Association (1997). 'Vegetarian diets'. In: *J Am Diet Assoc* 97, pp. 1317-1321.

Pursel, V.G. et al. (1989). 'Genetic engineering of livestock'. In: *Science* 244, pp. 1281-1288

Rijksoverheid en Dierenbescherming nos. 1-2 (1981). Tweede Kamer 1980-1981, 16 966.

Rozendaal, S. (2001). 'De man die het leven uitkleedde'. In: *Bionieuws* 18 (2001) 11, p. 5.

Stafleu, F.R. et al. (1996). Animal welfare: evolution and erosion of a moral concept. In: *Animal Welfare* 5, pp. 225-234.

Sterrenberg, L. & H. Rutten (2001). 'Agroproductieparken en dilemma's rond een poging tot systeeminnovatie'. In: *Tijdschrift voor Wetenschap, Technologie en Samenleving* 4.

Swoka (1998). *Maatschappelijke acceptatie van genetische modificatie bij dieren*. SWOKA report. Den Haag: Ministerie van Economische Zaken.

WCED (1987). *Our Common Future*. WCED: Oxford.

Wet op de dierproeven. In: Staatsblad van het Koninkrijk der Nederlanden, no. 500.

Wet op de dierproeven. *EU Richtlijn 86/609/EEC.*

Wolf, F.A. de. (2002). 'Production of recombinant gelatins and custom-designed polypeptides by methylotrophic yeast'. *Programme & abstract book 9th Netherlands Biotechnology Congress,* Ede 14-15 March 2002.

WWF-UK (2001). *The Status of Wild Atlantic Salmon. A River by River Assessment.* Survey: WWF-UK.

3.7 Report on workshop on the use of animals

Julika Vermolen

Who determines what will be produced and how do we cultivate trust in the consumer?

> *There were differences of opinion about animal welfare in livestock farming and the influence of genomics on it. It is important that consumers maintain their trust in the products that appear on the market. In this workshop introduced by the Leiden researcher Lino Paula, attention was given to factors that could have an influence, such as animal welfare.*

Sceptics say that economic interests still greatly determine what happens and what loses out in animal welfare and that this will not be any different with genomics. Others are more positive about animal welfare: producers are sensitive to social criticism and allow their developments to be influenced by it. The agenda of breeders is determined by social and economic feasibility (and these moreover are closely linked with each other). In short, techniques will thus not be allowed to rush on unrestrained and uncontrolled.

According to Brascamp it will take 20 years before a transgenic animal that produces food will be commercially attractive. This is because it is technically very complex for an introduced gene to be retained (and active) after reproduction/crossing of the transgenic animal. He thinks that this will not occur without cloning. Genomics, cloning and genetic modification are closely connected. Anyway you must also attract into the discussion more traditional techniques. This appears in some cases to be more effective than transgenesis (genetic modification).

Goals of breeding

There are differences in opinion on the question of who determines breeding goals: the breeding companies, the livestock farmer or researchers for example from Wageningen? The discussion goes further into the question of whether genomics will ensure a break in the trend in the direction of the developments. According to various participants a further intensification of agriculture and livestock farming will take place and that process cannot be reversed by social discussion. The participants considered that Brascamp was too optimistic when he said that social considerations or animal welfare will be taken to heart. It is expected that a larger market for alternatives for meat will occur; however meat production will not decrease as new markets will be created. Livestock farming will also fulfil other functions: as meat provider, and also as grazer of nature reserves and producers of medicines.

A participating meat producer proposed that for his company it was essential to get an idea of where we shall be putting the limits. Companies such as his ask the questions: what animal do you produce with all available techniques? How many offspring are acceptable? How quickly can a chicken be ready for slaughter – after six or 12 weeks? What is socially and economically responsible?

The question also arises of whether it counts if one animal can procreate itself without all the artificial means that we have available? We have gone a long way towards manipulation of production, for example the standard use of antibiotics in pig rearing. It is moreover important to be able to see that an animal production system can be optimalised too far away from the sub-system (or the individual animal). Too little attention is given to the greater system association. It does not just concern one chicken, but also what you feed to it, what happens to its offspring, how the ground is used and what is the significance of the feeding system, etc.

An essential point in the discussion is the importance of communication and knowledge transfer as the general public and consumers must be informed about what is happening. However those involved in the sector must also know what the general public and consumers think. Thus things have to be done from both sides. However, what do people want to know? Certainly not everything or in fact a great deal?

Choices

In the future more types of livestock farming will exist beside each other and so the biological market will develop alongside intensive livestock farming. This affects the choices that citizens make, for example during the week a quick snack versus healthy and hearty eating in the weekend. However international competences and subsidies also play a role in this development. According to others we must not allow ourselves to be led too much by the international competition: “Then we shall make products for which we cannot depend on the support of the citizens.” Furthermore it was noted that the social issues that come into play here, such as animal welfare and the environment, are not restricted to just the Netherlands or even Western Europe. As long as that is not yet the case then these themes will also in time come into play elsewhere. The participants observed a big difference between the attitude and purchasing behaviour of the client. For example in the supermarket, price difference determines the choice between biological or ‘normal’ food.

Trust

It is essential that the consumer has *trust* in what he buys, and that he maintains that trust. The image of the product is therefore important and in this care of animals also counts. It is an emotional discussion point and these emotions must be taken seriously and mapped so that technicians can take them into acount. With this information they should be able to sketch the developments in turn for the consumer. The vulnerability in that trust is in the technological aspects, as many people look on them as 'scary'. For example more producers are taking genetically modified organisms out of peanut butter. Other people think that the vulnerability is actually due its large-scale nature.

For early formation of an opinion, trust is the keyword. Clear information on developments and their disadvantages is therefore essential. Knowledge of the outlook on life in various parts of the world is important for the producer in order to determine the agenda. However before asking the opinion of the general public they must first be properly informed. This concerns the actual behaviour of the consumer not just their attitude. Based on knowledge of society the producer can then determine in which direction to start a breeding programme. Discussions between the general public and breeders and producers are thus important and topics should in any case be: food safety, animal welfare, and sustainability in the entire livestock farming system.

A few of the written suggestions for the societal agenda:

- attitude of consumer/citizen: determine trends. How to create and maintain trust?
- active confrontation between parties is required: contact of breeders with retailers and the general public.

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4 Suspicion and abundance: the fortunes of the food consumer

Hub Zwart

"The most essential connection between the animal organism and the surrounding world is that brought about by certain chemical substances which enter the organism, i.e., the food connection. In the lower forms of the animal world it is the direct contact between food and the animal organism or vice versa, which chiefly leads to alimentary metabolism. In the higher forms these relations become more numerous and remote. Now odours, sounds and pictures attract the animals to food substances already in wide regions of the surrounding world. And in the highest formation the sound of speech, as well as written and printed characters, sent by human beings all over the world in search of daily bread. Thus, numberless, diverse and distant external agents act, as it were, as food signals, directing the higher animals to acquire it and making them establish food connections with the external world." (Ivan Pavlov 1955)

4.1 The birth of the consumer and the symbolic meaning of food

Food, according to the famous Russian metabolic physiologist Ivan Pavlov, forms the major link between the organism and its outside world. Where lower organisms react more or less directly to the chemical substances in their surroundings, higher organisms' contact with food takes places via intermediary sensory perceptions (e.g., smells, sounds, and images). In the case of human beings another dimension can also be added. The route towards food progresses nowadays via symbols in spoken, written and printed texts. At least as important as impressions in the areas of smell or taste are symbolic elements such as letters, numbers and codes.

Since Pavlov, the importance of symbolic information, of letters, numbers and codes, has just increased. Human food goes beyond the physiological order (food understood as a collection of physiologically relevant chemical substances) to make up part of a symbolic order and a world of significance. Bread, butter and meat are more than just collections of energy and building materials. They are entities with a symbolic meaning that is marked by numbers, letters and other characters. Food consumption has become a moral and symbolic practice; the food product as such has gained moral significance.

At the end of the 18th century the philosopher Kant still described the consumer as an organism and he looked on the taste, pleasure and digestion of food as chemical and physiological phenomena (Kant 1800/1968; Onfray 1989). In his view food intake was operating at the level of direct chemical contact between sensory organs and foodstuffs, i.e., at the level of bodily perception. Aversion to food expressed itself, according to Kant, in the form of vomiting. Although he emphasised that a collectively enjoyed meal can provide good conditions for an interesting discussion, he paid little or no attention to the cognitive or symbolic dimensions of food as such. Food in his ethical sense was only relevant because individuals ran the risk of undermining their autonomy from excessive use (especially of alcoholic drink).

In the 19th century the socio-economic organisation of the production and consumption of food underwent important changes. The system of self-supply became marginalized and food products were from then on obtained on the basis of symbolic transactions. Most individuals became consumers, but taking in large levels of meaning on top of purely chemical components. At least as important as visible characteristics such as smell and colour is the symbolic information surrounding the food product: the advertising message, shop façade, image, trademark, price, expiry date, product information, and indications of the land of origin, i.e., between the food product in the chemical sense and the consuming organism in the physiological sense a range of symbolic elements nestles of which the importance and the complexity just increase.

One of the first authors who noticed and analysed the change of food from a physiological into a symbolic entity was the philosopher Karl Marx. According to Marx in the first place food products symbolised and represented the production process that created them. Factory-made bread has a different meaning to home-made bread even if this difference is barely or not at all visible at the chemical (ingredients) level. Factory-made bread in the 19th century was produced for a particular socio-economic target group, namely the city masses. This factory-type bread production produced the product bread and also a certain way of eating and a particular category of consumers. A mechanical method of food production did not just create certain food products (such as factory-made bread) but also a certain type of consumer:

"Die Weise der Konsumtion wird durch die Produktion produziert... Die Produktion schafft den Konsumenten... Die Produktion produziert nicht nur ein Gegenstand für das Subjekt, sondern auch ein Subjekt für den Gegenstand. Die Produktion produziert die Konsumtion." (Marx 1939/1983).

[The manner of consumption is created by production. That production creates the consumer...The production produces not only a resistance to the subject, but also a subject for the resistance. That production creates consumption.]

This vision is explained further later in this essay. Since Marx the symbolic significance of food has just become stronger and food consumption has become a moral and also a political practice.

Revolutionary changes

An important change that occurred in the 19th century is termed in this essay 'the birth of the consumer'. In order to understand the current shift and developments concerning consumption it is useful to take a look into the past. The current situation is the result of three revolutionary changes:

1. 'The genesis of the food product' (the impact of the Industrial Revolution on the socio-economic organisation of the production of food).
2. 'The birth of the consumer' (the changes in the socio-economic organisation of the consumption of food).
3. The biotechnology revolution, especially the emergence of food genomics.

Each of these changes is explained further in the following sections.

4.2 Food becomes a product

Although in this essay the emphasis lies on the consumption of food we first discuss some developments in the production area. Current production methods are namely the result of a long history. About nine thousand years ago, techniques were introduced that made possible a new agriculture-oriented way of life. On the one hand these were improvement techniques (such as selection and hybridisation), and on the other hand techniques for the preservation of foodstuffs (including fermentation). These techniques made possible an extremely sustainable system of existence, the so-called general human pattern. This lasted for many centuries, in fact until the 19th century. Before the Industrial Revolution, a great deal of the population of Western Europe lived in country communities that were basically self-sufficient as to their food supplies. The distance between production and consumption of food was small as consumers were closely involved in the food production process.

The Industrial Revolution made it possible to rationalise and to 'render scientific' the food production process. In this way this revolution introduced an element of remoteness, an increase of the distance between consumer and producer, both physical and spiritual. Important sections of the food production process were put out of sight of the consumer, they increasingly took place behind closed doors and gained the character of a *black box*. The familiarity with and transparency of food production declined and the dependence of consumers on large economic players who determined product supply and uniformity rapidly increased. Food production moved from the home into the factory. Cottage industry made way for industrial and machine-oriented production based on steam power and work-sharing, and craftsmanship made way for labour. Chemical processes such as fermentation, that earlier took place in the home, were moved to places where they could be used under optimised and controlled conditions. Small scale made way for large scale and products became safer, cheaper, more hygienic and had a longer shelf-life. Furthermore foodstuffs gained the form for the first time of *products* in the real sense: entities that a producer produced and were taken by a consumer. Food changed its character due to the increasing distance between production and consumption and it became a product in a market – a 'ware'.

Scientists naturally played an important role in the 'rendering scientific' of food production processes. Three scientific initiatives are briefly discussed below.

Wöhler and urea

In 1828 Friedrich Wöhler (1800-1882) succeeded in synthesising the organic compound urea *in vitro* in the laboratory. Until this time it was believed that organic and inorganic compounds fundamentally differed from each other. Organic compounds could only be created *in vivo*, in living systems, or in the body of organisms. The fact that organic compounds could be synthesised under laboratory conditions demystified the metabolic process and put into perspective the distinction between 'organic' and 'inorganic'. Wöhler's discovery made it possible in principle to take food production into our own hands and let it take place in a more efficient, more hygienic, more controllable and factory-oriented way. A factory is after all just a large laboratory. The differences between organic and inorganic, living and dead, and natural and unnatural were relative. In principle it was possible to use scientific knowledge for the preparation of factory-made consumption goods. The baking of bread or brewing of beer was transferred to large bakeries and breweries set up on the basis of scientific understanding.

Von Liebig and the stock cube

The second scientific initiative came from Justus von Liebig, one of the founders of organic chemistry. In 1825 he was Professor of Chemistry at Giessen University where in a side building he established the first modern laboratory. His first important discovery was not concerned so much with chemistry itself as with the manner in which this subject was taught at university: he introduced university practical classes. Education in chemistry moved from the lecture theatre to the laboratory, where alongside their theoretical knowledge students also exercised their practical skills. In about 1840 Von Liebig took his initiative for the second important change of course, and organic chemistry thus changed from a fundamental to an applied science.

This led to the discovery that really made him famous, namely meat extract, or the stock cube. Von Liebig thought that workers needed large amounts of protein in order to be productive. However, while the workers in the rapidly urbanising industrial areas of Western Europe were suffering from hunger, large amounts of meat were being wasted in Argentina. This was occurring because large numbers of cattle were being ranched there especially with an eye for leather production and the technical capability was lacking for transporting the meat to the starving in the European suburbs. Von Liebig developed a procedure for extracting and concentrating the important ingredients from the meat, to make them non-perishable and transportable. This was motivated from his theory (later proved to be incorrect) that workers especially needed proteins and to a much lesser degree carbohydrates in order to perform heavy physical work. Von Liebig's school can be seen as founding modern organic chemistry and also commercialising academic science. Research brought scientific papers and also patents that made Liebig's 'Fleisch Extrakt' (meat extract) a well-known consumer product.

Bougies and margarine

The third chemist who made an important contribution to the 'rendering scientific' of the food production process was Hypofyse Mee Bougies (1817-1880). In 1869 at the request of Napoleon III, who provided the facilities, he developed margarine. He applied for a patent for his discovery, which he sold in 1871 to the family Jurgens, who would establish the company Unilever in 1927. This discovery made it possible to produce a cheap non-perishable product on a large scale that could replace butter (which was scarce and too expensive for the city masses).

4.3 Biopolitics

The Industrial Revolution created distance between producer and consumer and also between raw material and product. In other words the independence of the food product increased. Indeed, it was been already proposed that food at last actually had become a 'product'. From the old days butter has been made from milk, which was an expensive high-value raw material. Because butter consists chemically mainly of fats, the chemist Mee Bougies asked the question whether it would not be possible to break the link between milk and butter. He replaced the raw material milk by another more common and less costly raw material, in the first place beef fat, and later vegetable fat. The distance between raw material and product increased and, as margarine seemed to be more than just fat alone, it became a product with a symbolic meaning and a social identity.

The initiative for margarine production was taken as mentioned by the French government in the person of Napoleon III. The European authorities had discovered the importance of the state of health of their populations, especially of the lower classes. This led to a series of measures in the areas of accommodation, hygiene and nutrition. This concern for the physical conditions of especially the urban masses led to scientific expertise being mobilised to improve their living standards. All of these measures and policy initiatives emerging from this were called 'biopolitics' by the French philosopher Michel Foucault (1976). In his book *Histoire de la sexualité. La volonté de savoir* he described the measures based on scientific insights that brought attention to the lifestyle (and nutritional habits) of the working class. Governments had discovered the importance of the physical condition of their human resource. It was especially the population groups in the new suburbs whose physical conditions caused the most concern. The 19th century was the century of industrialisation and also of nationalism. The *wealth of nations* was to a large degree determined by the human resources that could be mobilised for industrialisation and military goals. The physical conditions, accommodation, living standards and nutritional habits of the new working class were important economic and military factors.

Margarine as butter for the workers

This development determined the significance and the social profile of a product such as margarine. It was a class product prepared for a particular target group: the cities masses, for whom traditional 'real' butter was too expensive or otherwise unattainable. Whoever bought margarine was indicating that they belonged to a certain social class. The government encouraged the development of margarine, but at the same time they were concerned regarding the 'recognisability' of margarine as a product. The two chains or two identities of margarine and of real butter should not get entangled. In the same way that a clear social division existed between the elite and the urban masses the same sort of clear distinction between butter for the elite ('real' butter) and 'butter' for the workers (margarine) also should remain. Whoever made a successful career socially transferred their allegiance at a certain moment from margarine to butter. Such changes in the behaviour of consumers symbolised the new social status of those involved.

Tinned meat

A comparable change took place in the area of meat production. As mentioned Liebig's meat extract was introduced in the 19th century. In the U.S.A. especially another alternative was developed: tinned meat. This product had the same significance as margarine as it was a product intended for a certain social target group: it was cheap, available on a large scale and could be stored. The original product (recognisable meat) lost its form in the context of the production process. Before then it was the production process itself that determined the form of the product.

Tinned meat had significance in another sense. In 1905 the Marxist author Upton Sinclair published his novel *The Jungle* in which he describes how each morning a 'river of life', consisting of thousands of pigs and cattle arrived at the abattoir in Chicago to be processed by machines into tinned meat. The spectator was inescapably impressed by the efficiency of the process, according to Sinclair: meat production was a form of 'applied mathematics'. Further examination brings up the 'philosophical' question of what right we have to process these animals by machines, animals with feelings, their own existence and their own identity, i.e., reducing them to raw materials for the meat industry. The novel describes a dramatic development that occurred at that moment on a grand scale. The new method of production produced indeed a new product (tinned meat) and also a new style of consuming and thereby a new type of consumer. The parts of the food production process to which Sinclair wanted to pay attention in his book were kept out of sight of the public. What the consumer did see was no longer the slaughtered pig or calf but the end result of a complicated 'scientific' process: tinned meat. This product was more than a sum of the ingredients; it had become a symbol.

Marx analysed this development in his book *Das Kapital*. The food product according to Marx, is a symbol, a social sign or a hieroglyph, something that a particular method of production symbolised and embodied. Tinned meat represented (as a product) the method that created it and this caused a secret 'metaphysical' change in the product, according to Marx (1867/1979, pp. 85-88). It made something abstract (a particular method of production) into something clearly visible and tangible. In the case of Upton Sinclair, the tinned meat represented a new way of life, an *American way of life*. Those who bought the product associated themselves with this way of life, with this method of production and with this method of relating to animals and people. Those who consumed this meat made this method of production legitimate and became accomplices, as it were. Furthermore this meat was for a certain target group, the cities masses. Those who bought this product indicated thereby that they knew they belonged to this social group (the urbanised working class). The city elite or country people consumed *other* meat. They refused tinned meat because its consumption would indicate a denial of their identity. The 'otherness' of their meat also had much to do with the composition of it (e.g., the relationship between proteins and fats) but also covered especially its symbolic distinction. Tinned meat also satisfied a social need for new food products for a new class: cheap, nutritious, non-perishable, factory-made and prepared on a large scale. The dependence of the consumer had been maximised and the free consumer no longer existed. It was a key moment for modern consumerism. The moment of free well-considered choice from a range of alternatives had been taken away from many people. There were individuals who managed to climb the social ladder, the *self-made man*, who as soon as conditions allowed made the step over from tinned meat to 'real', recognisable, prototypical meat. This stepping over sealed and confirmed his new socio-economic identity and his social emancipation.

4.4 The birth of the consumer

In the 20th century, especially after 1920, an important change took place in the socio-economic organisation of food consumption. The consumer became emancipated and individualised, and that happened *en masse* with the consumer becoming a real consumer in the modern sense of the word. He was no longer an anonymous representative of a particular social class but an individual who made a choice from a range of products and thereby, and this is important, he assigned an important place to the moral profile of the product.

The history of the Verkade Dutch rusk

An interesting example for this change in the socio-economic organisation of food consumption is the history of the company Verkade. Founded in 1886, Verkade was more than a producer of a range of new products, such as rusks, biscuits and tea-warming candles. Verkade was, at least in the Netherlands, at the cradle of the consumer, in the modern sense of the word. The birth of the consumer is closely associated with the arrival of a new genre and a new medium that made possible communication between on the one hand the new producer and on the other side the new consumer. It was a genre that reduced the distance or alienation between producer and consumer, namely by advertising. The example of Verkade is especially interesting because this company, thanks to its extremely successful advertising policy, profiled itself as a moral player. Verkade made its name as producer of new food products but especially as publisher of a series of card-collecting albums that stimulated interest for the beauty and value of Dutch landscapes. In the advertising policy of Verkade the concept of 'nature' was granted an important role. Verkade was more than a producer of foodstuffs; it was also a moral actor who played a decisive role in the rediscovering and rehabilitation of Dutch nature reserves, often of the type of nature that was at that moment looked on as deserted, useless and dangerous and of which the value in fact was still to be discovered. The connection that Verkade wanted to have with its consumers was to a large degree a moral one and in their mutual communication moral images and messages played a decisive role. Consumers were talked to as individuals who could bring value to Dutch nature and in addition were prepared to transfer their own interest in and knowledge of the nature to their children, i.e., Verkade made it possible for the consumer to be involved in a good cause.

When Enricus Verkade founded a steam bread factory in 1886 in Zaandam, this initiative completely answered the complex of developments that are described above as 'biopolitics' (resulting in cheap food for the masses). There was a market for cheap and nutritious bread, especially aimed at consumers who had little buying power and had become recently urbanised, who inhabited the suburbs of nearby Amsterdam often in cramped circumstances. Craftsmanship was replaced by steam energy. Verkade not only aimed at maximising profit but also acted on the basis of good moral and idealistic considerations. The founder wanted to improve the living conditions of the proletariat. The area around the River Zaan north west of Amsterdam was at that time transforming from an old economy based on wind power into a modern industry. The traditional bakers could only cope with the new competition by working extremely long hours and keeping their bread prices low. For these reasons Verkade looked for other possibilities and other products, such as rusks.

In itself, the rusk was not new as it was also made by traditional bakers. The novelty by which Verkade made its name was its decision to sell its rusks *in packages*, not as was traditional in a loose (unpacked) state. These packages were given their own trademark and their own *logo*. The same procedure was also applied at a later time for ginger cake. The packaging improved the shelf-life of the product and especially its 'recognisability'. The consumer no longer looked for colour, hardness or other visible signs of freshness of the rusk product itself. He looked at the logo, the trademark and other symbolic elements that guaranteed freshness in a symbolic way.

Chemically the rusks from Verkade were no different from the products of their competitors. Verkade's success lay in the symbolic connection that the company was able to create between the producer and the consumer. At the same time that the distance between the producer and consumer was increasing considerably due to industrialisation and steam energy, the producer Verkade was able to bridge this gap *symbolically* in a simple way via text, characters and symbols, using packaging material with a trademark and a logo. The new consumer found their way to the product via symbols, as Pavlov had formulated.

Verkade went further: using packaging as a technique they made another just as important step in the direction of far-reaching 'symbolisation' of food consumption. This second novelty step was itself taken very simply. Verkade decided to add coloured pictures/cards to the packaging that the consumer could collect and stick into a specially provided album. In the first place these were cards of German origin, the so-called fairy tale albums. In 1906 Verkade brought their own first album on the market under the title *Lente* (Spring), written by the well-known amateur field biologist and conservationist Jac. P. Thijsse.

In the 1880s a generation of poets, writers and painters had for the first time paid attention to the value and beauty of more or less natural landscapes such as dunes and wetlands. This new interest in nature that in the first instance had an elitist character moved quickly to a broader social level. The workers movement also developed this new sensitivity for nature. Against the background of this interest the Verkade company decided that nature was to be the central theme of the albums and the nature cards that were to be collected by consumers. In this morality ideas regarding the elevation of the Dutch population explicitly played a role via good and affordable nutrition and also via spiritual food. Verkade's attention to the indigenous, natural landscape had a moral dimension from the start. The company wanted to reduce the distance that had developed between nature and the city inhabitants. At that time the Netherlands had extensive wetlands; the Zuider Zee had not yet been closed off and the Delta Works not yet built. The Association for Maintenance of Natural Monuments in the Netherlands had just had its first victory by saving the Naarder Lake from disappearing.

The popular author Jac. P. Thijsse, a teacher by profession, performed his task very well and L.W. R. Wenckebach, Jan van Oort and Jan Voerman jr. made the illustrations. A series of Dutch landscapes (Texel, the area around the River IJssel, the Zuider Zee coast, and Friesland) were made accessible for a large public at a time when aimless wandering and cycling through nature reserves had just been discovered. Although in later albums attention was also given to other topics, such as the Amsterdam Zoo (Artis), succulent plants, and the aquarium, indigenous nature was always clearly in the foreground.

Verkade knew how to reach the anonymous Dutch consumers at the time they were becoming emancipated and, more than previously, had something to choose – because before that time others determined what workers ate. Verkade brought to the people more than just rusks and biscuits; they created a new morally inspired way of communicating and consuming. In a period in which increasing prosperity stimulated the independence of consumers as regards food producers, Verkade found ways to reassociate the free consumers with them. The connection between consumer and producer was now no longer forced by socio-economic necessity but was created more or less by free will. The moral profile of both groups, producer and consumer, played a decisive role in this. Verkade profiled itself as a producer who, using good and affordable information, made Dutch nature accessible for large groups of the population. By consuming Verkade's products the consumer could express his interest in nature and his understanding of its responsibility as an educator.

In fact the nature theme had no connection to the product itself. Verkade rusks or biscuits were no more natural or more environmentally friendly than comparable competitive products. However Verkade presented itself as a moral player by associating itself with a moral ideal and creating interest for the beauty and uniqueness of the Dutch landscape, and also for its vulnerability. Attention was drawn to the natural value of Texel for example for the first time by the Verkade album on this area. Verkade could not put its market position down to the characteristics of the raw materials used in the production process, such as flour or yeast. However, it did succeed in distinguishing itself from its competitors thanks to its *moral* image. The accent shifted from raw materials (chemical compounds) to symbols, and from pure nutritional value to moral profile. The company managed to connect its name with an idealistic, idealising vision of landscapes, plants and animals. Verkade started a dialogue between producers and consumers, and also between large groups of Dutch people and their landscape.

The history of the Verkade album does not stand on its own, but it is part of a broader social process: the emancipation and individualisation of the consumer. From that point on was there a 'modern' consumer in the sense that they could make choices between a range of products on offer. This change also meant that producers started to invest in improvement of product quality and also customer relations and advertising. The identity and recognisability of the trade mark and logo, the *symbolic* link between producer and consumer, were of decisive importance. This development also shows in the example that was discussed earlier of margarine. In the first instance margarine was an obvious product for less prosperous population groups and there was no need for customer relations or advertising, as there was no choice as yet. The modern consumer did not yet exist and the production system produced its own consumers and its own style of consumption.

After 1920 the demand for margarine was actually no longer obvious and no longer guaranteed. This led to investments in quality improvements and especially after the Second World War also to an increasing emphasis on advertising. The user, and this is important, could therefore be spoken to *individually*. The deciding moment of whether to purchase a product shifted to a certain extent from producer to consumer. The producer at a certain level became dependent on the behaviour of consumers in the market. Advertising meant in a certain sense a recognition that the new consumer had developed a certain independence and power. The concept of health appeared at the foreground of margarine advertising. The old association of margarine with the consumption patterns of certain social classes ('margarine is the butter for the poor') was pushed into the background. The advertising message was directed at the health qualities of margarine, especially when scientific research showed a relationship between fat consumption and heart and blood vessel disease. Knowledge of the function of linoleic acid and polyunsaturated fatty acids had a clear impact on the behaviour of individual consumers (who were informed about this especially by advertisements). The accent lay no longer on the difference in status between artificially synthesised butter replacements such as margarine and ' real' butter. The person eating margarine no longer disqualified themselves from a social viewpoint, in fact quite the opposite. It is characteristic of modern consumers that whatever their prosperity they give attention to their own physical health especially on the topic of food intake. The condition of a person's own body has become a topic of attention and consumers have become conscious of the physical effects of excessive fat consumption.

In addition the level of prosperity and the purchasing power of the population increased after the Second World War. A market arose in which food producers competed with each other for the favour of consumer groups. Moral elements such as the praise of a healthy and responsible lifestyle play a big role in this.

This change can also be described in the terminology of the French philosopher Michel Foucault. The subject, the initiator of the development, is no longer the authorities but the consumer, and more so than previously. The emphasis shifted from 'biopolitics' to 'lifestyle'. The consumers started looking for products that supported and symbolised their way of life. Advertising and other forms of product information appeal to the growing attention of consumers for their health in relation to nutrition, among other things. The consumer is no longer a representative of a population group whose welfare is watched over by the authorities ('biopolitics'). The individual himself takes care of his own health and is encouraged (in a lifestyle) to do so (via advertising messages, etc.). Using compact, appealing information about products the autonomy of the consumer increases. Food products symbolise a particular way of life, for example 'healthy'. Normative concepts such as nature and health determine the image of the food product and food producer.

4.5 The emancipated consumer

Advertising is actually just one of the possibilities for producers to communicate with consumers and reduce the distance between them. The producer takes the initiative to advertise and produces his ideal consumer in and through the advertising message. Thereby advertising took on a double significance: one of improving autonomy and one also threatening autonomy. The advertising message talks to the consumer as an individual; in contrast the structural dependence of the consumer is not completely cancelled out – the offered information can also be one-sided and misleading. The fact that advertisements do not restore the threatened autonomy of consumers is emphasised by the vision on advertising held by the influential American behaviourist and advertising expert John Broadus Watson (Buckley 1989). As a researcher he made his name from the conditioning of the behaviour of white rats in a maze. By reward ('confirmation') it seemed to be possible to manipulate the behaviour of the rats, with communication between the researcher and test animal taking place via food.

Conditioning and manipulation

Due to his affair with a student (whom he later married) Watson found himself forced to leave the university. He looked for a new profession and his choice fell on *advertising*, an emerging profession at that time in the U.S.A. His biographer K.W. Buckley said that according to Watson the behaviour of the consumer in the market could be conditioned and manipulated just like rats in a maze. Using scientific knowledge producers could change the behaviour and the pattern of values of consumers. One of the techniques that Watson introduced in order to gain control of the behaviour of consumers was the appearance of scientists in commercials suggesting that they had scientifically studied the safety or efficacy of a particular product. Use was also made of well-known personalities who represented a seductive lifestyle and suggested that particular products were part of that lifestyle, especially concerning values such as position of freedom and sexual attraction. For example, thanks to well-known actresses the taboo on smoking for women was overcome. In short, the consumer was becoming more dependent on powerful producers with respect to materials and especially on the level of values and symbols. From the 1950s advertising became a crucial by-product of food producers.

Food ethics

The modern-day ethics of food are in fact an attempt to reinforce the threatened position of the consumer. One of the important topics within food ethics is recovery of the autonomy of consumers, i.e., making it possible for consumers to exercise their right to self-determination by reducing their dependence on the new mega-players of the foodstuffs market. These mega-players are a small number of powerful producers, each of whom brings a large number of brands on the market and thereby can exercise a great deal of influence on the market. In a world in which material things are packaged in complex symbolic messages the dependence of the consumer and their ability to be manipulated have been maximised.

Food ethics attempts to restore the balance, in the first place by taking a critical look at the product itself in a material sense. Is the product safe and nutritious? Will the consumer be exposed to damage, physiological or otherwise, even after long-term use?

The autonomy principle, with the emphasis on the symbolic level, is more important than the risk viewpoint. The producer must adequately inform the customer regarding the composition, ingredients and method of production so that the consumer is free to decide whether to purchase the product concerned. In this connection the product information on the label is crucial, as it is the equivalent in the area of food to the famous *informed consent* principle from medical ethics. Nowadays it is more important than ever that, via symbols and spoken and printed texts, consumers can find their way to purchasing the concerned product. The packaging indeed *veils* the characteristics of the product that the consumer can observe with their own senses (smell, colour and taste), but *unveils* what is invisible in a symbolic way. It informs the consumer about the chemical compounds from which the product is made and about the method of production. The thought behind this is that the consumer is able to decipher the images, codes and figures that surround the product.

The intention of this product information is to guarantee the autonomy of consumers, the subject. The real question is whether this is not just idealisation. Is the image of the free market, where well-informed consumers can make a free choice from a range of producers, not a myth?

Before going into this further it is possible to establish that the importance of the symbolic meaning of food is increasing. ‘Good’ and ‘bad’ products exist. The Outspan orange, that was a target in 1974 of a campaign against the political system of Apartheid that had created this product, was an example of a 'bad' product. The Outspan orange symbolised and materialised the political attitude in its land of origin. A 'moralisation' and 'politicalisation' of food consumption had started to become apparent. Consumers could, by either buying or not buying particular products, make clear who they were and where they stood in the context of certain social discussions.

Since then 'we are what we eat', but not in the physiological sense. It is not the chemical properties of the ingredients but the symbolic meaning or moral profile of the product which contribute to the creation of a moral identity. The symbolic meaning of food makes it possible for us to join in or to choose sides. Even there where concern over the *health* of particular food ingredients, such as saturated fatty acids seemed to come to the fore, we must not lose sight of the fact that health is not purely a physiological term. Moral and cultural facets also play an important role. Advertising messages that urge us to consume healthy food products are in fact making propaganda for a certain way of life. Responsible consumer behaviour does not occur by itself. It is part of a responsible, sustainable lifestyle that is not an individual affair, but a cultural phenomenon. It is an ideal that is shared with others.

4.6 The impact of food genomics

In the previous sections the importance of the symbolic meaning of food products for consumers was emphasised. In this section this viewpoint is brought forward to the present day. This raises the question of what the impact is of the recent biotechnology revolution, i.e., the emergence of food genomics, on the social and moral dimensions of food consumption. Food genomics is the result of this biotechnology revolution that started in 1954 with the famous publication of Watson and Crick on the structure of DNA. The social significance of this only became emphatically visible during the 1970s. In this period the new *recombinant* DNA technology created the possibility of combining DNA and transferring it from one organism to another. In 1973 Stanley Cohen introduced a gene from a toad into a bacterium; in 1976 *Genentech* was founded, the first commercial company dedicated to *genetic engineering*; in 1983 Kary Mullis introduced the *Polymerase Chain Reaction*; and in 1995 the first complete genome of an organism was mapped.

Reservations from the public arena to these possibilities were especially brought up for two reasons. To begin with there was a fear that there could be unforeseen risks, a fear that was expressed in the so-called *precautionary principle*. Secondly there was the idea that *gene transfer* or other forms of genetic modification could mean breaking the integrity of the involved organisms, the so-called *integrity prin-*

ciple. The moral logic of these two principles is different. In the first case it concerns a 'consequentialistic' principle; in the second case a deontologic principle. It is noticeable that generally supporters of genetic modification prefer 'consequentialistic' arguments (in terms of possible consequences and risks), but their opponents would think first deontologically (they evaluate the moral quality of the activity as such and formulate principal objections). The most important principle of food ethics, the autonomy principle, can expect broad support and is especially expressed in the requirement for product information that allows consumers to be able to make their own choices (democratisation of the supermarket). In the following sections the significance of genomics for food production and consumption is examined further. First the production side of the chain is examined using the example of Monsanto; attention is then given to the food product, and finally the position of the consumer.

4.7 The production side: Golden Rice

The chemical company Monsanto was founded in 1901 and it made its name (in the negative sense) in 1947 when one of its ships loaded with ammonium nitrate exploded in a Texas port, leaving more than 500 people dead. In the following years the company's attention shifted from chemistry towards agriculture. In 1993 the last chemical activities were closed and the company moved fully into biotechnology. One of their first successes was the compound Prosilac that increased milk production in cows. The company made the front pages with Golden Rice, in the production of which genetic modification played a role. Naturally rice contains little or no vitamin A (carotene) and a lack of this vitamin especially in Asia, where the population depend on rice for a great deal of their food, leads to millions of people suffering serious problems, and in particular blindness. Thanks to genetic modification it is possible to add the deficient vitamin to rice, whereas with traditional plant improvement this was not possible.

The positive side of the Golden Rice story teaches that Monsanto is a company that wanted to make an effective contribution to solving a global problem. Unfortunately it also had its negative side. According to their critics Monsanto used Golden Rice to improve their own image and to improve the acceptance of genetically modified food products. Golden Rice is a façade that allowed Monsanto to profile itself as a moral player. Thus Golden Rice is not a neutral product but one with a moral identity. It is not just a broadening of the product range but a possible solution for a global problem. Monsanto presented itself thereby as an involved and engaged producer. It appeared that the company wanted to set a moral ideal: the decrease of hunger worldwide, rather like companies such as Benetton who profile themselves as companies for or associated with another moral ideal, the multicultural society. Furthermore, Golden Rice is a product that is made for a particular global target group: the inhabitants of South-East Asia with little purchasing power. In the perspective of the more suspicious, more negative interpretation, Monsanto actually appears as a strategic player using Golden Rice in order to manipulate the consumer and improve the company's own image. Golden Rice is thus produced as an aid in the fight for the meaning of food products.

Golden Rice is just one case and Monsanto, the Microsoft of the seed producers, is battling on more fronts. At this time it is especially the debate around *killer* or *terminator genes* that is ongoing. Bt Corn is a Monsanto product that contains a gene (originating from a bacterium) that is a start for the production of proteins that are toxic for the damaging target species. It also concerns a product with moral significance: according to Monsanto the introduction of this modified crop will make it possible to reduce the use of pesticides, i.e., the amounts of poisonous compounds that are also damaging for non-target species – to which group eventually the human consumer also belongs. The product serves an important moral goal to contribute to sustainable agriculture but critics actually emphasise the dangers of this development. When containment is not successful and the artefact has a chance to spread, then non-target species, especially the larvae of Monarch butterflies can still be the victims. These victims could be the 'canary in the mine': the march towards an environmental disaster of much wider scope *(Science & Technology News Network* 25 April 2002). The moral image of this product is in other words still very weak; a *Gestalt* switch from good to evil, or from panacea to monster, could easily occur.

The fact that a food producer found it important to present itself as a moral player is in itself not new (see the case of Verkade above). The addition of important ingredients, especially vitamins, to food is also not new. The fact that organic compounds ('essential amino acids') exist that we cannot make ourselves but are essential for the normal functioning of our bodies was discovered at the beginning of the 20th century. Early attention was given to the relationship between rice consumption and beri beri – research in this area resulted in the Dutch researcher Christiaan Eijkman being awarded a Nobel prize. The uneasiness of consumer groups about food genomics is concerned with the fact that processes that have been going on for some time are now accelerating. It concerns especially the increasing independence of the food product in relation to the raw materials and the prototype (or the tomato as a recognisable product) and the increasing changeability (or plasticity) of the product by industrial processes. Food genomics can be seen as a radicalisation of earlier transformation processes. The possibilities for producers to both determine and manipulate the image of the food package increase drastically. The sight and characteristics of the product can be tuned more appropriately to the desires of consumers. What we must also realise is that new production methods generate new forms of consumption, and new styles of consumption generate new requirements for consumption. Supply and demand are linked to each other in a complicated and interactive way.

4.8 The food product: the return of the prototype

The plasticity of the food product is increasing and on that point the introduction of genetic modification radicalises a development that was started much earlier. We really have a paradoxical situation to deal with as is explained further below. As described above industrialisation of the food production process resulted in an increase of the distance between product and prototype. The form of tinned meat for example was determined by the machine and this also applied for example to tinned vegetables or soup. The natural organic form made way for a machine-driven and simplified form. This applies as much to the meat extract of Liebig as to the vegetable extract from Maggi. The prototype is turned into an aggregate of ingredients, that are in principle replaceable as the producer can add or remove ingredients. In this way the prototype disappears from the picture. Recognisable meat made way on a large scale, especially in city areas, to the stock cube or tinned meat, and the recognisable tomato was replaced by tomato puree containing ingredients that never came from the prototype (such as salt, colouring, taste enhancers, etc.).

The present-day visitor to the supermarket is actually a witness to a process that can be called the return of the prototype. Tinned meat is making way for minced meat and for beef steak. The tomato puree frees itself from the tin and the recognisable tomato reappears. Spaghetti creates the impression of again being made by craftsmen instead of machines and in our daily bread whole grains can be seen again. Genetic modification can enhance this process of the return of the prototype. For products that in nature have a limited shelf-life, such as tomatoes, genetic modification can be an answer for the desires of consumers for the visible presence of the prototype. The availability of the recognisable tomato is then less region or season-dependent. The supermarket of the future will appear to be the remarkable garden that the main character in the novel '*The time machine*' by H.G.Wells (1898) found in a distant future. Brightly coloured, immaculate fruits were available in unlimited supply and were resistant to all imaginable diseases that could be caused by insects or micro-organisms. On the one hand the prototype stands for naturalness, and on the other hand it generates unease and suspicion, as an artefact of the modern, 'geneticised' food production process.

The perfect tomato

Tomatoes have the natural characteristic that they rot quickly and from the perspective of the tomato plant itself that is a good characteristic and the result of millions of years of evolution. In this way the plant itself creates an adequately fertilised soil for its ungerminated seeds. Enzymes (especially polygalacturinase) that degrade cell structure are responsible for this rotting process. Rotting is, in other words, an active process that does not just *happen* to the tomato. The tomato is not passive but takes part itself in this process in its own interests. However, from a human perspective this is actually a 'bad' characteristic. The tomato concerned looks worse when it is rotting and the products of rotting are often unhealthy. We have a natural aversion to the smell and colour of rotting fruit and that is also a good thing.

One of the solutions for this problem, developed during the Industrial Revolution, was to put tomatoes in tins before the rotting process could begin. Genetic modification could lead to the return of the prototype tomato by switching off genes that code for the enzymes that start the rotting process. The tomato thus remains whole and the prototype does not need to be chopped into puree and even better the tomato then appears in various guises in modern-day supermarkets that are seen one by one: the cherry tomato, the fleshy tomato, and the 'Italian' tomato. It is not immediately obvious in terms of taste, smell or colour that genetic modification has been used and therefore we depend on symbolic information. The label informs us that the tomato has been contaminated in the symbolic sense of the word. Aversion or mistrust due to genetic modification is part of the symbolic dimension. It is not a physical disgust (this is more likely to occur with a rotting tomato) but a symbolic refusal at least by some consumer groups.

In the example of the tomato one or more genes are switched off (a so-called *knock-out mutant*). It is also actually possible to add genes and this is what happens in the case of Golden Rice. It appears that this application is only a beginning. Genetic modification makes it in principle possible to add functional ingredients to food. In the 19th century a major part of the Dutch population ate potatoes, a situation that was immortalised in Vincent van Gogh's famous painting – the potato eaters. This one-sided food consumption pattern was during the time of biopolitics a source of concern and led to physical complaints – which also made Vincent van Gogh clearly visible. After the consumer had gained a certain autonomy, experts attempted to bring more variety into food consumption patterns. Now we are approaching the age of genetically modified food we could in theory permit ourselves to remain a potato-eating people. Via genetic modification the potato could become a *carrier* for important constituents lacking in the non-modified prototype (Van Gogh's potato). In theory it is probably conceivable to make a potato that contains all the ingredients in the right relationship that the human organism needs. Other more specific additions are also imaginable. Patients, such as those with diabetes or kidney disease could eat a potato variety in which, due to genetic modification, a certain medicine is present, such as insulin, extra vitamin B or folic acid. Older people could eat products rich in minerals, vitamins, anti-oxidants and probiotics. Components that might cause allergies in some people could be preventively removed. The prototype would then be the raw material that can be improved in a multitude of ways by the food engineer, and especially in a very short time.

4.9 The new consumer

An important question of ethics is *cui bono?* i.e., in whose interest? The answer from producers is that the consumer has needs or interests in new products. With more of a suspicious mind one could stress that the offer is preceding demand. In addition genomics also has significance in another sense for profiling the consumer. As knowledge on the complex interaction between genetic make-up, physiological processes and bioactive compounds increases, new groups of consumers arise for whom the presence or absence of particular groups of genes in their genetic profile will help to determine their 'demand' as consumers. Hippocrates made a connection between structure and food and he distinguished four types of people (four 'temperaments') who required a particular diet depending on their constitution or natural structure. Attention to the relationship between nutrition and health gains a new accent with food genomics. What is healthy is not necessarily healthy for everyone and a proliferation of 'temperaments', so to speak, occurs with the appropriate dietetic practices.

The imminent medicalisation of our food

Margarine can also serve as an example of this development. A new chapter was added to the history of this product with the introduction of cholesterol-lowering ingredients (in the Netherlands for example, the product Becel ProActiv). Excess weight is increasingly being seen, especially in the U.S.A., as a disease, or as a question of constitution or genetic make-up, for which *functional foods* could offer a solution. Instead of practising moderation (the traditional, but especially *moral*, self-critical solution) a specific product is developed for a specific target group, with the product developer aiming at the genetic passport of individual consumers. Where there is the tendency for obesity, alteration of the diet or the use of additives are options. New products are being produced for groups of consumers with a particular genetic profile. Comments on this development especially concern the danger of medicalisation. The lines between healthy citizen and patient, and between food and medication are becoming more vague. Furthermore it can undermine the social meaning of food, that after all is based on a communality (the collective enjoyment of food). After eating from one pan has made way for eating from one's own plate, the emergence of *functional foods* could lead to the fact that all participants at the meal eat their own combination of ingredients, and their own combinations of permissible products.

Recognisability of food

The proliferation of new products makes it possible for consumers to develop their own moral identity. The choice is no longer limited to that between real butter and margarine, or between baker's bread or factory-made bread. Recognisability plays a crucial role in the symbolic significance of similar food products. It was already an *issue* with the introduction of products such as margarine and factory-made bread. Although the authorities in the 19^{th} century stimulated the production of margarine and other cheap and nutritious products there was some concern regarding the recognisability of these new products and margarine and real butter, for example, must not be confused with each other. A similar concern also arose with the introduction of genetically modified food products, and future generations of consumers should be able to select between traditional and genetically modified products. Both production chains should develop separately – but that seems to be an illusion. It would appear that the demarcation between both production lines will become more indistinct in time. Containment seems to be impossible, and contamination is unavoidable. This concern comes especially to the fore in discussions about traceability and it concerns especially the problems of product information. When should it be made clear on the label that genetically modified raw materials or organisms (GMOs) have been used?

There are different variations of this. In the first place there are traditional GMO-free products, both in composition and production. Alongside this are products for which during the production process use was made of GMOs but these GMOs are not present in the final product. There are also products that contain an exceptionally small level of GMOs (less than 1 %) and there are products that contain a considerable amount of GMOs. According to some (especially non-governmental organisations) the use of GMOs must be declared whenever somewhere in the production process GMOs have played a role. Others (especially producers) say that this should only take place if constituents from GMOs are traceably present in the final product.

This discussion is interesting because it becomes clear that the parties involved speak different moral languages and use different argumentation strategies although they both support the basic principle of consumer autonomy. Producers argue primarily in terms of chemical components and, in an extension to this, in terms of physiological risks for the consumer. In contrast, for critics of genetic manipulation the contamination is of a symbolic nature and chemical traceability is of no real concern. The relevant food product represents a particular method of production that uses GMOs, and the consumer should have the option of refusing this production method. There is talk of 'symbolic' contamination and this does not just mean traceable chemical constituents or health risks that are associated with it. It concerns the idea that these products, due to the *way* in which they have been made, have become 'contaminated'. It is interesting in this connection that Albert Heijn (a large supermarket chain) recently decided to change course. Until a short time ago Albert Heijn based their labelling policy on the traceability principle. Chemical analysis of the product as such must be able to show the presence of genetically modified ingredients or additives. They have now changed to the origin principle, which means that whenever GMOs are used somewhere in the production chain, this is stated on the label.

4.10 What is natural food?

A special place has been reserved in the food genomics debate for a problem with a long history: naturalness. Requisite misunderstandings exist over the meaning of the term 'naturalness' in the context of food debates. Seen from a historical viewpoint, moral attention for naturalness is an inheritance from Greek ethics. Naturalness was an important criterion for making a distinction between good and evil also in Greek food ethics. The Greek elite looked on good culinary practices very highly. Naturalness did not imply that food should not go through a stage of preparation at least not in the eyes of the dominant moral culture. The Greeks interpreted naturalness primarily as moderation which they looked on as a good medium between overexcess and self-neglect, and between greed and meanness. Moderation as a moral principle was emphatically linked to status. By practising moderation the Greek gentleman was expressing that he was an autonomic moral subject who was under self-control. Furthermore he was also letting people know that he belonged to a particular social category, that of the gentlemen. The lower classes staggered between season-bound profusion and scarcity, but the gentleman knew under all circumstances to keep himself under control. This moral is still relevant to a certain degree (One example is the Dutch TV ad designed to moderate alcohol consumption among the young- 'enjoy, but drink in moderation') and it has been democratised, i.e., spread around over all social groups. Alongside this dominant Greek food morality was also a minority position or interpretation that was taken by the cynics. They thought that naturalness meant that food had to be consumed as raw and unprocessed as possible. In the context of the Greek food morality this was really a marginal and highly dubious vision.

In contrast to the Greek morality stood the ancient Jewish morality as a rival paradigm. This introduced a completely different criterion: the distinction between permitted and not permitted – a distinction that still plays an important role in current discussions on food genomics. Consumption of meat from ruminants with split hooves was permitted; consumption of pork was rejected. Although considerations of health and hygiene probably did play a role – pigs live an objectionable, unhygienic lifestyle because they consume their own faeces – in the first place it was a symbolic contamination. By keeping to this rule, the involved person made it clear that he belonged to a particular moral culture and had a particular moral identity. The saying 'a man is what he eats' is associated with the symbolic meaning of food, and less on its material characteristics.

Although the logic of moderation is somewhat present in the current context, it seems that the current debate on biotechnology and food, and then especially on *Frankenstein foods* should take place especially in terms of the distinction between permitted or not, or whether symbolically contaminated or not. Although health considerations do play a role and some consumers undoubtedly live with the idea that products that contain GMOs are less healthy than products that are the result of traditional improvement or preparation methods, it concerns especially a symbolic contamination. The genetically modified product represents a production method and an attitude over plants and animals that men reject, more on the grounds of the integrity principle than considerations that affect their own health. By refusing the relevant products the person involved demonstrates his moral identity.

The autonomy of the consumer

Returning to the starting point of the discussion: the autonomy of the consumer. Modern food ethics rests on the suggestion that the supermarket is one of the places where individuals can and should voice their opinion about social developments and especially about the way in which food is produced. Consumers should have the power to make a choice between in their eyes 'good' and 'bad' products, i.e., the supermarket is a place where the modern consumer is able to express their moral identity. They can transform themselves there into a moral subject, namely by buying products that make a certain social engagement recognisable (such as biological products) or that make a particular style of life possible (*slow* food, *health* food, *fast* food). Thanks to adequate and regulated product information the dependence of the producers could be reduced and individual consumers could actually be able to make their own choices. Now that the prototype is no longer reliable and no longer stands for naturalness, it is the shapes, colours and smells of the food product itself that will determine the choice.

It is the symbols, the logos, the figures and letters on the packaging that point the consumer to the desired food product.

We could ask the suspicious question whether the identity and lifestyle that consumers construct in this way is not to a large extent prefabricated? Are the conditions available for the consumers to allow them to prove their own right of self-determination? It seems to be impossible to bridge the gap between the scientifically educated food expert on the one side and the average consumer on the other as very different languages are spoken on each side. For important groups of consumers 'naturalness' is an important consideration and this is expressed in numerous advertisements. For many chemists and other researchers involved as scientific experts in the food production process however naturalness has become a meaningless term. This is because the term naturalness as we use it cannot be defined in terms of ingredients. The Greek philosophical logic that created the term naturalness recognises that natural products require processing (in this case improvement and preparation) and that we put our stamp on these things. It emphasised that we must take into account a certain moderation or restraint. Man gives form to things and alters natural things to his needs and this also applies to crops or animal products that are changed into bread or cheese. However, it still makes sense within Greek moral logic to make a distinction between 'natural' and 'unnatural'. Then it does not really matter about the presence or absence of particular ingredients but more on a particular attitude towards plants and animals that both producers and consumers share. A natural product is improved and prepared in such a way that the producer brings out the possibilities that the crop had in nature. A natural production process invites the plant as it were to bring its possibilities out into the public eye. From a modern-day scientific viewpoint in contrast a product is more an aggregate of ingredients that can be added or removed. The producer possesses as it were an alphabet or a box of ingredients that can be added to products or can be transferred from one product to another. Genetic modification has reinforced, not to say proved this viewpoint, the power of producers to treat crops in this way.

4.11 Finally

The objective of food ethics is recovery of the autonomy of the consumer especially at this time (due to the emergence of food genomics and the increased reach of advertisements) when the position of power of producers is being strengthened. The new emancipated consumer makes his choices in a symbolic reality that is for a large part pre-structured by the producer. The emergence of food genomics will have important consequences for the range of food products. Two developments that will be reinforced by food genomics have been discussed:

the addition of functional ingredients and the return of the prototype. Concerning the addition of functional ingredients the case of Golden Rice has been described above: a product with a moral aspect that was aimed at a particular moral and meaningful target group. Other functional additions will apply to other groups of consumers, such as target groups with high purchasing power in the West who are primarily interested in a healthy and dynamic lifestyle.

The image of the free market that offers consumers the possibility to construct their own identity and lifestyle must really be put into perspective. What we call a free market appears at second glance to be a myth. This market is controlled increasingly by a smaller and smaller number of mega-players: powerful trade names that determine the supply (both the composition and the appearance of the product). In other words the free market is an out-of-date concept. The lifestyles of consumers are to a large extent prefabricated and the image of the autonomic consumer is an idealisation. The current consumer finds himself somewhere on a line between two extremes: the ideal typical consumer who as an autonomic subject looks for his way in the supermarket that should be a reflection of his own desires and the famous white rat in Watson's maze whose behaviour can be conditioned by scientists who are either food experts or advertising experts. When we talk about consumer and market it generally is about ideal types. The actual supermarket lies somewhere between 'biopower' and 'lifestyle'.

The return of the prototype for example appeals, it is true, to our desires for recognisability and naturalness but at the same time is an expression of the stylised assets and power of the producer (i.e., the plasticity of the product), that in the age of food genomics has drastically increased. The process of food production and consumption finds itself in a paradoxical situation. Producers say they are prepared to direct themselves towards the desires and preferences of consumers ('chain reversal'). They propose at the same time that there is a 'crisis of trust' with consumers. The fact that consumers can determine the design and composition of food products in the supermarket is perhaps true from the perspective of large numbers. From the perspective of the individual consumer in contrast the situation is usually experienced in a completely different way. He witnesses the sudden appearance and disappearance of food products and ingredients, and of changes that he can evaluate positively or negatively without being able to exercise any notable influence.

The modern-day consumer lives as it were in a vacuum. He thinks and expects to be able to choose but he now only has a choice of symbols, illusions and lifestyles developed for him by others. Our food is a living example of this: eat, but be careful what it is.

References

Boekel, M. van (2001). *Van disciplines naar ontwerpen. Levensmiddelen-technologie in perspectief*. Speech. Wageningen.

Buckley, K.W. (1989). *Mechanical man. John Broadus Watson and the beginnings of behaviorism*. New York: Guilford.

Coesèl, M. (2002). *Natuurlijk Verkade*. Zaandam: Terra.

Foucault, M. (1976). *Histoire de la sexualité 1. La volonté de savoir*. Paris: Gallimard. [Transl. by Robert Hurley (1987), *The History of Sexuality Volume 1. An Introduction*. New York: Pantheon].

Kant, I. (1800/1968). 'Anthropologie in pragmatischer Hinsicht'. In: *Schriften zur Anthropologie, Geschichtsphilosophie, Politik und Pädagogik 2*. Frankfurt am Main: Suhrkamp.

Marx, K. (1939/1983). *Einleitung zu den Grundrissen der Kritik der politischen Ökonomie. Marx Engels Werke 42*. Berlin: Dietz.

Onfray, M. (1989). *Le ventre des philosophes. Critique de la raison diététique*. Paris: Grasset.

Pavlov, I.P. (1955). *Selected works* (translation from the Russian by S. Belsky) Moscow: Foreign Languages Publishing House.

4.12 Report of the workshops on the socio-economic organisation of food consumption

Astrid van de Graaf

How far does the freedom of choice reach for consumers?

> *The meaning of food for consumers was the central topic of this workshop. Does it have a purely symbolic significance from which the consumer derives identity? Which choices does the consumer make and will they be influenced in the future by the gene passport?*

As a micro-organism directly reacts to a chemical compound so man finds his way to his food via images, words and figures. Eating food is not just about getting sufficient chemical compounds inside when enjoying food but also about the symbolic meaning that food fulfils, according to Hub Zwart of the University of Nijmegen. He introduced the workshop with a historical consideration of food. The choice of a particular foodstuff tells who you are and what you stand for. “You are what you eat and thus what you buy.” For example by choosing genetically modified food the consumer assumes a moral identity. In that way he becomes himself a player and he implicitly legitimises the method of production. This symbolism will increase dramatically with the emergence of genomics.

The large role of symbolism must not be overestimated, according to the participants. Consumers look especially at the price and buy what they feel like eating. Genetically modified products have little chance because of social resistance. If later the useful application of genetically modified ingredients or products becomes clear, then the consumer – and the patient – will make choices based on the functional value of food. The reduction of food to symbolism blocks out discussion on technical possibilities of choice.

Prototype
Due to food genomics, mentioned in the same breath here as genetic modification, the image of the original foodstuffs will again enormously increase. By this Zwart meant the return of the prototype: the tomato with a longer shelf-life replaces tomato puree from a tin and calls up the symbolic value of naturalness. The emancipating consumer broken free from the anonymous masses makes individual choices from the

food on offer and thereby proclaims a particular lifestyle. This aspect can be used effectively by producers in their marketing strategy, such as Becel fits well with people who find a healthy life important. The attention for nutritional value shifts towards normal values such as nature and health. A number of participants commented that the purchasing of enriched foodstuffs is much easier than altering the pattern of consumption especially when particular ingredients will only have an effect in the long term.

The individualisation trend will just continue due to nutrigenomics and the development of health foods, according to Zwart. At the same time he noticed that this development is at odds with the value of the meal: a social activity that creates a bond because the same food is enjoyed by all. In addition it teaches children to take a wide range of foods and not just pancakes and French fries. When later four different dishes appear on the table, that are tuned to each person's genetic make-up, the social or family bond will be broken. The question is whether the gene passport will lead to forced variation within the family.

Gap

Another aspect that Zwart brought up was the increasing distance between production and consumption since the start of the Industrial Revolution. The consumer is more remote from the product that he buys in the shop and currently has little insight into the way it was made. This gap will get bigger due to genomics. However both the citizen and the consumer think it is important that the chain is transparent and that health claims are well founded. Genomics is able to prove that particular ingredients in our daily food do have a benefit on health, but who takes care of the expertise for countering these claims? Will we later need an Approval Service for Genomics Goods? Only a small part of the population is aware of the health aspects of food but safety in contrast is important although it cannot be 100% guaranteed.

"Is freedom of choice an illusion and the free market a myth?" is the next question. The more and more emancipated consumer can select for himself but is not autonomic in this. He must make a choice from a range that is to a large extent determined and dominated by a limited number of players (the 'big players': food companies and supermarket chains). The supermarket sells what the masses buy and has no space for individual desires. The consumer is tempted in turn by special offers and marketing. The objection is that the consumer has in fact gained more possibilities of choice and this trend will just continue. The gene passport means in the first place a limitation of the freedom of choice because many people will no longer be able to eat everything. Opposite to this, the consumer still shows an increasing need for products that are appropriately tuned to his body.

Life expectancy

Proper food supplies, hygiene and health care have doubled life expectancy probably in less than two centuries, but the quality of life can still be further improved, especially in the area of health. Thanks to genomics, a substantial step can be taken, observed Frans Kok of the University of Wageningen during an earlier experts' meeting (see Appendix 2). Is the consumer prepared to pay a certain price: the 'toll' for a long healthy life? Or is the consumer prepared to let someone screen his genetic make-up despite the possible unpleasant consequences? Will the consumer, in order to avoid symptoms occurring in later life, take in food for which it is still not clear that it is absolutely safe (safety versus the risk-benefit balance)? And will he also be willing to pay more for this?

If the developments in the area of food genomics continue and everyone has a gene passport then the distribution pattern of food will change, according to one participant. Distribution will no longer go through the supermarket but via differentiated food chains. So-called communities of people will arise with a particular genetic profile and shops with the appropriate products. People will derive their identities from these communities and this will create a new way of communicating about food, or ingredients with a particular symbolism. It is even imaginable that products will be 'purified' on genetic profiles (i.e., by switching off damaging compounds such as certain allergens for some people, genetically guided) so that everyone can eat everything.

The fact that new products emerging from genomics will lead to social changes in the near future seemed to be agreed by everyone. The intimacy and emotional link with our food will become greater and will indeed affect our body right through to our genes. It is therefore important not to wait, but to anticipate and initiate discussions now.

Some of the written suggestions for the societal agenda:

- the relationship between food genomics and genetic modification must be clarified;
- use food genomics in order to study the health effect of functional and fast foods, and also 'normal' food;
- how can research and development in food genomics take place in a demand-driven manner
- stimulate research into the social effect of food genomics on our eating culture.

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5 The issue of food genomics: about reluctant citizens and united experts

Hedwig te Molder & Jan Gutteling

5.1 Introduction

After cloning and genetic modification, there is now a new conversation topic for the coffee table: genomics. The substantial investments in what is called so pleasantly the social component of genomics raise suspicions that the stimulus by the government to deliver speeches and to debate is not completely without obligations. And they will talk. As usual we will be regaled with flowery stories about what can and cannot in this budding area of science. With food genomics we are provided with for example sophisticated possibilities for altering our food package according to our hereditary constitution. For the sake of convenience we here use the term 'food genomics' for both the study into the relationship between nutrition and inherited characteristics of people, and for research into the hereditary material of plants.

As stated in the recent experts' meeting: "Just as there are already specific foods for people with diabetes, gluten allergy and an increased cholesterol level, there will be, thanks to nutrigenomics, foods that will come on the market specifically for people with an increased inherited risk of intestinal cancer or depression for example." (Appendix 2).

For the time being the term genomics will only ring a bell for a small minority. Although the esoteric character of the term undoubtedly contributes to this limited renown, other reasons are also probably lurking in the background. Experts scrupulously avoid association with genetic modification and emphasise the neutral, ordering nature of genomics: it is first concerned with *mapping* the complete DNA information of man, plants and other animals, as Professor Stiekema recently argued in an interview (*Resource* 3 2001) which can also be read in the report of the experts' meeting of 31 January 2001 (Appendix 2).

Learning from earlier social conflicts on biotechnology, the pressure is on the experts to turn over a new leaf and skirt around the loaded debate on genetic modification whenever possible. In this respect the attitude of some experts makes one think back to the discussion a number of years ago in which the term ‘manipulation’ had to make way urgently for the less emotive term ‘modification’.

In the meantime it is difficult to deny that genomics and genetic modification are very closely linked to each other. For food genomics, the area of genomics to which we limit ourselves here, there will be considerably fewer applications on the horizon if the way to genetic modification is blocked (Jansen 2001). Furthermore the development pathway is much longer for applications that take place via the traditional route of selective crossing. In short, it is highly possible that genetic modification will play a considerable role in applications of food genomics.

No matter how this relationship will develop in practice, the public will not be bothered at all by the territorial fight that scientists will allow over this point. The associations with genetically modified food force themselves on us, earlier or later, whether we want them to or not. From this perspective, and from the understanding that for each evaluation of scientific developments the historical context plays an important role, it is worth taking the trouble to look at earlier experiences from the social debate on genetically modified foods (Wynne 1996, pp.19-46). Starting from the current impasse in this discussion, this contribution is an argument that effective technology development in the area of genomics assumes we should look into the reactions of consumers and the general public even more deeply than previously and then especially at the assumed weakness of this.

5.2 The embedding of knowledge and technology in everyday life

Let us first formulate the issue somewhat more broadly: what do we know in general about the relevance of scientific knowledge in our everyday existence? We could conclude that this relevance is not easy to find from studies aimed at evaluation of science by ‘ordinary’ lay people. Eventually scientific information sources will be evaluated according to “the extent to which they assist in the understanding and control of one’s life” (Irwin et al. 1996, p. 63). The media sociologist Silverstone once said about new media that they must become domesticated, i.e., tamed for daily use, so that they can become part of our ‘normal’ lives (Silverstone 1998, pp. 17-34). Time after time it seems that scientific knowledge and much of the technology that emerges from it is only barely relevant to daily practice. The comment that "you can't do anything with it" can cause scientists' blood to boil but also correctly touches a sensitive point in many cases.

In any case the usefulness of scientific knowledge should not be too narrowly defined: it does not *per se* mean a reasoned sort of usefulness, that occurs based on functional considerations. Questions of identity for example play an essential role in the way in which we deal with our food habits (Caplan 1997). Whether we follow up on nutritional advice that is accurately tuned to our personal constitution (one of the possible applications of food genomics) depends on the calculated advantages and disadvantages and also for example on the question of whether this technology is associated with our own identity or lifestyle.

A related condition for acceptance and use is that knowledge and technology must be allowed to embed into our daily *discourse* and this does not appear to be easy. Those who practice the cultural research tradition of risk and risk perception have found this phenomenon labelled as a lack of image: we go back to old stories and myths that in part feed and in some cases block our powers of imagination (Van Dijck 1997, pp. 83-96). A dominant cultural source is the Frankenstein myth that wakes up both deep anxieties and limitless enthusiasm for science and technology. During the recent food scare in England the term *Frankenstein food* played an important role in causing the panic that broke out after the scientist Pusztai had warned about the, in his opinion, unsound test methods for genetically modified foods (Van den Belt et al. 1999, p.103). The debate became very black-and-white due to this with little space for intrinsic deliberation.

5.3 Societal debates on biotechnology

What conclusions can now be drawn if we look with these insights into the progress of the *organised* societal debate on genetic modification? From the 1980s various debates have taken place in the Netherlands regarding the opportunities and risks of modern biotechnology. The approach and organisation of these public debates have been analysed by government, institutes and science. It was not until the 1990s that the public were given a role in this. In 1993 the first real public debate was organised with the very direct question 'Genetic modification of animals – should it be allowed?' This debate took place mainly with a lay panel of 16 persons and a panel of experts, according to the model of the Danish consensus conference (Van Est et al. 2002). The results were put into words in a 'closing declaration' of the lay panel intended for the Lower House of the Dutch Parliament. The initiative for this first public debate came from the former NOTA (Netherlands Organisation for Technology Assessment, today named the Rathenau Instituut), the PWT Foundation (an organisation to disseminate information on science and technology today named WeTeN) and SWOKA (a consumer research organisation). Under the title *Food and Genes,* the sixth and up to now last debate over genetic modification was held recently (Hanssen et al. 2001).

One of the most remarkable 'results' of this series of organised public discussions is that they have not succeeded in becoming really public. This observation can be found from an important section of the respondents who were questioned after the *Food and Genes* debate: more than 40 % could not answer the question of what had they noticed most during the debate, about the same percentage found it especially noticeable that people had heard so little (of the debate). How can we interpret this?

A simple explanation lies in the role of the media. Except for the debate on food and genes, organised debates in the Netherlands have been able to attract very little coverage in the media. In the *Food and Genes* debate, what was remarkable was the nature of the interest. About three-quarters of all media attention had no direct relevance to the theme of genetically modified foods, but concentrated on the controversy between the Terlouw Commission that led the debate and 15 social organisations on the rules for the debate. From the above study, it appeared that after the end of the debate this question had hardly bothered any of those questioned: only two percent found that this affair was the most noticeable part of the debate. It would appear that the preferences of the media appealed badly to public sentiment. It also showed that a certain amount of media attention does not guarantee that a public discussion bursts forth.

The question of course remains: what does interest the public? Although there is more than one explanation for the lack of lively debate, it is very plausible to assume that the discussion themes had no connection to everyday life. The daily usefulness was not visible, tangible or otherwise recognisable and thus we did not worry about it very much. This agrees with the much heard remark during the *Food and Genes* debate: it is not possible to explain to the general public what the added value of genetically modified foods now is. There are disputed advantages for producers and the Third World but it is unclear exactly what the citizen-consumer gets out of it. In combination with the unclear risks, the lack of a demonstrable added value could explain why the debate has shaken so little loose, at least in the public sphere outside the NGOs.

5.4 Information requirements and the passion to participate

At the same time another apparently conflicting reaction can currently be seen. It became clear from the above-mentioned study of the *Food and Genes* debate that the public wants to have more information on biotechnology and its applications. When asked about the current provision of information, the reply was that it was clearly too little and especially the role of government was called into question. Were they monitoring things properly? Was the information given by the government correct? Who makes the rules? It was also noticeable that the public wanted to be treated less paternalistically and to participate more in the decision-making. Earlier studies into decision-making processes and the flow of social information about the risks of modern biotechnology confirmed that the public claims for itself an important place in that process (De Jong et al. 2000, pp. 165-180).

The results of the study of the *Food and Genes* debate were intriguing because this self-signalled passion to participate suggests the public would also be willing to vent their feelings about gene foods. The question is actually how must we interpret this desire for participation and information? In a fascinating article on the role of trust in risk perception, the sociologist Szerzynski argued that expressions of trust and mistrust directed at institutes that carry responsibility in the area of risk prevention must not be looked on purely as the result of cognitive processes (Szerszynski 1999, pp. 239-252). In other words, with such expressions the speakers are describing not just their mental state but are also performing a 'social act' (see also Potter 1996; Te Molder 1999, pp. 245-263).

It is therefore possible to look at expressions of mistrust as a way of getting institutes to take action, or as Szersynski formulates it: "to bind the trusted into a relationship and attitude of responsibility" (Szerszynski 1999, pp. 239). Irwin and colleagues show how an apparently 'unambiguous' request for information often contains more than just the satisfaction of a need for information (Irwin et al. 1996, p. 63). Many of those asking the questions want to seduce the appropriate institutes to take initiatives at the same time. Finally, it is obvious that people with complaints and comments on the misbehaviour of this or that organisation or person are not only making a complaint but are also giving out a signal of involvement (the indifferent do not even bother to complain). In that way they are rather confirming their relationship with the organisation in question than undermining it.

With the call for information and participation that appeared to come from the study of the public resulting from the *Food and Genes* debate, something of that sort could be going on. The observation that here it is purely about the demand for knowledge and participatory influence seems to be far too simple. The tame debate and the apparent lack of involvement talked of here, are not consistent with the explicit request for information and participation urged simultaneously, unless the information and participation need can be interpreted as a way to move the authorities and other responsible institutions into action. In that case one has to say that citizens would like to see these types of things well organised (and kept under control), but may not wish to get involved automatically in the circus of participation that is initiated with even greater regularity around current social topics. This seemed also to be the case in the first public opinion poll that took place within the framework of the public debate on *Food and Genes* in June 2001. From a representative sample of 1019 citizens of 18 years and older, the great majority (73%) said that they did not agree with the statement 'In my opinion only the government should determine how modern technology progresses; 77% agreed with the statement 'Social organisations such as Greenpeace or the Consumers Association should have more influence on decision-making related to genetic manipulation'. No less than 93% endorsed the statement 'I think that it is a good idea that the government and social organisations cooperate more towards finding a solution for the use of genetic manipulation and food'.

5.5 Where is the autonomous consumer?

It is clear that the desire to see everything well managed but without being directly involved is not politically correct. The question is actually why such a desire is not legitimate. Whether it is now laziness, cognition or recognition of ones own limits, the fact is that few living souls can or want to comply with the overstressed requirements of the modern consumer-citizen. This consumer is involved, well informed and continually looking forward to taking his own well-considered decisions. This is the image of the mature, autonomous consumer who inhabits the pages of the policy reports – terms such as freedom of choice of the consumer and right to information fit smoothly with this identity. Daily practice actually shows a completely different image, namely of the passive, apparently indifferent consumer who is not ready actively to react to information and omits even to read labels.

Undoubtedly the first image agrees more with the pleasant policy initiatives. A somewhat slow consumer-citizen is 'activated' with difficulty and is typically a less interested, less involved conversation partner. The roots of this dominant image lie more fundamentally in the political-liberal body of thought that traditionally plays an important role in the discussion on consumer rights (Van den Belt et al. 1999, p.103). However, the ever critical and oh-so-autonomous consumer is very hard to remove from the discussions on technology development and thus obstructs the creation of a more realistic image (Frissen 2001).

In a certain way this almost romantic image of the consumer is not just maintained but also misused. The much argued freedom of choice in the case of genetically modified foods has appeared to be especially also a 'safe' way in practice: they shift the judgement to the consumer precisely at the moment when the consumer mindlessly dives into the shelves and takes a product. They rarely if ever read the labels, even quickly. Freedom of choice assumes a measure of reasonable self-control that the consumer at that moment should and probably also wants to delegate. The fact that the discussion concentrates on this idea hinders proper debate on development of the technology itself and the actual conditions under which this has taken or will take place.

5.6 Public disputes: what next?

The image of the autonomous consumer has paradoxically enough made the same consumer open to blackmail. You will participate; if not then you will lose the right to a different sort of involvement of a more passive nature. Genomics and food genomics may suffer the same fate. The essential question for trust in technological development and responsible institutions is how the voice of the consumer-citizen will be heard. This trust issue will remain an important topic in the next few years, as it is more complex than is often assumed and goes further than the restoration of belief in governments and institutions. Among other things, trust is based on the manner with which politics involves the public in its decision-making, how companies cope with consumer interests, and the perception of the way in which modern biotechnology will influence the lives of individuals. Public trust is finally the referee that decides whether and how a technology develops in the community.

In order to restore trust, openness towards risks and uncertainties is essential. Considering the intrinsic uncertainties of modern technology that trust can never be absolute and unconditional. This means that the debate, the dialogue with the public, has become a continuous process for all involved – not least for government and companies. The dialogue on genomics is a crucial test for this.

Politically correct behaviour, i.e., involving the public in large numbers at specific moments in the development of knowledge or a technology, does not seem to be the proper way. A similar reflex reaction does not remain unnoticed by the public. The Dutch writer Remco Campert recently put this strikingly: "I was spoken to on the street by someone who asked whether I was a citizen. In order to get rid of him I just denied it" (CAMU 2002). The continuity of the debate, in combination with the expected desire to exercise influence without participation on a large scale makes small-scale initiatives such as long-term consumer or citizen panels more likely.

Food genomics with its potential consequences is a complicated subject. It requires imagination to identify and evaluate these future consequences. How people will make use of the knowledge that a genetic map will provide in terms of short and long term risks and the consequences this will have on daily feeding patterns? There are also the product advantages that crops could have on the basis of information that is gained from genomics. Long-term involvement means that you can get really into the possible social impact of the technology and can train your imaginative powers somewhat. The fact that these panels or forums only make it possible for a selection of participants who in the long term no longer look blankly at the technology (and who does that anyway?), is in short not *per se* a disadvantage but also an advantage. In any case we have not said that large-scale debates should be abandoned – but the reflex with which they are organised should be abandoned. A large-scale public debate assumes a high degree of involvement from a large group of participants and thus a reasonably direct link to our everyday worries and discussions about them. The tendency exists to overestimate this connection yet underestimate the importance of it. We cannot predict whether the genetic map and the principle of custom-made foods will be received with the same enthusiasm as how they were propagated. Long-term issues always have problems finding a place in daily conversation.

One thing that is certain is that in an *early* stage of the technology development, the social consequences must be evaluated. However at the same time many of the daily consequences cannot be envisaged at this stage and especially not for genomics. It is of the greatest importance that, during the development of the technology, possibilities remain for intervention and management and if necessary for decision reversal. The advantages of such a strategy are amply balanced in the long term against the costs. Attention for the initiatives organised by the authorities should really never mean the death of attempts that individuals undertake to influence the development of technology. The most lively debate occurs from spontaneous day-to-day involvement and no organised initiative will change anything of that (Frissen & Te Molder 1998). It is no accident that *communities* on the Internet set up by users themselves are the most vital and busiest forums of discussion. Being alert to early initiatives and supporting them, also or perhaps exactly in the case of alarm sounding 'bell-ringers', it is a precarious but eventually very effective way to provide social comment on technological developments (Rip 1991, pp. 299-312). Because early signals also lead to possible misunderstandings, it is important that authorities and other involved players not orient themselves to trust as such, but especially to support certain forms of 'mistrust'.

The above discussion assumes finally that there is some clarity about the way in which and degree to which the results of this sort of discussion panel and other initiatives can exercise influence on the decision-making committees. If there is something that was lacking over recent years concerning the set-up of these public debates then it is the clarity of their management scope. The public, as far as they are already involved, has great doubts whether the results of a debate will have an influence on political decisions. Part of the reason is that in the Netherlands there is no suitable channel for translating the results of public debates into political decisions by which the process, in case it is present, remains out of sight of citizens.

5.7 A new role for the genomics expert?

Experts will play a crucial role in the upcoming debate on genomics and food genomics. Actually the expert has always been present but the trend for leaving communication about new technology to communication specialists, science journalists and such like has made him into an ogre, not completely despite but also thanks to these experts. All too eagerly experts refer to the information officer when it concerns controversies within sciences involved or uncertainties over the consequences of a particular technology. Food genomics, with its predictable doubts over possible risks, also appears susceptible to multiple referral and this is unjustified. The criticism directed at experts over the recent past and the shortcomings of the prevailing technical approach to risk communication (in which the scientists' role was embedded) makes this tendency to delegation rather understandable.

Failure of the technical approach

Traditionally risk communication from the authorities, private enterprises and scientific experts consists of providing 'rational' information that is aimed at increasing the knowledge of the public. The idea behind this is that when the public comes into contact with the 'facts' they may change their irrational views on the risks and their subjective perceptions will fall more in line with the objective scientific evaluation (Liu & Smith 1990, pp. 331-349).

Risk communication is seen as a linear process with one-way traffic by which the experts inform the lay people (Gutteling & Wiegman 1996). This perspective on risk communication is seen as the technical approach (Rowan 1994, pp. 391-409). In the most extreme form it consists of one-sided, top-down information flows from the expert to the public based on the idea that this latter group just as the expert himself has a need for accurate (read: technical, quantitative, or statistical) information and scientific expertise. If the public refuses to agree with the risk outlook of the experts then this is assigned to a lack of understanding or a misunderstanding. This could be corrected by offering the correct information again or by applying persuasive strategies.

There are a number of reasons why such a technical approach, in which the superiority of experts is resolute, is doomed to failure (Cvetkovich et al. 1989, pp. 253-276). The first point of criticism is aimed at the incorrect premise that the public keeps to the same style of analysis as the source of risk information, when the public deals with risk-related messages. By consistently keeping to this rationalist-based communication strategy, doubts from the public on the nature and scope of risks will more likely be strengthened instead of being removed (Rowan 1994, pp. 391-409). It is then not surprising that there are many examples reported of situations in which the public lose their trust in the people who use a similar top-down approach of risk information (Peters et al. 1997, pp. 43-54).

A second point of criticism is that followers of the technical approach mistakenly believe that risks are apolitical. A process that starts as an apparently simple transfer of risk information soon becomes a political issue around fundamental questions about the acceptance of risks (Kasperson 1986, p. 275). Experience in the debate on genetic modification speaks volumes here. More generally, the process in which social choices are made, and the degree in which the advantages and disadvantages of particular activities are distributed fairly over different groups in the community, can no longer be ignored. It has also become clear that a monopoly on risk information in order to create public trust is everything but desirable.

A third and last annotation: the technical approach assumes that the public observes risks in the same way as the originator although studies show that this is seldom the case. There are extensive study reports on public reaction to risks. A number of social and behavioural science disciplines have contributed to that body of knowledge (Rowan 1994, pp. 391-409). Those studies show that this so-called risk experience is not only associated with 'objective' risk characteristics of a situation or an activity. Social unrest occurs when a large group of people experience the relevant risk as threatening. This occurs for example when the consequences are insufficiently known by the experts or public, when people are exposed involuntarily to the risk and when an individual can do little to keep the risk under control. Almost always the public believes that the authorities and/or business have taken insufficient, inconclusive or untimely risk-limiting measures. It seems that citizens have less and less trust that government policy is adequate in risk situations (Slovic 2000).

Studies also show that the risk perception of the public is very different from that of experts. The views of the latter are especially based on 'objective', statistical, actuarial data aimed at the social but not individual consequences of risks. Douglas and Wildavsky (1982, pp. 49-51) propose that when one studies the relationship between the physical characteristics of a risk and the risk perception one also needs to take account of social and cultural processes that contribute to how people interpret risks. Slovic (1993) observes that there are numerous mechanisms that assist social reinforcement of risks, such as media reporting, the involvement of various social groups (e.g., environmental groups), and the signal value of an incident or an accident for determining the seriousness of the risk.

The uniformity of experts

These insights and experiences have left organisations scratching behind their ears when it is in their interest to work towards a more effective communication process. Assigning more priority to the view on risks in the community is thereby an important first step; the setting up of communication with the public along professional lines is a second. In practice this means 'professionalising' and especially making large investments in public relations and spokespersons, despite the fact that in the meantime the disadvantages of a purely instrumental approach are sufficiently well known.

The fact that experts talk less and less themselves leaving reporting to hired communication experts is an important cause of the apparent homogeneity that groups of experts show to the public. Seldom in history has one seen such a united lobby of biotechnologists facing an almost as homogeneous anti-lobby of a number of social organisations as in the debate on genetically modified foods. For the time being we should not expect anything different from food genomics, many applications of which will use genetic modification. Making visible to the public the presence of diversity, feelings of uncertainty and controversies are important conditions, however paradoxical, for a good dialogue with the public. Infallible scientists who always agree will not be trusted, and rightly so.

Experts themselves are finally the most credible source for this type of risk information, and that does not exclude communication experts, but gives them another role (Szerszynski 1999; Hanssen et al. 2001). It is too simple an argument to say that self-interest would be an interfering factor in the credibility of this information. When evaluating information from others, people are continually taking into account potential interests and this applies not only to experts. Lay people are in general fully capable of separating the wheat from the chaff as long as the diversity of information sources is carefully monitored.

Of course with the involvement of experts the differences in risk perception between the experts and the general public are not immediately removed. In the longer term it is important to bring natural scientists into contact at an early stage with insights from other disciplines in this area, and many Dutch universities already apply this principle in practice. In the case of, for example, biotechnology that practice is also enforced by the social unrest around this topic. In the short term, it is important to actively support companies and researchers already balancing between the two worlds and who develop initiatives in this area. An example of this is the phenomenon of the Community Advisory Panels who currently function around a number of chemical companies in the Netherlands (Gurabardhi & Gutteling 2001).

5.8 Towards a societal agenda

Despite the friction that is partly inherent in the communication between experts and lay people, it is important that more experts be present at forthcoming debates about food genomics. Many experts dissociate themselves from communication with a wider public or leave it conveniently to communication specialists or professional spokespersons. The experts themselves are primarily responsible for this communication. It may be possible to avoid the rebirth of the Frankenstein myth: it does not concern here obscure scientists preparing their genetic brews in backrooms; at least that must be proved. Transparency regarding any risks and the way in which scientists cope with them, including 'internal' conflict and uncertainties, is of great importance. Openness on potential risks will allow citizens to gain trust that experts themselves will monitor the safety and significance of their own research products (which is not the only guarantee that we must build in).

The attention for 'small scale' and acceptance of diversity in both the form of public initiatives and the degree of involvement of the public itself argued here are closely associated with this 'new' expert role. The more we come into contact with the 'day-to-day' significance of technology for both the public and experts, the more the debate on technological developments will approach its roots. Whatever this pathway will exactly deliver, it should spare us a predictable and difficult to digest debate in the (near) future.

References

Belt, H. van den et al. (1999). *Functional foods. Van dilemma's naar beleid?* Den Haag: Ministerie van Landbouw, Natuurbeheer en Visserij. Programma Technologisch Aspectenonderzoek

Caplan, P. (ed.) (1997). *Food, Health and Identity.* London: Routledge.

Cvetkovich, G. et al. (1989). 'Designing technological hazard information programs. Towards a model of risk-adaptive decision making'. In: C.A.J. Vlek & G. Cvetkovich (eds.). *Social decision methodology for technological projects.* Dordrecht: Kluwer Academic Publishers, pp. 253-276.

CAMU, *de Volkskrant*, 18/02/2002.

Didde, R., 'De biologische storingsmonteur komt eraan. Genomics leest de activiteiten van genen'. In: *Resource, Magazine van Wageningen Universiteit en Researchcentrum* 3 (2001) 2, pp. 6-8.

Dijck J. van. 'Het verbeeldingstekort. Over kloning, media, wetenschap en sciencefiction'. In: *Kennis en Methode* 21 (1997) 2, pp. 83-96.

Douglas, M. & A. Wildavsky (1982). 'How can we know the risks we face? Why risk selection is a social process'. In: *Risk analysis* 2, pp. 49-51.

Durant, J., M. Bauer & G. Gaskell (eds.) (1998). *Biotechnology in the public sphere. A European source book.* London: Science Museum.

Est, R. van et al. (2002). 'The Netherlands. Seeking to involve a wider audience in Technology Assessment'. In: S. Joss & S. Bellucci (eds). *Participatory Assessment. European perspectives.* London: Centre for the study for democracy, University of Westminster.

Frissen, V. & H. te Molder (red.) (1998). *Van forum tot supermarkt? Consumenten en burgers in de informatiesamenleving.* Leuven: ACCO.

Frissen, V. (2001). *De nieuwe kleren van de keizer?* Position paper for the Ministry of Economical Affairs. The Hague.

Gaskell, G. & M. Bauer (eds.) (2001). *Biotechnology 1996 – 2000. The years of controversy.* London: Science Museum.

Gurabardhi, Z., & J.M. Gutteling (2001). *De relatie tussen externe risicocommunicatie en de interne communicatie van organisaties. Handbook of Internal Communication.* Alphen a/d Rijn: Samsom.

Gutteling, J.M. & O. Wiegman (1996). *Exploring Risk Communication*. Dordrecht: Kluwer Academic Publishers.

Hanssen, L. et al. (2001). *In de marge van het publiek debat Eten en Genen. Flankerend onderzoek in opdracht van de Commissie Biotechnologie en Voedsel*. Enschede: Aspect 69.

Interdepartementale Commissie Biotechnologie (2000). *Integrale Nota Biotechnologie* (Appendix).

Irwin, A., A. Dale & D. Smith (1996). 'Science and Hell's Kitchen: The Local Understanding of Hazard Issues'. In: A. Irwin & B. Wynne (eds.), *Misunderstanding Science? The Public Reconstruction of Science and Technology,* p.63. Cambridge: Cambridge University Press.

Jansen, L. (2001). *Genomics. Over de noodzaak van genetische modificatie*. Den Haag: Rathenau Instituut.

Jong, J.M. de et al. 'Genetische manipulatie. Maatschappelijke reacties en communicatieprocessen'. In: *Tijdschrift voor Communicatiewetenschap* 28 (2000) 2, pp.165-180.

Joss, S. & J. Durant (eds.) (1995). *Public participation in science. The role of consensus conferences in Europe*. London: Science Museum.

Kasperson, R.E. (1986). 'Six propositions on public participation and their relevance for risk communication'. In: *Risk Analysis* 6, pp. 275-281.

Liu, J.T., & V.K. Smith (1990). 'Risk communication and attitude change. Taiwan's national debate over nuclear power'. In: *Journal of Risk and Uncertainty,* 3, pp. 331-349.

Molder, H. te (1999). Discourse of Dilemmas. An analysis of communication planners'accounts. In: *British Journal of Social Psychology* 38, pp. 245-263. (also available via www.rathenau.nl)

Over de organisatie van publieke debatten (1999). Den Haag: Ministerie van VWS.

Peters, R.G. et al. 'The determinants of trust and credibility in environmental risk communication. An empirical study'. In: *Risk analysis* 17 (1997) 1, pp. 43-54.

Potter, J. (1996). *Representing Reality. Discourse, rhetoric and social construction*, London: Sage.

Rip, A. (1991) 'The Danger Culture of Industrial Society'. In: Kasperson, R.E. & P.J.M. Stallen (eds.). *Communicating Risks to the Public*. Groningen: Martinus Nijhoff, pp. 299-312.

Rowan, K.E. (1994). 'The technical and democratic approaches to risk situation: their appeal, limitation, and rhetorical alternative'. In: *Argumentation* 8, pp. 391-409.

Silverstone, R. (1998). 'Talking about the Screen Machine. De toekomst van nieuwe media in Europese huishoudens'. In: V. Frissen & H. te Molder (red.). *Van forum tot supermarkt? Consumenten en burgers in de informatiesamenleving*, pp. 17-34. Leuven: ACCO.

Slovic, P. (1993). 'Perceptions of environmental hazards. Psychological perspectives'. In: Garling & Golledge (eds.), *Behaviour and environment. Psychological and geographical approaches*. Amsterdam: Elsevier Science Publishers.

Slovic, P. (2000). *The perception of risk*. London: Earthscan.

Stichting Consument & Biotechnologie (2001). *Xenotransplantatie kan dat? Eindrapport van het publiek debat xenotransplantatie*. Den Haag: Stichting Consument & Biotechnologie.

Swaans, K. & L. Hanssen (1998). *Vormen van publieke discussie. Van monoloog naar dialoog*. Utrecht: Stichting WeTeN.

Swierstra, T. (2000). *Kloneren in de polder. Het maatschappelijk debat over kloneren in Nederland februari 1997 – oktober 1999*. Den Haag: Rathenau Instituut.

Szerszynski, B. (1999). 'Risk and Trust. The Performative Dimension'. In: *Environmental Values* 8, pp. 239-252.

Wynne, B. (1996). 'Misunderstood misunderstandings. Social identities and public uptake of science'. In: A. Irwin & B. Wynne (eds.). *Misunderstanding Science? The Public Reconstruction of Science and Technology*, pp. 19-46. Cambridge: Cambridge University Press.

5.9 Report on workshops on the desires and concerns of citizens and consumers

Astrid van der Graaf

The public wants more information and influence, but does not want to participate in the many debates

This workshop especially concerned the way of communicating with the public about new technology. Who should do that, and in what form? What role should the public themselves play in this?

In order to restore the trust of the public in modern food technology, open and transparent communication is essential. Participation of communication experts on genomics is a pre-condition for restoring this trust, according to Hedwig te Molder of Wageningen University and Jan Gutteling of the University of Twente. The question is how can we get the 'clumsy' and 'sensitive' scientist to make a clear explanation of their findings in such a way that it can also be understood by the public? Some advice from a communication professional would seem to be appropriate. Genomics is a diffuse field involving various related disciplines which makes it difficult to identify the single genomics expert. For public communication, experts from environment, patient, and development organisations should also play a role so that the different fears, positions and arguments become clearly apparent. The expected positive contribution from the expert in the dialogue is furthermore not undisputed in the light of past experience. Even so Te Molder and Gutteling estimate highly the value of authenticity and trustworthiness for the messenger, characteristics that may be lacking with an inexperienced spokesperson. The aim of the communication must also be clear if the messenger wants to successfully inform or convince his audience.

Whether a large-scale social debate is the most ideal form for involving the public in the issues surrounding food genomics is very doubtful as the debate is possibly too elitist. A subject that does not yet 'live' cannot be brought to life by fixed moments of participation, also not if the idea is that it is 'now or never'. If it is clear that the debate will influence the decisions of the authorities, this will improve participation, but the subject must of course be relevant to participants also.

Paradox

In addition there is also the so-called participation paradox: wanting to participate, but not actually participating. The public wants more information, more involvement in and more influence on the decision-making but does not believe that they themselves should participate in all sorts of debates. This role is allocated to the pressure groups that speak up for their concerns and desires. They expect that these stakeholders will do a good job so that everything will be well organised and controlled. A number of participants emphasised that the public is still too afraid to take part in debates because they think that they do not know enough. They only dare to speak up and make choices when they have been sufficiently well informed. According to some speakers, there is also a so-called spectators' democracy in which the messenger is more important than the message. Others would welcome the fact that the pre-conditions for nutrigenomics are so well organised that the consumer has trust without being bothered by detailed information over how and what.

A large-scale debate at this time on genomics appears to stand no chance. But then how can it? Small-scale discussions that are connected to the experiences of the citizen (man in the street) and his personal interests can be initiated. Current affairs or feelings of social unrest are a good indication of this. Use can be made in this discussion of existing structures such as employer's organisations, community centres, senior citizens clubs, or schools, supported by a discussion package if necessary. It is important therefore to gain a better insight into public perception of technology (i.e., what the citizen thinks) and into the factors that determine public reaction.

Discussions about medicines usually concern a single compound or a single pathway in the biochemical system, whereas food is a mixture of components that can cause a multifactorial effect on the entire cell and eventually the entire body. This is where genomics is most suited, according to Ben van Ommen of TNO Nutrition, the leader of the workshop on behalf of the natural scientists. In ten years the personal gene passport will tell a person which food is best suited to their genetic make-up and if necessary, personal nutrition can then be developed. In five years we shall have gained all the information based on genetic sub-groups (polymorphic populations) about the food that best suits our genes, which could furthermore reduce the risk of chronic diseases in the future. This will result in further blurring of the line between food and medicine. As long as this genetically responsible food tastes good and looks good there will be no objections, according to the participants. And we do not have to return to the original tomato to achieve this. In addition producers can change the composition of the food without changing the taste, for example French fries with healthy fats. Due to the developments in the area of food technology, attention for consumer desires will be greater than ever. The Dutch have themselves a large degree of trust in their food and the monitoring authorities. Trust in the safety of functional foods can only be achieved via very good marketing strategies, according to some of the participants, although the scientists say that modern eggs are less safe than functional foods will ever be in the future.

New foods can be developed via genomics. In addition this knowledge can also help to finally prove what is correct about the acclaimed health claims and what are the health effects of for example too high levels of pesticides. In this way genomics can provide important results on food safety. The question is how can the public ensure that these issues will actually be studied? Who determines the research agenda – the government, science/scientists, or social organisations representing the public? For exactly these sort of questions it is important for the public to be involved at an early stage.

Terminology

A recurring discussion is about the meaning of terms. Thus 'the public' consists of the 'consumer' and the 'citizen', two roles in one person. What someone believes is desirable as a *citizen* (i.e., his own attitude), does not mean that he will put this same into practice as a *consumer* (i.e., in his own behaviour). A few participants wanted to add the *patient* to this because a person in this role lowers their acceptance levels more easily for new technology. Therefore the 'consumer' remains difficult to define. The consumer does not have a single feeding pattern but buys everything at once and decides rather fancifully between 'slow' and 'fast' food – which are often synonyms for 'good' and 'bad'. The often sketched image of the mature consumer, autonomous and well informed, is also very dubious. How can a researcher looking into public perception handle this?

Another obstacle is the difference between the terms genomics (i.e., measuring gene activity) and genetic modification (i.e., altering genes). In order to clarify the discussion, a distinction is essential but the public will not be able to keep these two terms apart easily. Moreover genetic modification will play a role in the application of genomics. In order to demystify the term genomics, the application of genomics should be more emphasised in communications to the public.

Some of the written suggestions received for the societal agenda:

- it is necessary to think about the form of public debate: the result of the societal debate *Food and Genes* showed that the current way of communicating is not adequate;
- it is sensible to involve citizens in developments and research at an early stage (earlier than the product stage);

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- look for a way by which nutrigenomics can be organised such that consumers have trust in it, without them being 'bothered' by unnecessary details, etcetera.

6 Societal issues and dilemmas: an overview

Rinie van Est & Lucien Hanssen

In the previous chapters, existing and new societal issues associated with food genomics research have been identified and mentioned. It appears that food genomics fits within the current discussion on the consequences of modern biotechnology research and the pre-conditions that society wants to apply to it. Application possibilities for food genomics are diverse and cover the entire food chain. They impact the way in which seed is improved and crops are cultivated, how animals are used or not in meat production or for research goals, which food products appear on our plates and what socio-cultural meaning we give to our food. The societal discussion on genetically modified foods has remained limited to the production side of the food chain. Genomics research and the products that come from it will broaden this discussion. Besides ‘genes for your food’ (the production side) the debate also concerns ‘food for your genes’ (the consumption side). The discussion thus moves closer to the consumer, his genetic make-up and his nutrition pattern. Genomics affects us literally in our genes. Crucial questions include How will society react to these developments? Does the citizen or consumer as a result have anything to choose from? To the solutions of which societal problems does food genomics research contribute?

Such complex questions are difficult to answer. At least an overview is needed of the social and moral aspects that play or will play a role in food genomics. In this closing chapter we try to put all this in perspective. We base our discussion on the five previous essays and on the subjects that scientists and social involved parties brought up during the experts’ meeting and the working conference in 2002. In the working conference it was made clear that the representatives present, from industry, research institutions, societal organisations and government, had not then adopted fixed positions. Instead there was a need for clarification and interpretation of the issues that are or will be associated with food genomics. In the early phase of that research area, pronouncements from scientists and other involved parties were often speculative in nature. Expectations about applications that genomics knowledge would provide vary, with especially wide variations in the times mentioned at which the products and services would appear on the market. Estimates of possible societal effects show a correspondingly great uncertainty and unpredictability and this makes it difficult to indicate the urgency of particular issues.

With this overview the Rathenau Institute definitely does not claim to have the last word. It is a snapshot in an interaction between science, technology and society. We offer a temporary framework for reflecting on the societal agenda for food genomics. We discuss the five essay topics each in a separate section: (6.1) socio-economic organisation of food production; (6.2) global food security; (6.3) use of animals; (6.4) socio-economic organisation of food consumption; and (6.5) desires and concerns of citizens and consumers. After a short summary of the essay, conclusions are drawn, societal issues are designated and clear recommendations are made by which food genomics research and the societal discussion about it can be given further direction, content and shape.

6.1 Socio-economic organisation of food production

In the first chapter Guido Ruivenkamp placed genomics research in the context of an enhanced industrialisation of agriculture. The central theme of his essay is that industrialisation undermines the position of agriculture in the food production chain. This occurs firstly because industrial agriculture for the production of seeds and the use of artificial fertiliser and pesticides has become more dependent on life sciences and agrochemical companies. Secondly the agrarian basis of food production is gradually being replaced by an industrial, biochemical basis. The agricultural product therefore functions less as a food product and more as an industrial semi-manufactured material. In time food products themselves may even be replaced by synthetic industrial products. The control in the food chain is therefore shifting in the direction of the food processing industry.

According to Ruivenkamp genomics research confirms and intensifies the above mentioned developments. Research will lead to a new wave of patents for seed improvement and food technology that will further reinforce the position of the multinationals in the food chain. He foresees the development of ‘assembled’ foods consisting of a number of basic foodstuffs (such as carbohydrates, fats and proteins), functional components (such as vitamins and minerals) and additives (such as taste and colour compounds). At the same time the author asks in what way genomics research can be set up in order to support the appropriate regional agricultural practices in the West and in the Third World. The following conclusion can be drawn from this essay and its discussion:

Current food genomics research is associated with a vision of agriculture and food production with the keywords of industrialisation, economic rationalisation, technical efficiency, upscaling and globalisation. In food production, the autonomy of the farmer decreases and the influence of internationally operating life-sciences companies increases.

This vision – which is also dominant in Dutch politics – is becoming more often discussed during the current debate. A movement is also apparent against the globalisation and especially the industrialisation of food production and for the maintenance of a cultural and regional diversity of traditional food products. This discussion has more points of attention. Broad management of non-agrarian activities, such as recreation, landscape management and care of the landscape, is for example a way of reducing this dependence. Concerning the methods of production, respect for socio-cultural life in the country, our natural surroundings and being kind to animals is coming more prominently into the picture. 'Biological' products especially are considered by Dutch politics as a socially responsible method of producing. The government is attempting by 2010 to have ten percent of Dutch agricultural area under biological cultivation.

According to participants of the working conference the interests and visions of the farmers play a minor role in food genomics research at the moment. There is also an almost complete lack of perspective of Dutch agriculture itself in genomics research. This is a remarkable blind spot considering that possible applications such as bioplastics, energy crops or the production of proteins via micro-organisms could have radical consequences for Dutch agriculture and its functions such as ground use and landscape management. The above points lead to the following two questions:

Can genomics research contribute to developments outside the dominant context of large-scale industrialised agriculture and is it, for example, possible that genomics research will be used for biological and small-scale agriculture aimed at the demand for regional quality products?

What is the influence of genomics on agriculture in the broader sense, i.e., the socio-economic position and role of the farmer, ground use, quality of the landscape or water management?

It appeared also from the working conference that food genomics can and must also be used outside the context of the large-scale industrialised agriculture. For example the idea was put forward to develop biological agriculture sensors and indicators for quality control and quality measurement to give them such a form that even small producers themselves can use them. Current genomics research is still barely directed at similar alternative development directions. This leads to the following recommendation:

> *In the short term a political decision is desired on the question: whether, and if yes to what degree, genomics research should be used for biological and small-scale regional agriculture.*

6.2 Global sustainable food security

In Chapter 2 Bart Gremmen analysed the contribution that food genomics research can make to sustainable food production and to fighting hunger in the world. He proposed that the problems surrounding food provisioning are urgent. At this moment there are an estimated 840 million people who are undernourished (FAO 2002) and the recent World Food Summit in Rome (2002) had the goal of halving the number of undernourished people by 2015. Gremmen indicated that the world food problem cannot be solved simply via technological developments. Processes such as trade protection in the field of agriculture of the European Union and the U.S.A., global food transport and political stability are also important.

The food problem is one with complex, international, social angles and technology is just a part of the solution. The international political will to get to grips with this problem is lacking at the moment, witness for example the limited attention from the West for the World Food Summit in Rome (2002). Gremmen thinks that genomics research can and must contribute to the solution of the food problem, but not all participants of the working conference agreed with his opinion. They indicated that there were often low-tech local alternatives available. The situation is clearly different for some 'upcoming' countries such as China and India, who have the technology in their own hands. Chinese researchers, for example, surprised the rest of the scientific world in April 2002 by announcing the genome sequence of an important rice variety and they closed deals last year with several large Western investors. Therefore we come to the following conclusion:

> *Food genomics research is not getting off the ground in most Third World countries and is therefore increasing the knowledge gap between the rich West and Third World countries.*

Gremmen indicates in his essay that this gap will become even wider due to developments in the area of patenting. Seventy percent of all patents for genetic modification of the most important food crops are in the hands of just five biotechnology companies and genomics will not cause any changes to this phenomenon. Gremmen pleads that governments in the rich countries should stimulate research programmes that are not interesting for the big companies but are important for food production in Third World countries. As with medicines, so-called 'orphan' crops or crops that are not commercially interesting could emerge . Governments could stimulate research into these crops for example by applying tax measures and also by financing targeted programmes of public institutions. The only perspective for poor countries is their richness in biodiversity and food genomics is after all a prime example of being interested in the diversity of genetic resources.

Those who think that food genomics can help to solve the world food problem want to use genomics knowledge to improve local crop varieties in developing countries. The problem is that this type of study cannot be performed in the country itself. Therefore they plead for genomics research in the West to be partially targeted towards local crops, that is, the orphan crops of the Third World. The fact that this is only happening in a very limited way leads to the following recommendation:

> *In the short term a political decision is needed on the question: whether, and if yes to what degree, genomics research should be used for improving local crop varieties in developing countries.*

6.3 Use of animals

It is important not to forget that current meat production puts a heavy toll on energy, water and land use. Although the market for alternatives (so-called meat replacements) is expected to grow, meat production will not decrease. The increasing and richer world population in combination with 'americanisation' of food patterns is bringing in large new markets (such as China).

Genomics can play a role in this issue in a number of ways. For example, by improving the food conversion of vegetable to animal protein or by developing transgenic livestock or aquacultures for food production. An alternative route which does not use animals is the industrial production of high-value proteins by normal and transgenic micro-organisms. This production method is a very promising development in the direction of a more sustainable production of proteins. In the Netherlands this is being studied within the programme *Profetas* (*Protein Foods, Environment, Technology and Society*), including social aspects. Representatives of farmers' organisations indicated during the working conference that they do not want to give priority to research into the production of high-value proteins. They are probably afraid of, in their eyes, disadvantageous consequences for the agrarian sector if a shift occurs towards industrial production of high-value proteins. For example by thinking of protein-rich products for which it does not matter any more where the raw material comes from (soya beans, palm nuts, peas or lucerne, etc.) food companies will be more independent in the choice of their raw materials. This increased sourcing freedom could make farmers worldwide increasingly manipulated by the international market.

In Chapter 3 Lino Paula describes the effect of food genomics on the use of animals. First he examines the question of what influence the development of food genomics will have on our attitude to farm animals. Food genomics will give an extra impulse to health-improving ingredients and thereby bring extra attention to the influence of food on human health. Paula points out that within a new evaluation framework for the consumption of meat, the disadvantages for health will be more accentuated. Until now there have been almost no meat replacements that would form an alternative for large groups of consumers. The quality and the variation are too limited and there is little texture to the meat. Paula expects that meat replacements will come on the market that will find their way to the consumer because these products will score substantially better than meat on criteria such as the environment and animal welfare. Three sets of questions result from the above points:

> *What does the growing prosperity on a world scale mean for the intake of high-value animal protein? Which food resources are needed for this and what role can food genomics play in its development?*
>
> *What are the ecological, social and spatial consequences for normal agriculture in the Netherlands and elsewhere of an increasing role for the microbial production line? How do world trade flows change as a result?*
>
> *Does genomics research fit with further intensification of livestock farming or will genomics ensure a break in that trend? Are we going to develop transgenic livestock or aquaculture for food production? Will we use transgenic animals for the production of medicines or high-value materials? Can genomics change the image of the use of animals? Can genomics take the consumer closer to full alternatives for meat?*

Paula also examines the influence of genomics on the use of laboratory animals. However, he does not dare to suggest that genomics in the long term will lead to a net growth in their use. On the one hand food genomics links up with the trend for functional foods. These innovations are coupled with extensive efficacy and safety tests, which includes many laboratory animals. On the other hand genomics research can be used to develop alternatives (e.g., in vitro or in silico), which could reduce the number of animals used. Paula gained approval during the working conference for this plea because a stimulus for the development of alternatives to laboratory animal tests provides benefits from social, economic and innovative viewpoints. (Parliament has already taken up this point. Nine hundred thousand Euro have been earmarked within the genomics research budget for research into alternatives for laboratory animal tests). This leads to the recommendation:

In the framework of genomics research the development of alternatives for laboratory animal tests must be stimulated, with special attention being given to the implementation of alternative test methods.

6.4 Socio-economic organisation of food consumption

In the fourth chapter Hub Zwart indicates that food consumption does not mean that we just take in nutrients. It is more about the meaning of food: the pleasure that we experience when eating, the socially cohesive character or comfort of food consumption. In our modern-day culture nutrition is also consumption of *lifestyle* symbols and of moral significance, according to Zwart. He expects that food genomics will increase the possibilities of manipulating the composition and the image of food products.

New products offer producers and consumers the chance to profile themselves in new ways. Golden Rice gave the biotech company Monsanto for example the possibility to present itself as an involved, engaged company that wanted to contribute to the solution of a huge global problem. According to their critics Monsanto in contrast used Golden Rice to improve its own image and to promote the acceptance of genetically modified foods. Zwart also observed that the consumer is not completely free to choose his symbols because the consumer must go along with what the producer has created in symbolic significance based on market research. Consumers thus make choices in a symbolic reality that is pre-structured to a large extent by marketing experts from industry and the retailers. The marketing experts of course attempt to play on consumer demands but the limits within which that occurs are determined by the food industry itself.

New products also make it possible for consumers to develop their own moral identity. Cultural and political factors play an important role in the significance of a product. This meaning is achieved by the way in which food is produced, the reputation of a brand name or company, the environment in which the food is consumed or the social networks in which consumers move themselves. Consumers react to this in different ways: they can embrace high-tech functional foods or actually reject the rationalisation and ‘scientification’ or rendering scientific of the food production process – and the whole range between these two, and both trends and combinations of them are already apparent at the moment. Alongside the growth of the functional food market there is an apparent growing movement against the globalisation and industrialisation of food production and for the maintenance of the cultural and regional diversity of traditional food production. Coalitions of farmers, consumers (e.g., the *slow food* movement), environmental activists and anti-globalists are busy increasing the public's awareness of this.

6.4.1 Genetification and individualisation of food

The role of symbolism must not be overestimated. The working conference participants thought that the reduction of food to symbolism was obstructing discussion on the technical possibilities and the functional value of food. Both perspectives – the symbolic and the functional value of food – are complementary and form a useful starting point for a discussion on the social influence of genomics research on food consumption. That is why we add to the perspective of Zwart, that of the functional value of food. The scientific knowledge on biologically active components has seen an explosive growth in the last ten years. This knowledge forms the basis for development of new functional foods and public revaluation of the value to health of existing foods. One promising development is that of 'custom-made' functional foods, or personalised nutrition.

Food genomics research fits with the development of new knowledge on the relationship between food and health and on new functional foods and will accelerate this development. Therefore genomics research will lead to a number of social issues that are closely linked to the current discussion on functional food (e.g., health claims, blurring of the distinction between food and medicines, medicalisation of eating habits, etc.). Genomics research itself creates the expectation that food can be tuned to the genetic profile of the individual. There is a big hereditary variation in sensitivity to diseases and disorders varying from intestinal cancer to food poisoning. Thanks to genomics research this variation can be mapped and advice over food can be tuned to a person's genetic make-up. It is estimated by several genomics researchers that this choice for consumers will be available within 10 to 25 years. Finally people will have their own gene passport with the possibility of *personalised nutrition*, their own food that has a preventive effect on their health. In this scenario the consumption of food has been individualised and rendered scientific to a large degree and during the working conference some found this an image of doom. The above points lead to the following three conclusions:

> *Food genomics with its new knowledge and possibilities for making functional foods can intrusively change the manner in which people*

give significance to food and the socio-cultural association with food.

Cultural and moral factors are subtle and substantial success factors for the way in which society will handle new food products.

Food genomics, because of the expected further scientification, genetification and individualisation of food consumption, will further intensify the political and social discussion on new foods and nutrition patterns.

6.4.2 Public trust

In the current acceptance of modern biotechnology there is a clear distinction between *red* applications, such as medicines and diagnostics, and *green* applications, such as transgenic crops. Research by the Eurobarometer showed that 'the appreciation of the usefulness' and 'the disturbance of the natural order' are good predictors of the amount of support for a specific application of modern biotechnology (Gaskell & Bauer 2001). A third important reason to reject innovative research is the lack of moral acceptability for whatever application. This image was confirmed in the recently organised public debate Food and Genes. The Dutch public doubt the benefits of gene food, it is concerned about possible health and environmental risks, and is making inquiries about new alternatives (Hanssen et al. 2001).

Industry can make the advantages of food genomics more explicit for the consumer and patient if they succeed in showing the benefits of functional foods, whether genetically modified or not. An optimistic assumption of genomics researchers is that, with the second generation of genetically modified foods with health claims, discussions on gene technology will be of a passing nature. Because of the immediate personal advantages the consumer will accept this type of product without too much looking around and will take eventual risks anyway. However another scenario is also actually possible. Considering that genomics brings the worlds of foods and pharmaceuticals closer together, it is possible that food genomics will become involved with both the green (e.g., naturalness, safety, control in the chain, etc.) and red (e.g., genetic privacy, insurance, diseases of civilisation, etc.) social issues in the current debate on biotechnology. A crucial question that demands further research and debate is then also:

In what way will consumers actually make use of new food products and new scientific insights on health and nutrition?

Some related topics are connected to the above question and must be included when answering it. A brief overview follows.

Nutrition is more than health

People do not act as rational beings when it concerns their health and in practice it seems that their choices are not always well reasoned. Thus everyone knows that smoking has very serious consequences in the long term; however almost half of the Dutch population do not find that is a reason to stop. The same applies to unhealthy eating and its relationship with heart and vascular disease. With respect to nutrition, consumers certainly do not allow themselves to be led only by health considerations but also by price, taste and the social or moral significance of food. Despite this researchers expect that, thanks to genomics, conscious and healthy food will get an impulse.

Risk perception of new foods

When using medicines, people accept to a certain degree side effects but with food the consumer expects a high level of safety. What happens if the line between foods and medicines becomes blurred? Is the consumer then prepared to accept the risks of new food products and if so how far will they accept them? Should the producer guarantee that foods are absolutely safe or will the consumer accept a certain risk because thereby the chance of getting a disorder later in life is reduced? Is the consumer prepared to pay more for his food as a long-term investment in his health? In the perception of the consumer are we going to go from a question of safety of foodstuffs to a weighing up of risks and benefits?

Fear of compulsion

Other concerns have also been expressed, such as the fear that healthy eating might gain a compulsive character. Thus a scenario is possible in which insurance companies threaten to increase their premiums if people do not keep to their personal diet that is based on their genetic make-up for certain diseases.

Eating as a social activity

The trend that has now set in for individualisation of nutrition patterns, and that will only continue due to nutrigenomics and the development of *personalised diets*, can undermine the social significance of 'collectively eating from the same pan' as a binding element in households. Eating the same food at the same time is also an important part of growing up as it compels children for instance to eat a wider variety of foods and not just pancakes and French fries. The fear is that when there are four dishes of food on the table each tuned to each individual's genetic make-up, then a part of the social family bonds will be lost. In his essay, Zwart explicitly explores this point and asks whether the gene passport will lead to forced variation within the family.

Genetic privacy

A genetic passport can also have less pleasant sides to it. Genetic screening could for example lead to the conclusion that a person has a big chance of getting a serious illness although they may not always want to know that. Genetic privacy, or maintaining control of your personal genetic information, is an important topic for the consumer. Is the consumer prepared to allow himself to be screened?

Health effects of traditional food products

Several participants in the working conference indicated that the development of functional foods in itself is desirable. There is however the fear that attention to the food package as a whole and its varied composition will be pushed into the background, for example if genomics research is especially directed towards research into health effects of the patentable, commercially attractive, functional foods or their ingredients. The health effects of 'ordinary' food products, such as potatoes, bread and even 'junk' food, should also be included in that study. This point of discussion leads to the following definite recommendation:

> *Study health effects of functional foods together with traditional foodstuffs.*

6.4.3 Regulations and scientific independence

As well as for the consumer, genomics also offers the government and the community as a whole new chances, dilemmas and choices. This requires amendments to laws and regulations at both national and European levels in which it is important to develop a suitable regulation framework for approval of all sorts of health claims on foods and food safety is an important condition in this. The consumer should not have any side effects from food that is freely available in the shop; for medicines side effects are somewhat accepted to a certain degree. The Food Act (in Dutch the Warenwet) states clear limits for foodstuffs on what they can and cannot do and also especially what effects a manufacturer may and may not claim on the packaging. Medical claims are forbidden, but health claims are permitted under certain conditions.

Companies prefer to see that these new foodstuffs fall under the Food Act because that at least avoids a long road of testing if they want to maintain their claim that the products can prevent certain diseases. Such claims fall under the Medicines Act. It is clear that the line between food and medicines is becoming blurred, with all the resulting questions and problems. If there is a lack of good regulation then contamination of the food market could occur. Consumers no longer see the wood for the trees: they think that they are behaving healthily but could run into danger which they will often only see too late. We can here rightly speak of new risks and we then also come to following recommendation:

The line between food and medicine is becoming blurred: the government must ensure a suitable regulation framework exists for approval and testing of health claims for food.

The contribution of science to the foundation of such health claims is becoming greater. At the same time this same science must evaluate as an independent party how correct these claims are and what side-effects the new products could have. According to some of those involved the current association between food science and industry is too close. Therefore a further recommendation is:

The government must via institutes or the flow of money, etc., ensure the scientific independence and provision of information in the public domain with regard to the track records of producers and products, healthy nutrition patterns and the role of functional foods therein, and the risks that are associated with it.

6.4.4 Socio-economic changes in the food chain

Under the influence of nutrigenomics and its applications, the line is becoming blurred between food and medicine and also the former separated worlds of the chains of pharmaceuticals and food can become closer to each other. This can lead to more socio-economic changes, for example on the macro-scale the gradual merging of the pharmaceutical and food processing industries could take place. At the micro level possible responsibilities are shifting and new roles are being created, e.g., a food consultant in the supermarket who advises clients on healthy food or a company sending food advice over the Internet based on a genetic test. However for the time being there is little view on possible socio-economic changes. Insight into existing trends and possible scenarios is really essential for a good debate on the societal impact of food genomics. This leads to the following recommendation:

Stimulate socio-scientific research into and hold debates over the possible socio-economic changes at the macro, meso and micro scales to which nutrigenomics can lead.

6.5 Desires and concerns of citizens and consumers

Genomics researchers do not like to see that a connection is being made between genomics and the current social unrest about the market introduction of transgenic crops and gene food. They also hope that the 'neutral' term genomics will not be confused with the 'contaminated' term genetic manipulation. Others, especially social scientists and representatives of social groups, emphasise in fact the importance of holding discussions on biotechnology and food and food genomics together. There is a number of reasons for this: genomics and gene technology are closely related to each other from the technological, infrastructural and organisational viewpoints. The academic delineation between genomics and gene technology therefore has little significance from a social point of view and will almost certainly perish in public discourse. Public research on genomics by the Foundation for the Consumer and Biotechnology in 2002 confirmed that the citizen at this moment closely associates genomics with genetic modification.

The relationship between genomics and genetic manipulation cannot be denied as the techniques and insights from genomics research are used in genetic modification. Conversely, genetic modification forms an important part of fundamental research into the function of genes. It is to be expected that due to this interrelationship a number of social issues that play a role in the current debate on gene food will recur with food genomics. Separation of the social discussions on genomics and genetic modification has the danger that the 'social' lessons learnt from the introduction of various biotechnology applications will not be heeded during the introduction of new genomics applications. From this study it appears that many social aspects that play a role in ongoing discussions on genetic modification, functional foods, the world food problem, the use of animals, etc., are relevant for food genomics. These relationships with existing social surroundings offer excellent starting points for a discussion on the social aspects of food genomics. These insights lead to the following conclusion:

> *It is very important that the social discussion on food genomics, as far as its content goes, is associated with and from a process viewpoint learns lessons from the ongoing debates and controversies in the agro-food sector.*

Hedwig te Molder and Jan Gutteling in their essay make a number of recommendations for communication to the public about food genomics, which are based on experience gained from earlier social debates, such as the recent Food and Genes debate. According to these authors it is not a good idea to involve the general public simply at defined moments in the discussions and they would like to see smaller scale initiatives with consumer or citizen panels. They also expect a great deal from 'spontaneous' discussions, which are discussion forums organised by critical consumers themselves that give a voice to social feelings or signal possible misunderstandings. These authors also believe that trust in food genomics stands or falls with the trust in the intellectual supporters of these new developments. Therefore they consider that the role of the genomics experts is essential to win the social argument. They also believe that the fact that risk communication is shifting increasingly towards public relations experts is an undesirable development. This leads to the following recommendation:

> *Give genomics researchers a visible role in communication to the community about food genomics. It is especially important to be open about the differences between the expert views about these issues. Researchers must realise that their vision, that comes from a particular context and vision of life, will often be doubted by other involved persons with other visions and positions.*

Societal involvement

The government and the Lower House have expressed the wish of taking into account social aspects during genomics research. Therefore it is now possible to give a place and a vote to the interests of all important involved and concerned parties. For this it is first necessary to clarify the social influence of applications of food genomics research as well as the way in which the societal groups (e.g., consumers, environmental organisations, farmers, animal protectionists, etc.) evaluate these consequences. It is then important to give that evaluation a say in the programming of the research. That is possible by involving the parties to the establishing of the research agenda or giving them the opportunity to perform their own research, if necessary in consultation with independent researchers and other social groups.

At present the input of social parties within genomics research is very limited. At this time it is mainly policy makers and scientists from public and private research institutions that determine the direction of genomics research. Current food genomics research strongly supports food production on an industrial biochemistry basis. Research into industrial fermentation processes form for example one of the spearheads in the Dutch genomics programme. The research agenda seems to reflect and continue the central position of power of the food processing industry in the food chain. Established interests in science and industry appear to be prejudiced and they lack sufficient counterbalance. From this the following conclusion can be drawn:

From a societal perspective the research agenda for food genomics has been set up and composed too one-sidedly with for example the perspectives of the farmer and consumer missing. In order to create a societal consensus the interests of the farmer, consumer and patient must all be given a place and a voice in genomics research.

Many societal groups appear to ask how far genomics in its current format contributes to the solution of big problems such as food sufficiency, the environment, animal protection, welfare diseases, etc. Many also assume that genomics is indeed the solution or can contribute to reduction of such societal problems. The essays show that the impact of genomics on the above-mentioned problems depends especially on explicit or implicit political choices and goals. Gremmen observes for example that genomics can contribute to the solution of the world food problem, but with one condition – research in the West must also be directed to the improvement of local crops in the Third World. Paula has a similar observation on the use of production and test animals. Ruivenkamp also makes this point regarding the reinforcement of regional agricultural practices and biological agriculture. This leads to the next question:

To what degree is current genomics research directed towards finding a solution to societal problems in the area of food, such as food sufficiency, food safety, animal protection or diseases of civilisation?

Te Molder and Gutteling indicate in their essay that debates and other large-scale activities around food genomics are not very expedient at this time as there is no social controversy and the general public knows little of what is involved. The lack of clear contrasts now offers possibilities for a fruitful exchange between the players, their visions and their domains of knowledge. The political desire to take account of social aspects is another reason. The concern was expressed many times at the working conference that such participation means that social parties can only talk about the social and moral consequences of the current research programme, that was realised without their input. Alongside the danger of a limited social discussion there is also the danger that social organisations will distance themselves early on from genomics research. Therefore our next recommendation is:

Involve citizens, patients, consumers and social parties in the current research, programming of future research and in the general discussion on food genomics, initially on a small scale. Serious involvement of societal groups requires perspectives on the real influence of these parties on the agenda of food genomics research. In order to build up societal trust and make it last, it is important that real influence is offered within the period of the current strategy plan of the Netherlands Genomics Initiative, which runs through to 2006.

An important task can in that way be put aside for the *Centre for Genomics and Society* that will start in 2003 and is an activity that falls under the strategy plan. This centre has tasks that include broadening the research agenda of genomics and establishing a societal agenda for genomics. The final chapter, in which relevant social and moral issues and questions have been brought together, can therefore serve as an overture for the agro-food sector.

6.6 Final observations: desirability of openness

The Rathenau Institute has made it clear in many projects that scientific and technological developments do not take place in a vacuum: economic attitudes and patterns of values and standards help to determine which applications are attractive and feasible. National research programmes are linked in general to the dominant ideas on desired developments and culture, and often neglect alternative possibilities of technological development. This also applies to genomics research. At this time it is mainly policy makers and scientists from public and private research institutions who determine the direction of genomics research, and close association exists between these two groups. It is desirable to broaden the research programme from various societal visions. This is important in order to give 'equal rights' to other visions, but especially because it is uncertain in which direction food production will develop in the future. Diversity of societal visions is the best guarantee for a long term and robust research strategy. As an analogue of the standard of political pluralism in our existing democratic order, it is important that there is an aim for *innovation pluralism* in research and development.
This means:
1. mapping the contribution that genomics can give, outside the dominant context of for example functional foods or large-scale industrialised agriculture;
2. making money available for research into alternatives, such as developing alternatives for laboratory animal experiments and knowledge on health effects of 'normal' food;
3. giving parties with possible other visions, knowledge and interests a voice in defining the research programme.

Broadening of the research agenda and setting up a societal agenda is only possible if those who now dominate the genomics research programme open themselves for other arguments, visions and interests. The desirability of openness is an important lesson that can be drawn from the biotechnology debate. In this those involved from industry have for years not realised that the advantages of biotechnology that they sketch are doubted by those involved who have a different value orientation. Openness requires courage and insight from those who up to now have put a lot into getting genomics research off the ground and given it its form. Opening the discussion means for them after all that they partly give away control over the direction and the agenda and especially a confrontation with criticisms and opposing interests. Being open for opposing voices is choosing for a short-term painful and uncertain but long-term purifying and stabilising process. In order to generate public trust in food genomics there is no other way than that of openness – trust can after all only flourish in openness. In this way a situation occurs in which scientific and technological developments and their embedding in society mutually stimulate and inspire each other.

References

FAO (2002). *Food insecurity. When people must live with hunger and fear starvation. The state of food insecurity in the world.* Rome: Food and Agricultural Organization (FAO) of the United Nations.

Gaskell, G. & M. Bauer (eds.) (2001). *Biotechnology 1996-2000. The years of controversy*. London: Science Museum.

Hanssen, L. et al. (2001). *In de marge van het publiek debat Eten en Genen. Flankerend onderzoek in opdracht van de Commissie Biotechnologie en Voedsel*. Aspect 69. Enschede: Universiteit van Twente.

Stichting Consument & Biotechnologie (2002). *Publieksonderzoek Genomics. Onderzoeksverslag*. Den Haag: Stichting Consument & Biotechnologie.

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Appendix 1

Food genomics in the Netherlands: possible products and societal issues – a summary[1]

Christien Enzing & Annelieke van der Giessen

Over the past ten years the genomes of man, and various plants, animals and micro-organisms have been mapped. We now know the number and locations of many genes on the DNA of many organisms; we know that RNA transfers the DNA code and produces protein on the basis of this; and that the entire process of metabolism is about the behaviour of these proteins and metabolites. Nevertheless, we are still in the dark when it comes to the mechanisms that help genes direct the different routes of the metabolic pathways. *Functional genomics* is the research field that seeks to explain complete biological processes based on information of DNA (genome), RNA (transcriptome), protein (proteome) and metabolites (metabolome).

Contribution of functional genomics to the agrofood production chain

Since the early nineteen nineties, research in the field of life sciences has accelerated rapidly especially due to the development of the microarray chip, high throughput analysis techniques (such as 2D gel electrophoresis, mass spectroscopy) and the availability of ever more and ever faster computers and advanced software (bioinformatics).

Food genomics is the specific application of functional genomics techniques to research issues regarding agriculture, food and nutrition. Functional genomics research finds its applications throughout the whole food production chain.

At the beginning of the chain, once the genes of agricultural crops have been mapped, new points of application will be discovered to better enable plants to resist disease and raise productivity. Crops will then be selected on the basis of vitality, life expectancy and resistance to disease. But besides stronger resistance and higher productivity, functional genomics also offers new approaches to refine products on the basis of crops' agronomic characteristics such as drought tolerance and pollutant (eg metal) resistance. As for *non-food* applications of plants, the information obtained from functional genomics research will be used to refine products for the production of such things as tailored biopolymers, vegetable oils and diagnostic systems or medicines for the pharmaceutical industry. The same applies to breeding programmes: since the gene map of productive livestock carries significant information, here too one will be able to undertake work in a more accurately targeted fashion. In terms of animal welfare, genomics will contribute to the development of veterinary diagnostics and vaccines, and will help develop more objective parameters for animal welfare.

Functional genomics will provide information on how to grow plants in such a way as to optimise certain characteristics (such as flavour and composition) and yields (e.g. grain weight, tuber size) *simultaneously*. In addition, this know-how offers possibilities to set up objective quality parameters of crops and decorative plants that will be very relevant in the logistics chain to the consumer.

Certain ingredients of food products are made with micro-organisms (yeast, bacteria and fungi). Well-known examples of these are baking yeast and the enzymes that are used to clarify fruit juices that are turbid by nature. Metabolomics techniques will provide methods to better fine-tune the production process in micro-organisms. They will also be used to improve the fermentation processes of products that are naturally made on the basis of micro-organisms (usually bacteria), such as taste, bite and other quality aspects of beer, wine, cheese and yoghurt.

Food health is a significant domain of functional genomics research. This covers the study of the effects of food ingredients (nutrients) on health, of the individual genetic differences between humans and the effect of these differences on nutrition and diet *(genotyping)*, and of the role of (intestinal) bacteria on health. The combination of functional genomics and food nutritional science is called *nutrigenomics*. Food researchers are constantly searching for metabolic processes and the active bio-molecules in these processes that are related to certain complaints and whose pathways can be influenced by food components. Functional genomics research is expected to provide greater insights into the effects of food components in the body. This should support health claims of both existing and new food products. This research might lay the foundation for the development of brand new types of high quality food such as *personalised foods*, which meet consumers' individual genetic profiles. Functional genomics research will also provide information on the differences in human reactions to food ingredients, due to gradual differences in their individual chromosomes. Moreover, it will offer better insight into the effect of food components on genetic activity. Finally, functional genomics techniques will also help to measure (and substantiate) the health effect of bacteria that have been added to our food, so-called *probiotica*. Functional genomics will also help us better study the function of intestinal flora.

In terms of food safety, functional genomics research will allow new *biomarkers* to be developed to measure the safety and quality of the food throughout the chain. The same applies to new biomarkers to show specific food perishing or the presence of pathogenic microorganisms in food products.

Although functional genomics will add significant methods, techniques and research strategies to crop and livestock breeding, and food and food-related medical research, it will only lead to new products and processes in the longer term, say in 10 to 15 years. In the shorter term, new diagnostic tools can be expected.

Food genomics research in the Netherlands

An analysis of then current agrofood genomics research in the Netherlands made in Spring 2002, showed that major efforts were being invested in the field. Researchers at six universities and eight research institutes were working (together) on at least 106 projects pertaining to food genomics research. The share of projects focusing on issues at the end of the food chain represented the largest part of these (73%). They are principally targeting research on food production processes, new food products, and medical research into the relationship between food and health. Here the recently founded Centre for Human Nutrigenomics (a joint venture of Wageningen University and Research Centre, the University of Maastricht, TNO Food and Nutrition, the National Institute for Public Health and NIZO, the Dutch Institute for Dairy Research) is the main executive party. Then comes food safety and food quality research being carried out mainly at the RIKILT- Institute of Food Safety (about 15%) and finally the functional genomics research for plant breeding (about 12%) mostly being performed at the Wageningen University and Research Centre.

In 2002 a five-year national genomics programme was initiated with the main goal of supporting Dutch knowledge infrastructure in the field of functional genomics. The government assigned the Netherlands Genomics Initiative (NGI, in Dutch: Nationale Regie-Orgaan Genomics), 188.8 million euro to address the various elements (research, instruments, innovation, social aspects and communication) in a co-ordinated manner. Agrofood genomics is an important part of this programme. Under the supervision of NGI, four genomics centres are currently being set up. Two will (partly) be dedicated to agrofood genomics: plant breeding (Centre for Biosystems Genomics) and microbial genomics (Kluyver Centre for Genomics of Industrial Fermentation).

Many companies were involved in food genomics research in the Netherlands in 2002. However, very few of these companies are carrying out food genomics research themselves. Most of them are merely involved in food genomics research activities of universities and public research institutes through IOP (Innovative Research Programme) projects and the four genomics centres.

Having put the Dutch efforts in 2002 in an international perspective, we concluded that the Dutch government scores reasonably well in supporting food genomics research, especially when compared to France, Germany and Denmark. US budgets, however, overshadow European efforts. The Netherlands has a strong position in potato breeding research; a position that will become even stronger once the Wageningen Centre for Biosystems Genomics is in operation. France is busy catching up with the Netherlands in this field. The US and Britain especially are supporting research on the relationship between food and health (nutrigenomics) on a programmed basis. This field is also developing strongly in the Netherlands.

Societal discussion about food genomics research – researchers' opinions

One of the main targets of the investigation was to learn from researchers involved in food genomics research which issues could come up during societal discussions on the matter.

Researchers agreed on the main societal impact of food genomics research – through its products and processes it will help improve the population's general health status and lead to healthier, longer and happier lives. Nevertheless, they stated, a societal discussion about food genomics is subject to very different opinions and points of attention.

For instance there are different opinions as to *when* societal discussions should be held on food genomics. Many researchers believe it is still too early because food genomics research has only just started. It will take at least ten years from now before there are many concrete applications. According to these researchers a societal discussion will only be necessary and possible if we have concrete products that we can talk about. Another group, on the other hand, believes this is precisely the proper moment to initiate societal discussion. After all, initiatives by the Netherlands Genomics Initiative are already being taken, whereby attention should also be paid to the social aspects of this genomics work.

When asking these researchers what issues should be addressed in a societal debate on food genomics, it emerged that food safety topped the list of issues, followed closely by information supply and communication. Other issues include privacy, government responsibilities, companies and science, food as medicine, ethical issues as to whether to act or not, animal welfare and freedom of choice, also in connection with various food production systems.

Food safety

Although researchers recognise that food genomics cannot but contribute to greater food safety in the broad sense, many of them still expect discussions about the relationship between food genomics and food safety in a more narrow sense. They expect this as they believe the Dutch public in general is rather distrusting of the safety of many food products. This distrust is exacerbated by the fact that the Dutch public is not easily able to see or detect differences between food products based on food genomics and those based on genetic modification. They felt that improved methods to measure toxicity would also lead to extra 'red alerts' and food safety incidents would stimulate further public debate on food safety.

Information and communication

Some researchers give highest priority to information supply and communication. "Clear, open and unbiased communication is essential to convince people of the use of food genomics." Food genomics offers a good opportunity because it provides exactly the right methods to show consumers that something is either good or bad. Instead of showing simple acceptance, consumers and the professionals in close contact with consumers will actually see the evidence. This is an opportunity for scientists and manufacturers, for now they will finally be able to substantiate their claims." One should therefore have social discussion mainly to inform people honestly about the applications and their usefulness for society. Other researchers noted that people are not particularly interested in this matter (to most laymen it is hardly fathomable) and that communication therefore is useless.

Privacy

The development of gene profiles and personalised diets is leading to greater knowledge of individuals. Some researchers expected that this might endanger personal privacy. They believe that we should think about the consequences of this knowledge. Who will have access to such personal gene profiles? What will insurance companies, banks, and the government do with it?

Responsibility

Several researchers argue that government support for fundamental research is decreasing and accordingly that science increasingly depends on government programmes and contract research for industry. To what extent is this affecting the independence of science? In addition, food genomics could also be used to support health claims. Scientific support for health claims could help increase consumer trust, but when will scientific support be ‘sufficient’ and who will guard the integrity of the health claims?

Food or medicine

The role of food products as food OR medicine is strongly put forward by some researchers. They believe that food genomics risks blurring the distinction between food and medicine. This will possibly lead to questions concerning regulation and related matters. How should we distinguish between food and medicine? What will these new food products cost and who will pay for them? And, do we want to put medicines in food?

Ethical issues

The researchers also mention ethical issues that should be discussed in the public debate. Some ethical issues are more general. Do we want to implement or create everything that might be possible from a technological perspective? Will it be acceptable to stop developments that might contribute to the health and welfare of society? To what extent do we want to inform people about their possible future health problems? Another ethical issue is that related to *animal welfare*. Researchers expect that this will become an important issue. While on the one hand, genomics research will lead to the use of more test animals to research unknown gene functions, on the other hand genomics research should lead to less test animals.

Consumer choice

The issue freedom of choice is put forward in relation to different subjects. According to the researchers, food genomics will offer consumers options in health food products. The question is whether they will choose the healthy food products and what the consequences will be if they don’t? Freedom of choice is also related to the type of food production systems. Some researchers believe that the public debate should also address the type of food supply and production systems. Are there other ways of producing food than the present highly intensive systems and what should the role of food genomics be in this? How should genomics contribute to sustainability? The choice for a specific food production system will certainly have consequences and consumers will have to choose.

Genomics and genetic modification

One of the main fears mentioned repeatedly by researchers was the fear that discussions and especially negative emotions on genetically modified foods would cross over to food genomics. According to researchers, the common man sees no difference between genetic modification, biotechnology and genomics. They are simply not able to recognise the different technologies, their applications and involved consequences. Researchers, bearing in mind the effects of the BSE and dioxin crises for instance, notice an increasing suspicion as to food ingredients; the 'classical agricultural industry' too suffering from this suspicion. These fears impact the discussion of genetic modification and might cause the general public to develop a negative picture of food genomics. So, the societal discussion about food genomics will undoubtedly involve issues that had already been mentioned during public debates on genetic modification and functional food. Moreover, many issues researchers bring up dovetail with these debates, for instance food safety, information supply, government responsibility, scientists and entrepreneurs, some ethical issues and animal welfare. On the other hand, researchers do not mention important issues that are brought up during discussions on biotechnology, such as the environment and power. Researchers did bring up new issues such as privacy in view of the use of the so-called gene passport and consumers' responsibility when it comes to food behaviour.

Co-development of food genomics research and society

Both food genomics researchers and participants of earlier debates attach great importance to information supply and communication. Developments such as food genomics, however, are very complex by nature and take a long time before products will come to the market. At the moment developments are still in their initial stages, it will take about ten years from now before they are actually realised. What does this mean for the information and communication processes, which had better start as soon as possible? Who should be responsible for informing the public on developments in food genomics?

A great challenge is to start a societal process based on all the lessons one can draw from the recently held debates, involving researchers, entrepreneurs, consumers and societal organisations. The aim of this process is to involve future users one way or the other in the development of food genomics and its applications. What information will be available, when and what exactly should be communicated? Researchers will have to present the outcomes of their research and future technological developments; consumers and other relevant societal organisations will have to indicate what their current and future needs – that genomics research might influence –, will look like. There is a need for approved instruments and experiences with early participation of future users in co-development processes of new technologies.

This is all about interaction between the various stakeholders (close and distant) that should lead to innovations relevant from both societal *and* economic perspectives. This interaction between supply and demand parties is a great challenge for the national direction of genomics research in the Netherlands over coming years.

1. Original Dutch publication: Enzing, C. & A. van der Giessen (2003). *Voedings-genomicsonderzoek in Nederland. Mogelijke producten en maatschappelijke aspecten*. Den Haag: Rathenau Instituut. Werkdocument 89.

Appendix 2

Report on experts meeting Food Genomics

Joost van Kasteren

Participants Experts Meeting at Rathenau Institute
31 January 2002, Utrecht

Drs. O. Crapels	Rathenau Institute
Drs. C. Enzing	TNO-STB
Dr.ir. Q.C. van Est	Rathenau Institute
Drs. A. van der Giessen	TNO-STB
Dr. B. Gremmen	Wageningen University
Dr. J. Gutteling	University of Twente
Drs. L. Hanssen	Deining
Prof.dr. W. Jongen	Wageningen University
K. Jonkers	Wageningen University
Ir. J. van Kasteren	Joost van Kasteren Mediaproductions
Prof.dr. F. Kok	Wageningen University
Dr. H. te Molder	Wageningen University
Dr.ir. B. van Ommen	TNO Food and Nutrition Research
Drs. L. Paula	University of Leiden
Prof.dr. A. van Tunen	Swammerdam Institute for Life Sciences
Prof.dr.ir. T. Verrips	Unilever Research & Development
Prof.dr. H. Zwart	Catholic University Nijmegen

Introduction

Just like explorers in the 14^{th} and 15^{th} centuries created maps of the world so molecular biologists are mapping heredity in our time, and gene maps are rapidly being created for man, micro-organisms, plants and animals. The compass and sextant of the early explorers have been replaced by machines called sequencers that automatically determine the sequence of base-pairs of DNA and supercomputers that arrange the data. The established base sequence can be compared with the coastline on a map. From there the researchers travel inland to examine how the hereditary information is translated into the functioning of the cell and finally in the characteristics of the organism.

It is expected that genomics will have consequences for both the production and the consumption of food. On the production side, knowledge of the genome offers the possibility to alter the characteristics of food crops and livestock much more towards our own desires and needs than is now possible. Processing of raw materials into foodstuffs can take place more efficiently if we have more knowledge of enzymatic transformations and an important part of this knowledge comes from the genome. Issues that play a role here concern the privatisation of knowledge by patents on genetic information and techniques to retrieve this information, the perspectives of genomics for more sustainable agriculture and for improvement of food sufficiency, and the possible consequences for biodiversity, among others.

On the consumption side, knowledge of the gene map offers the possibility to alter our menu to suit our own genetic make-up. Conversely, the food industry can bring on to the market foods that are (or have been made) suitable for consumers with particular genetic characteristics. Just like there are now specific foods for people with diabetes, gluten allergy and an increased level of blood cholesterol, there will be, thanks to food genomics, foods on the market specifically for people with an increased inherited risk of for example intestinal cancer or depression. One of the questions raised is whether, and if yes in what way, our nutrition pattern and our eating culture will change. Can we still enjoy our food if nutrition must be sensible? Another question is whether functional foods must be looked at as medicine or as food and furthermore whether the current approval procedures are adequate.

In order to list and review relevant points for a social agenda for food genomics the Rathenau Institute brought together a number of experts from the natural and social sciences on 31 January 2002. The conflicts of interest provided perspectives for further research and also led to a bridging of the 'gulf of mutual incomprehension', that tends to separate the world of natural and social sciences, according to C.P. Snow. In the follow-up to this meeting five essays were written by social scientists and commented upon by natural scientists as to the influence of genomics research on:

- organisation of food production;
- food security;
- food consumption;
- desires and concerns of the public;
- use of animals.

In the following, for each topic a report has been made of the first skirmishes between natural and social scientists.

Food production

According to Theo Verrips, Chief Scientist at Unilever and Professor of Molecular Biology at the University of Utrecht, greater knowledge of both plants and the human genome will have substantial consequences for the organisation of food production. In the first instance knowledge of the plant genome will lead to higher production and better quality because for example the time of sowing, fertilising and harvesting can be more accurately established. Knowledge of the human genome will consequently lead to the fact that the composition of foodstuffs can be altered for the genetic make-up of people. In some cases it may also mean that crops will be genetically modified for example to prevent allergies or to stimulate the immune system.

Due to the fact that there are many variants of certain inherited characteristics (so-called polymorphism), according to Verrips there will be more differentiation in the supply of food. For example, depending on your skin type you can purchase a suntan cream with a certain protection factor and in the future you will be able to buy a tomato or an apple that best suits your genetic constitution. This differentiation will have enormous consequences for the production and distribution of food, from sowing the crops up to stocking the shelves in the supermarket. Verrips suspects that this sort of product will come on the market in 10 to 15 years. Considering the earlier experiences with *Becel ProActive*, a margarine that lowers cholesterol levels, he thinks that the consumer is in fact also prepared to purchase these products, as long as you can make the advantages clear. The higher price would not be, according to him, a problem because the outgoings for food are only a few percent of a person's income. Furthermore such nutriceuticals are always much cheaper than medicines.

Wim Jongen, Professor of Food Technology and Director of one of the knowledge units of Wageningen University, indicated that the links in the food production chain differ in the time scale by which they change. Changes in the marketplace tend to take place in a period of six months to two years whereas technological renewal in the processing industry typically takes from two to 15 years. If you want to alter raw material supply (primary production) you are talking of changes that can take 10 to 15 years. Jongen suggested that although the knowledge is available, you cannot expect that new products will be available from the one day to the next. The processes of change do not run parallel to each other but have different timescales. These points must be taken into account for development and applications of genomics.

Koen Jonkers, student of Bioprocess Technology in Wageningen and speaking on behalf of Guido Ruivenkamp, felt that food genomics in itself should be placed in a particular context. This is that the primary producer, the farmer, is becoming more dependent on multinational companies for his seed and other inputs, such as artificial fertilisers and pesticides, and also for the sale of his products. In that process the products change from end products into raw materials for further processing. One of the consequences of multinationalisation is that crops that are of little importance for the processing industry, such as sorghum or cassava, receive very little attention from improvers or agronomists.

Without making a moral judgement, Jonkers asked whether food genomics could also play a role in other contexts, for example, in the further development of crops or, even more broadly, farming systems that do not form part of the food chains registered by large companies. Would it be possible to use the knowledge and technology for alternative forms of agriculture such as small farmers in developing countries and biological farmers in the developed world. Or is Big Science by definition dependent on Big Money?

As far as there is an answer to be given to this question the last is probably correct. It costs a lot of money to be able to join this research, not least because of the expensive sequencers and other facilities needed. Using that knowledge for the improvement of a poor person's crops such as cassava for example costs money not least because of the licences required.

Food security

According to Arjen van Tunen, Professor of Plant Biotechnology at the University of Amsterdam and Director of the Swammerdam Advanced Genomics Institute, the application of biotechnology, including genomics, is essential for increasing food sufficiency, but not only that. In order to feed adequately the approximately 8 billion people who will inhabit this planet by 2030 other measures are also necessary, for example improvement in the distribution of food, and also agronomic measures, such as the use of artificial fertilisers and pesticides and improvement of irrigation. In addition it seems impossible to avoid extending the area of agricultural land even though it will be at the cost of nature reserves.

Genomics will be able to contribute by producing increased yields from better resistance to diseases and pests, and abiotic factors such as salt and drought. Furthermore the nutritional value of agricultural products will be raised and the cultivation of medicinal crops is also being considered. The problem is actually that most developing countries do not have sufficient funds or the infrastructure to step into genomics. Only big countries such as India and China could play a role but then they will have to get round the patents of mainly US universities and companies. Another possibility is to set up public- private cooperatives between public institutions in the West and South, and commercial companies.

Bart Gremmen, senior lecturer Applied Philosophy of Wageningen University, likewise sees major obstacles ahead for developing countries wanting to move into genomics. He believes that Big Science is performed by a limited number of global players, which acts as a meritocracy and because of this institutes in the Third World do not get a chance to take part in the production of knowledge. They should finally benefit from application of the knowledge if it was not that there is a strong tendency to protect products, methods and techniques using patents. A country such as India attempts to get round that problem by not recognising patents on plant biotechnology and to keep to a lighter protection in the form of farmers' breeding rights. Another possibility is, according to Gremmen, to amend the prices of licenses to the country in which the licensee is located. There is also the possibility of forced licences where the price of the licence is set by an external institution. Gremmen also believes that so-called 'orphan' plants will appear that must be dealt with by the authorities.

Frans Kok, Professor of Nutrition and Health at Wageningen University and Director of the research school VLAG (Levensmiddelentechnologie, Agrobiotechnologie en Gezondheid (Food Technology, Agrobiotechnology, Nutrition and Health Sciences) is a member of the Terlouw Commission (which in 2001 organised a national public debate on GM foods) addressed the position of a number of social organisations pleading for biological agriculture and better distribution of food as a solution for the world food problem. Van Tunen thinks that that is no serious alternative. In principle you should be able to grow sufficient grain in North America and Australia for the entire world population, but its distribution would be an enormous problem, without mention of the economic disruption. This was supported by Gremmen who believes that the solution suggested by the social organisations will become deadlocked in demographic development. Verrips commented that social groups in China and India have a completely different position and he asked what is the importance of Dutch NGOs? Lino Paula, Lecturer in Biology & Society at the University of Leiden and specialist at the Animal and Society Department of the University of Utrecht, pointed out that biological agriculture may not be the solution but the social organisations do have a point regarding the non-sustainable character of the current food supply. Furthermore the American eating pattern involving a high consumption of meat is not an alternative for some developing countries.

Food consumption

Sufficient food of reasonable quality in combination with improved hygiene and healthcare in industrialised countries has led to a doubling of life expectancy according to Frans Kok, Professor of Nutrition and Health at Wageningen University. However there is still quite a lot to achieve with regard to quality of life. Women around the world have an average of 11 years of reduced quality of life as a result of health problems; for men this is an average of seven years. Good nutritional advice has provided all that was necessary for improving the quality of life, but, according to Kok, if we also take into account hereditary characteristics (the genotype) then we will still take a great step forwards. There is after all a considerable hereditary variation in sensitivity to disorders, varying from intestinal cancer to food poisoning. Thanks to genomics we can map that variation and adapt the food intake to that genetic constitution.

According to Kok the question is whether the consumer is prepared to let himself be genetically screened. A genetic passport can after all have less pleasant consequences, such as establishing that you have a larger than normal chance of becoming the victim of a particular serious disease. Another question is whether, and if in the affirmative, how far the consumer is prepared to take risks with his food. Should the producer guarantee that the food is absolutely safe or will the consumer accept a certain risk thereby reducing the risk of a disorder in later life. Will the consumer be prepared to pay more for his food as an investment in his health? In the perception of the consumer do we go from a question of safety to a risk-benefit evaluation.

According to Verrips the consumer realises well enough that absolute one hundred percent safety does not exist. Experience shows us that people react fairly mildly if for example something goes wrong with tinned food, such as a *Clostridium botulinum*. The chance of this is very low but not zero. Jongen thinks that the consumer does perhaps realise that absolute safety of food does not exist but that the government does require this because people have no framework to evaluate the benefits against the risks. The lack of such a framework is an obstruction to the introduction of food with health-improving effects.

Hub Zwart, Professor of Philosophy at the Faculty of Physics of the Catholic University Nijmegen approached the topic of food consumption not so much from the viewpoint of potential advantages and possible risks but from the question as to how much genomics will mark a break in the trend for nutrition. According to him a number of developments had already started in the 19th century, such as the increasing distance between producers and consumers of food, and the reduction of agricultural products to agrarian raw materials. The attention given by the government to good nutrition also dates from that time because the poor health of the city masses stood in the way of economic growth. The development of margarine in the 19th century strongly stimulated by the French government illustrates that the government demands an important role when it concerns sufficient and safe food supply.

This only began to change in the 1950s when the consumer shifted from being the object of governmental concern to being the subject. He could choose his own food via advertising and advice, and thanks to increased prosperity, at least to a certain level. The nutrition pattern is no longer the result of government policy but of own choices, at least within the framework of mainly large-scale and industrial food production. Zwart asked whether genomics would lead to an increase in the autonomy of the consumer giving him the possibility to make his own choices. In that connection there is a definite case for politicisation of the supermarket.

Another question is whether we, thanks to genomics, can expect the return of the original product. Will the longer shelf-life tomato created by genomics push tomato puree into the background again? Such questions could give an impulse to the old philosophical debate going back to Plato on the question of whether things have their own will or whether they are purely a sum of the elements of which they are built, according to Zwart. In the first case you cannot continue manipulating without being punished because then you affect the intrinsic value of the thing, the tomato; in the second case the possibilities for manipulation are infinite. Verrips noted that the consumer says that he wants ‘wholesome’ food, but in practice the trend is in the other direction towards fast food, that is the result of a large number of processes. The ‘slow’ food movement appears to go against this, but Hedwig te Molder of the Chair of Communication and Innovation Studies of Wageningen University, believes that this is one mind with two thoughts. The consumer enjoys fast food during the week and he wants to eat fresh and unsprayed food in the weekend.

Desires and concerns of the consumer

According to Ben van Ommen of TNO Nutrition, knowledge of the human genome will lead to foods that have a preventive action on for example intestinal cancer, osteoporosis, heart and vascular diseases and other disorders that threaten health. If we put these developments on a timescale, we see that food is now being made based on one phenotype. Within five years he expects that consumers will be able to choose their food based on whether they belong to particular ‘genetic sub-groups’. Within 10 years consumers will be able to choose their food based on their own individual genetic make-up. Van Ommen expects that then we shall have a gene passport with the possibility of 'personalised nutrition', with a preventive action. Then it will be up to the consumer to determine how much use he will make of this in order to alter his nutrition.

Communication scientists Hedwig te Molder and Jan Gutteling believe that Van Ommen overestimates what people will do with the gene passport. In general people are not so keen to do something that only has a potential effect on their long-term health. For example, everyone knows that smoking has rather serious consequences on health in the long term yet almost half of the Dutch population have found this an insufficiently good reason to stop smoking. The same goes for unhealthy eating and the chances of heart and vascular diseases. According to Te Molder and Gutteling, experts have the tendency to look at man as a rational being especially when it concerns their health. However in practice the choices that someone makes are not always so reasoned. People do not let themselves be led only by health considerations, especially concerning food, but also by the symbolic significance of food, i.e., the degree by which a certain type of food contributes to a person's identity.

Furthermore they believe that the consumer is definitely not waiting expectantly for the often praised freedom of choice for example if it concerns non-genetically modified foods. The image of the autonomic consumer who inhabits the pages of the policy reports is a caricature, and in practice most consumers are passive and cannot or only barely can argue their choice. The often-argued freedom of choice puts the discussion needlessly on the consumer and in this way a fundamental discussion on technology is evaded. The consumer is only too willing to delegate his voice to a smaller group of critical representatives (not the NGOs) who must also be involved in the early stages of technological development, not from laziness but because people know their own limits.

Regarding the role of experts, according to Te Molder and Gutteling, they have kept too much hidden in the debate on gene technology. They have either withdrawn themselves from communication with the public and keep repeating their own mantras on the possibilities of gene technology and the modest risks or they give the impression of considering themselves infallible which is creating the paradoxical consequence that they are no longer trusted. These authors thus believe that it is better for the debate when experts are open about the differences in opinion between experts. Verrips does not agree and he refers to the experts promoting openness halfway through the 1970s, when the researchers themselves announced a moratorium on recombinant DNA research. The sad consequence was that in the years following, the relevant technology, the basis for genetic modification, was looked on as extremely dangerous.

Te Molder and Gutteling observed that genomics at this moment is definitely not a topic for social debate. This also cannot happen as the topic is definitely not yet a live one. Genomics is something that happens in the laboratory and there is no connection with peoples' daily lives. If you want to initiate a debate then you need to stimulate images by the development of 'stories' that make it possible for people to see genomics as part of their daily discourse, as a subject at the dinner table. These stories make it possible for genomics to be 'domesticated' by the people.

Van Tunen doubts whether this is possible. He made a comparison with the development of the personal computer that started at the end of the 1960s, but it was only when many people had a PC on their desks that it became clear what the consequences were for their daily lives. Te Molder and Gutteling recognised that it is difficult but they believe it is still necessary in any case to initiate such a debate.

Animal welfare

Jongen pointed out that application of genomics could turn out to be positive for animal welfare, with knowledge of heredity offering the possibility of relieving animals from diseases or stress. This would be due to changes in their nutrition and social climate, and not so much on them being genetically adapted to the conditions. Another positive effect is not so closely connected to their welfare but to the health of ecosystems. Knowledge of genomics will probably make it easier to domesticate animals so that for example in fisheries you can make the step from hunting for fish to fish livestock farming with its nasty consequences for the seas and oceans.

In contrast Lino Paula pointed out that the development of food genomics could have negative consequences for the position of animals. For instance the further medicalisation of food could lead to the requirement for extra laboratory animal tests. It is not in any case necessary as application of genomics could also lead to reduction in the number of laboratory animal tests as a result of the use of other 'model' systems, e.g., cells or even 'in silico' experiments on the computer or with a DNA chip.

An important question is how those in livestock farming will handle the knowledge of the genome. It could lead to better nutrition and better care for animals but it is not unimaginable that animals will be genetically manipulated to reduce their sensitivity to stress, for example. In the Netherlands the 'no, unless' policy applies, but the line between traditional improvement and transgenesis is starting to gradually fade, for example with 'marker assisted breeding'.

Transgenesis does not agree with what is called the intrinsic value of animals. This intrinsic value reaches further than just care for animal welfare which is entrusted to us; it also concerns respect for the 'completeness' or integrity of animals. At the same time it cannot be denied that farm animals and pets are the result of centuries of managed evolution. The evolutionary process, thanks to knowledge of the gene map, will be able to be much more directed towards desired characteristics.

Paula asked whether the term integrity of animals in this context is adequate as it is somewhat paradoxical and also difficult to maintain in the context of a 'genomics' breeding programme. At the same time he does not want to lose the idea behind the term intrinsic value, namely that the animal is part of our moral map. The conflict between using animals and their integrity requires a solution, especially considering developments in the area of genomics.

Appendix 3

Genes for your food – Food for your genes

Participants at working conference
5 June 2002, The Hague

M.C. van den Akker	IMSA Amsterdam
G. Albers	Nutreco
Ir. J.B.F.C. van den Assum	Ministry of LNV
Dr.ir. C.J.A. Barel	Ministry of LNV
Dr. P.J.A. Bertens	NIABA
F. Biesboer	Journalist
Drs. Boonstra	Greenpeace Nederland
Prof.dr.Ir. E.W. Brascamp	Agriculture University Wageningen
Drs. O.J.P. Crapels	Rathenau Institute
Dr. J.C. Dagevos	LEI
Drs.ir.F.W. van Dam	Consumer and Biotechnology Foundation
Prof.dr. M.C.E. van Dam-Mieras	WRR / Open University Netherlands
Drs. A.J. van Dijk	Rathenau Institute
A. Dijkstra	Twente University
Drs. C.M. Enzing	TNO-STB
Dr.ir. Q.C. van Est	Rathenau Institute
B. de Geus	NWO
Dr.ir. A.A. van de Graaf	Con-Tekst
M. de Graeff	STT
Dr. B. Gremmen	Ministry of LNV
Dr. J.M. Gutteling	Twente University
Drs. L.S.A.M. Hanssen	Deining
M. Hildebrandt	VUB
K.J. Hin	Center for Agriculture and Environment
A. van ‘t Hoog	Bionieuws
H.J. Huizing	Innovation Network
Dr. L. Jansen	Food Center
J.W. van der Kamp	TNO Food
Drs. M.F. de Lange	Ministry of LNV
W. de Lange	X – Y
Prof.dr. N.J. Leschot	Institute for Anthropogenetics
H. Logtenberg	Ministry of Justice

A. Mensink	Numico
Dr. H.F.M. te Molder	Wageningen University
Drs. E.H.M. Moors	Utrecht University
Dr. B. van Ommen	TNO Food and Nutrition Research
Drs. L.E. Paula	Leiden University – IEEW
M. van Poelvoorde	Dutch Society for Housewives
H. van de Pol	European Biotech. Consultancy
Dr. G.T.P. Ruivenkamp	Wageningen University
R.A. Schilpzand	Schuttelaar & Partners
Mr.drs. J. Staman	Rathenau Institute
G. van der Starre	NWO
Dr.ir. L. Sterrenberg	Rathenau Institute
D. Stijnen	ATO
Dr. J.A.A. Swart	RUG, Biological Center
Prof.dr. A. van Thunen	Director Swammerdam
Prof.dr. H. van Trijp	Wageningen University
Dr.ir. S. Vellema M.Sc.	Wageningen University
Dr. H. Verhoog	Louis Bolk Institute
Drs. J.E.M. Vermolen	Rathenau Institue
Dr. C. van der Weele	Wageningen University
Ir. M.J. van der Weele-Minderhoud	Dutch Association for Country-women
Dr. H.J. van der Windt	Groningen University
Dr. A. ten Wolde	VNO – NCW
Dr. D. van Zaane	Wageningen University Research Center
Dr. H.A.E. Zwart	Catholic University Nijmegen