1 Genomics and food production – the social choices

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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 prod-

uct 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 micro-organisms 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 industrial-

ising 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.

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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 possibil-

ities 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.