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# Ecological cereal breeding and genetic engineering

A Discussion Paper

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## Introduction

This paper is addressed to those persons who are concerned with the question whether organic agriculture needs its own plant breeding as well as to people with a general interest in the application of genetic engineering to the agricultural plant breeding, whether they be opponents1 or advocates.

In this paper I would like to raise some questions regarding the aims of organic agriculture and present some points of view supporting an 'ecological cereal/grain breeding.' I am aware that I write from a very personal standpoint for I want to make it clear that my whole person is involved in this problem and I cannot give simple objective statements. I write from practical experiences gained from a biodynamic or organic, wheat breeding project as well as what I could acquire from my agricultural studies specialising in agrarian biotechnology at the Swiss Federal Institute of Technology, Zurich.

Nowadays in all ecological associations concerned with breeding as well as in the Swiss government's organic regulations, the introduction of genetically modified organisms is forbidden.2 Nevertheless not all the questions affecting the relationship of genetic engineering and organic agriculture have been discussed exhaustively. The issue also touches other so called conventional methods of plant breeding which until now were, at most, discussed only in marginal groups. A clearly defined point of view is essential. This will mainly include the following questions:

1. Why is genetic engineering rejected?

2. Where should the line be drawn between what is 'still allowed' and 'forbidden'?

3. What other conceivable alternatives are there?

I would like to pursue these questions.

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## 1. Why is genetic engineering rejected?

I do not intend here to go into details of the particular risks posed by genetic engineering in agriculture in general, since these are dealt with very thoroughly elsewhere. Therefore I will not go into such matters as the uncontrolled spread of GMO's in nature, the transmission of resistances to human beings etc. These questions have been discussed in depth elsewhere.3 Apart from that, I have the impression that many individual questions do not represent the origin of the rejection but that they are seized on by critics or advocates of genetic engineering whose minds are already made up. I have heard some discussions where the advocates had the better arguments yet could not convince their opponents. There was always a 'but nevertheless'. We must explore this 'but nevertheless' more deeply so that we can form clear concepts and retain the ability to act in the future.

Most of the following points are not only concerned with genetic engineering but with general tendencies in agriculture and nutrition. I believe however that for many people genetic engineering represents but the tip of an iceberg to which, suddenly, their attention is drawn. Now they concentrate on this tip.

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## 1.1 Instinctive and emotional rejection

In this first section I should like to discuss those grounds for the opposition to genetic engineering which are often considered irrational. It seems to me important that they should be more deeply explored. They may be based on a deeper, not yet understood wisdom or on mere prejudice. The reader is asked to ask him/herself what hidden emotional grounds really cause the balance to tip for or against genetic engineering.

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### 1.1.1 Instinct or appetite

In spite of air pollution, instinct prefers vegetables grown out of doors to those grown in greenhouses. It associates outdoor vegetables with the interaction of the plant with the atmosphere, the unfiltered sunlight and natural soil, as well as a close connection of the plant with local and seasonal conditions. Ecological reasoning (no soil under glass soil, no costly energy) is supported by an instinct for what is 'healthy'.

Behind this instinct lies perhaps an intuitive feeling of the true nutritive value of plants. They represent something whole, sound, healing that we do not possess and which nourishes us. It arises from the interaction of the plant with its material, spatial and seasonal surroundings. With the consumption of food there arises in us again an interaction on many levels (substances, energy, development of formative and growth forces, information). Many people even consider that preferably one should eat plants from one’s own locality because these transmit just those forces that the inhabitants of that district need.4

Instinct resists 'tinkering' with this 'wholeness' (which can be seen as close in meaning to 'holiness'). On the cultivation side it concerns the development of soil-free cultivation such as hydroponics. With breeding it is a matter of penetrating deeper and deeper into the substance of inheritance.

I consider that these instincts should not be ridiculed just because they may escape rational explanation. There lies a wisdom in our instincts other than that in our head. Perhaps this wisdom is actually of greater significance for the well being of our body.

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### 1.1.2 Intuitive feeling for the boundaries of the ecosystem

Whatever one likes to call it, be it 'self-organisation of matter/substance', 'reproduction', 'life force' or 'etheric', in self-reproducing living organisms one is dealing with a power that is beyond human control. Life reacts in its own way to our manipulations. The results lead to much speculation, discussion, calculations and argument. However it may well happen that the answer will be unexpected and indirect and will affect quite other areas than anticipated or even later generations. Whoever would have thought when refrigerators were introduced what this could have to do with the atmosphere of the Earth?5 We feel the weight of responsibility that we invite with our interferences and do not want thoughtlessly to encumber future generations with still another mortgage; above all in the agriculture of the wealthy North where surplus rather than want is the rule.

Fear of the helplessness of the ecosystem is not irrational but arises from painful experiences during the last decades. No wonder that it cannot be pushed out of the way by the most eloquent arguments of the advocates of genetic engineering. The terrifyingly sudden advances of genetic engineering do not build confidence, rather do they arouse our feeling for the time dimensions in the realm of the living.

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### 1.1.3 Concern for health

Will our own 'ecosystem', our health, be disturbed by our interferences? For instance will new allergies appear? What are the long term effects of genetically engineered foodstuffs on public health if one thinks beyond the present generation? How will it affect our immune system, our fertility, our ability to achieve things? How will a minute effect develop over generations, will it behave like interest and compound interest? Women especially often ask these questions. I do not think that this is only concern for their own health and that only anxiety and egotism lie behind these questions. Rather is it the remains of an instinct. When it comes to food women are used to thinking about others. In our society they have the primary responsibility for food.

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### 1.1.4 The older the better

Many people tend to think that traditional food and old varieties are 'healthy' and on the other hand that newer developments are 'decadent' and 'degenerate'. With such an attitude everything to do with genetic engineering is 'super decadent'. This attitude is comprehensible and most people have something of it in them only in different grades (what the peasant does not know he does not eat). Nevertheless changes in eating habit and what is on the menu always occur. (For instance the introduction of the potato into Europe in the 18th century.) Often these are only one aspect of a whole series of social upheavals. It might be queried whether in our increasingly alienated and virtual world, alien ('de-natured') food perhaps has its legitimate place. Here is the parting of the ways. The increasing demand for convenience products would seem to answer in the affirmative. Against this there is also an increasing demand for the most naturally produced products and the experience of many organic consumers that they definitely feel better nourished by such products. If the future of nutrition really will consist of man-made substitutes, then from the point of view of organic consumers we are still very far from it.

In the long run organic agriculture faces the question: does it want to help create a world of substitutes or will it pursue quite other concepts? Are these concepts merely the Middle Ages warmed up or something that contains the future of organic agriculture? Organic agriculture needs vision for the future. In any case, 'the older the better' is by itself no adequate argument against genetic engineering for dynamic people looking to the future.

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### 1.1.5 Reverence

'Reverence for creation' is accepted by people of a religious or spiritually orientated nature as a basis for rejecting genetic engineering. In doing so the various plants and especially animals are considered as gifts from God or as spiritual entities which should not be wilfully mixed by man and should not be forced into conditions foreign to their species by genetic engineering.

However, I consider the intervention of man in nature as proper to mankind even if mistakes can be made entailing suffering. It could even happen that something is 'adopted' by nature. In any case this question should be studied further. The widespread claim of many advocates of genetic engineering that it is a continuation of evolution6 masks the still prevalent confusion and difference of opinion concerning the process of evolution.7

Reverence for creation has an antiquated sound. I am of the opinion that, this theme demands fundamental as well as philosophical work on the question of evolution and the concept of species. Such work unfortunately is very inadequately supported financially because it is considered 'theoretical' and not of practical use. Today it would be of benefit to the critics of genetic engineering if more material were available on this subject.8

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### 1.1.6 Sacred DNA

In our western society, in its most crass form in the USA, there is an ever increasing tendency to make the gene, i.e. the DNA molecule, the cause responsible for all the phenomena on the realm of the living. This tendency, which becomes more and more a general feeling regarding life, and which to me does not appear to be rational in many cases, leads many people to the view that mankind should not interfere in this last 'sanctuary'. An almost religious reverence for this 'equivalent of the Christian soul' 9 the material 'ultimate cause' of life would like to place DNA under a taboo. Mankind with his short-sightedness and doubtful morality should not have responsibility for future generations. It were preferable that this responsibility should remain with chance, evolution and the molecule.

From the way I describe this attitude it can already be seen what I think of it. I believe that at this point the critic of genetic engineering falls into the trap of exactly this thinking that genetic engineering has produced. If I were convinced that 'DNA is the cause of life' I would find the advocates of genetic engineering justified: if DNA is the cause of 'biological' mistakes let us improve them! Or are molecules our new gods? Hence all international bioethical conventions also will not last long. Indeed even now they are full of grey zones and escape-clauses,10 and it is inevitable that they will be increasingly weakened, because DNA-thinking simply calls for genetic engineering!

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## 1.2 Rational rejection

In this second section I would like to consider two reasons that arise without plunging into the world of instincts, fears and taboos, reasons that I would therefore like to designate as rational. They also have much to do with general social criticism. Readers that above all reject genetic engineering on these grounds must nevertheless ask themselves whether these reasons can just as well be used in favour of genetic engineering together with the familiar arguments for a more rational plant breeding, whose products could help to reduce the world-wide supply of pesticides.

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### 1.2.1 Motives of the practitioners of genetic engineering

Up till now the motives for the genetic modification of plants are not in most cases concerned with nutrition. The transgenic plants are mainly intended to facilitate cultivation (Bt maize, Roundup ready Soya), to improve the commercial aspect of breeding (male sterility of rape), facilitate marketing (Flavr Savr tomatoes) or the creation of new products for market (rape with medium-chain fatty acids). Future projects do indeed begin to address directly nutritive quality also (wheat without allergic substances), however there is always a sound business motive behind them. Large firms such as Novartis make no secret of the fact that they are only interested in working with plants requiring large annual quantities of seed (hybrid maize) and that the expenditure on genetic engineering only pays when the results can be patented. Is it from such motives that the healthy nourishment of the future will be produced?

The critics of genetic engineering should however not overlook the fact that there is a difference between industrial and university research. In the Swiss Federal Institute of Technology, Zurich the emphasis of genetic engineering with crop plants is expressly laid on projects designed to benefit the inhabitants of Third World countries (for instance, insect resistant rice, rice containing Vitamin A, virus resistant manioc, etc.).11 Of course one can question how much these humanitarian aims gloss over the scientific ambitions and career advancement of the researchers. But then naturally one must return precisely this question to the organic researcher.

If one is not to be indiscriminate and unfair, the question of motives will lead to genetic engineering projects having to be evaluated very differently.

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### 1.2.2 Opposing global power concentration

It is incontestable that concentrated global industrial interests want to make use of genetic engineering. Control of the basic foodstuffs of mankind is already, to a large extent, in the hands of a few transnational corporations (TNCs). With continuing bankruptcies and take-overs these become ever fewer. This development awakens protective and self-protective instincts. Legitimised by governments, these TNCs secure ever more power by privatising their profits and leaving behind their losses for society to solve. (unemployment, environmental problems, consumption of resources). Genetic engineering is the tip of the iceberg of ‘foreign controlled basic foods'. With rebellion against this there will also be rebellion against these global power structures. Ecological, decentralised, indigenous projects stand like 'David' face to face with this Goliath. They endeavour at least in parts to hinder the 'technological package’12 of global agriculture under the dictatorship of the chemical giants.13

But what if today someone wanted to work genetically in an unselfish, small, decentralised etc. way? Genetic engineering for organic agriculture? – Would he or she be able to do it? –

Today perhaps not, it would be far too costly – but if the methods were once established? We only have to look at the computer business –unquestionably a power colossus. And yet it was just development in the realm of the computer that enabled many non self-seeking, small, decentralised, creative projects to exist and exert their influence.

Rebellion against the global power of the agro-industry is therefore not necessarily a lasting argument against genetic engineering.

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## 1.3 Rejection of the scientific approach to genetic engineering

### 1.3.1 Scepticism regarding the application of atomism in the realm of the living

The euphoric hope of achieving wonderful macrocosmic results with atomistic transformation (genetically engineered resistant plants for a world wide ecological agriculture!) is seldom shared by ecologically thinking and also spiritually orientated people. Many oppose molecule-orientated biology with a general scepticism and strive for a paradigm shift in science and society.14 From the sixties to the nineties of this century the, at first more or less instinctive rejection of agro chemistry with its waste of resources and pollution of the environment, has led to an increased ecological thinking that asks global questions about interconnections and cycles and holds to the concept of 'sustainability' and tries to define it. Gradually the new ideas then become ever more accepted and now are slipping (unfortunately far too belatedly) into global politics. Something similar is now necessary in the field of genetics. The instinctive uneasiness regarding genetics requires a new way of thinking about life, heredity and evolution which also corresponds with our feeling for life and consequently causes less uneasiness. He who would maintain that the current way of thinking is derived from nature, has presumably not yet sufficiently considered how the general feeling about life and mankind's cultural development imprints the scientific standpoints, paradigms and models of an era and on occasion changes this imprint again.15

I believe that the rejection of genetic engineering can only last if it is based on this scientifically critical method and if new ways of thinking are communicated and investigated experimentally.

In a way of thinking complimentary to genetic engineering the environment of the organism must play at least as great a role as its genetic code. The resultant plant breeding therefore will not strive for patents for seed that are intended to be sold all over the world, but it will concern itself with regional needs and conditions. It will put up with the lengthy process of developing varieties over many years as a process during which the influences of the locality and the hereditary characteristics of the plant contribute equally.

It is from such a complementary way of thinking that for instance biodynamic agriculture has arisen. Whereas in modern industrial agriculture, hereditary material and environment are made uniform over increasingly greater areas by means of breeding, tillage and fertilising, in biodynamic agriculture the locality of the individual farm plays the central role and determines the ultimate goal.16 Everything is directed towards individualising and regionalising and it is of the greatest importance that the inherited traits always develop in connection with the environment.17

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2. If genetic engineering in plant breeding is to be opposed, where is the border line between 'still allowed' and 'forbidden'?

Whereas up to the seventies, established plant breeding methods relied on observation of inheritance in single plants and populations, today breeding methods approach more and more model-thinking, i.e. the idea that all the characters of a living organism are genetically codified and that the expression of these codes is molecularly regulated.

By breeding, the plant is to be so changed that the characters desired by the human being can be permanently fixed, (i.e. inherited over generations) and interaction with the environment can be reduced to a minimum. A good general survey of agricultural plant breeding is to be found in Heiko Becker's 'Pflanzenzuchtung.'18

Since the end of the 19th century the development of breeding methods has come step by step ever nearer to this aim. Plants have been more and more manipulated. I would like to present this development in note form. A basic knowledge of botany and genetics is assumed, which can be looked up in any botanical text books or even in reference books.

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2.1 Steps in plant breeding from mass selection to genetic engineering

1. Selection of characteristic, homogenous varieties from traditional local or indigenous origin (e.g. land races) that generally exhibit more or less variable populations, by testing the offspring.

2. Crossing of homogenous varieties to create new variability followed by subsequent selection.

3. Intentional introduction by crossing in of desired traits for instance resistances. (Even if ‘genes' such as 'mlo' or 'Lr 27' are in question the manipulations are carried out with pollen and ears of grain - not with DNA).

4. Artificial infection of plants in greenhouse or field by means of contact with neighbouring infected plants or a concentrated liquid spray of fungal spores. This is done to select for resistance. (On account of the high cost this is not widely practised).

5. Intentional use of the heterosis effect in hybrid breeding. (This often requires preparatory steps: some years of inbreeding if cross-pollinated species are involved, or in the case of self-pollinated species, the artificial production of male sterility – cytoplasmic, chemical or by genetic engineering.)

6. Crossing to introduce characters from more distantly related species. (This often necessitates the cultivation of the crossed embryos in a nutritive medium, since embryos left in the seeds would die owing to incompatibility. This is called ‘embryo rescue'.19)

7. Colchicinising (treating with the toxin of the autumn crocus, Colchicum autumnale), to double the number of chromosomes).20 In many vegetable and fodder crops this enables a stronger expression of certain traits such as frost resistance. It also permits the crossing of two different species or even families, because it can render fertile the sterile offspring of crosses.

The most well known example in practice is triticale, a new species of grain, the result of crossing wheat (Triticum) and rye (Secale), two different families.

8. Inducing mutations with chemicals or ionising radiations and subsequent selection. This method enjoyed a certain boom 10 to 20 years ago but is not much used nowadays since the mutations are mostly disadvantageous. There exist however, short-strawed strains of wheat that were obtained in this way.21

9. Anther culture. In this way it is possible, in the case of self-fertile heterozygotes whose progeny in the next generation would otherwise diversify, to 'freeze up' so to speak the haploid chromosome set of the pollen or the ovule. The pollen or the unfertilised ovule must be placed on a special sterile nutrient medium, fused by treating with colchicine and raised to become haploid plants, followed by subsequent colchicinising.22 Thus with one stroke one obtains a homogenous plant which would otherwise only be achieved by many generations of selection. Anther culture is established mostly in barley and potatoes. With wheat and maize it is still at the experimental stage.

10. In-vitro-selection. If seedlings or tissue fragments can be selected in culture dishes for resistance against a fungal toxin, the cost of field trials is less because many plants will be discarded from the outset. For many traits, such methods are very successful and great efforts are being made to introduce them into routine breeding.23

11. Somatic hybridising (i.e. non-sexual fusion of two somatic cells). The advantage of this method is that by the fusion of cells with different numbers of chromosomes (for instance different species of Solanum24) fertile products of the crossing are obtained at once because diploid cells are being somatically fused. Polyploid plants are obtained containing all the chromosomes of both parents instead of the usual half set of chromosomes from each. For this, cells are required whose cell walls have been digested away by means of enzymes and are only enclosed by a membrane, (these are then called protoplasts). With the loss of their cell walls, protoplasts have also lost their typical shape and are spherical like egg cells. This mixture of cells to be fused is then exposed to electric pulses. In order to get from the cell mixture the ‘right’ product of the fusion (since fusion of two cells from similar plants can also occur) one different selectable character in each of the original plants is necessary. Only cells that survive this double selection are genuine products of fusion. (The easiest way to achieve such selectable markers is by genetic engineering, for instance by incorporating antibiotic resistance into the original plants.) Protoplast fusion has been investigated and applied to potatoes, for instance. In the EU regulations concerning the deliberate release of genetically modified organisms into the environment somatic hybrids are not considered as GMO's and do not require authorization.25 The most recent draft of the EU organic regulations in which the introduction of GMOs in organic cultivation is forbidden, follows the above definition. Thus protoplastic fusion is permitted in organic farming according to the recent draft of the EU regulations and according to the Swiss regulations regarding organic cultivation.26

12. Marker-assisted selection. For the purpose of diagnosis, DNA from all the plants from which selection is to be made, is isolated and, with the help of enzymes, broken up into smaller or larger pieces. These, in a gel-like mass, are separated in an electric field (gel electrophoresis) according to their size. By various methods, individual pieces are made visible by radioactive or fluorescent markings. Then, on the gel under ultra-violet light, or on an X-ray film of the gel, a characteristic band pattern for every genotype can be seen. By means of the enzyme and DNA probe used and from their size (i.e. the number of their base pairs determined with the help of standards), these bands can be defined). Presently there are a

number of modified methods, but the principle is the same. One looks out for bands that correlate statistically with the particular feature. Once such 'markers' have been found one has a simple criterion for selection. A fragment of leaf of the relevant plant furnishes sufficient DNA for such a diagnosis since the DNA can be artificially multiplied in the laboratory. Selection with the aid of markers is very extensively researched for every sort of cultivated plant and every conceivable trait. At the present time many breeders consider it to be the investment for the future that will bring about the greatest changes during the next decade. In the coming years it will be integrated into practically all the major breeding programmes. Above all, it will enormously accelerate the process of breeding. Selection will be automated and take place in the laboratory. It will be possible to reduce field trials drastically. For perennial plants it will be of particular interest as well as for projects where one wants to combine many dominantly inherited resistances to the same disease in one variety (pyramidising). Otherwise there is no means of knowing in such projects whether a further resistance exists if the first is already active. This might provide a contribution to permanent disease resistances. Also for complex traits inherited as polygenes the method would promise a speeding up of selection.27 This method certainly implies working with isolated DNA, but without invasion of the genome of the plant and is therefore not seriously disputed. One must be aware that much genetic engineering with bacteria was and is necessary to establish marker-assisted selection.

13. Gene transfer. With gene transfer there are also many degrees of departure from the 'natural' according to the origin of the genes and the technology employed in the transfer.

a. Origin of the Gene

* 'switching-off' the genes (for instance the 'softening gene' of the tomato). For this the plant's own DNA of the gene in question will be incorporated in the genome of the cell in a reading-direction (sense) that is opposed to the normal reading-direction (anti-sense).

* Foreign genes can come from the same plant species as the plant to be 'transformed' or from more distant species or even from quite other organisms such as for instance the European corn-borer resistant maize of Novartis with genes from Bacillus thuringiensis. The tendency now is that these or similarly successfully inserted genes are introduced into other plants, enabling more and more successful results to be announced by the research scientists involved. With the case of BT the number of transfers is boundless and extends to all plants with insect pest problems.28 Criticism of genetic engineering even increases this tendency because the genetic engineer is under incredible pressure to produce results as quickly as possible before restrictive legislation is introduced.

* With newly incorporated genes we are dealing in practice with 'synthetic' genes in which the new piece of DNA containing the new genetic information is linked with one or more expression signals, i.e. genes that control expression. These signals originate from plants, micro-organisms or viruses. They are DNA sequences that control the expression of the new character and also when in development, in what organ and how much of the new protein will be formed.

* In addition, most of the new genes are provided with selectable marker genes. These should not be confused with the idea of 'marker' as employed in point 12 above. In contrast to point 12 we are here really dealing with a foreign artificially introduced gene. These selectable markers are mostly antibiotic resistance genes originating from bacteria. Thus from the many cells used in one transformation experiment from which only very few incorporate the DNA,

the desirable ones are selected. After the transfer all cells which do not develop the new resistance die from the antibiotic added to the nutritive medium.

b. Methods of Transfer

* The simplest methods are based on a horizontal (not sexual) gene transfer which occurs in nature. Agrobacterium tumefaciens for instance, is a fee-living soil bacterium that can cause tumour formation in plants because its plasmid-DNA, which is ring-shaped and separate from the rest of the DNA, smuggles itself into the plant cell. The plant integrates a part of this DNA at – so it appears – a random position in its chromosomes. Thus its genetic constitution is altered and it produces plant hormones in a concentration that hinders form development as well as substances that feed the bacterium but that the plant itself cannot utilise. The plasmids can be isolated, modified and again inserted into the bacteria and these then applied to the plants. For this pieces of plant, e.g. leaf fragments, on a sterile nutritive medium are used. Then with the help of plant hormones these are induced to sprout new plantlets on their borders and these are often transgenic.

* For what is known as 'ballistic' methods, plant meristem (e.g. shoot tips) or cultured callus material drawn out of plant pieces with the help of hormones (formless lumps of cells, capable of division) are used. Then microscopically small globules or bullets of gold or tungsten, prepared with modified plasmid DNA are 'shot' into the cells with the hope that the foreign DNA will land in the nucleus of a cell and become incorporated in it and that the transformed cells will integrate with and predominate in the meristem or callus. Selection of the ‘right’ cells follows as described above with the help of a gene for an antibiotic resistance that, in addition to the target gene must be incorporated in the DNA.

* For 'direct' gene transfer (without the detour via the other organisms and without the protective cell wall) one requires naked protoplasts (see 'Somatic hybridisation'). Foreign plasmid DNA is added to the fluid in which the protoplasts float. Through various treatments the tender membrane, which is all that encloses the cell, can be made porous so that the intake of DNA is possible by the addition of calcium salt or by submission to regular pulsations of electric current as described above for cell fusion. Both methods are successful and are routine with bacteria. There is a problem however with plants that often have difficult and protracted recovery of their vitality and above all fertility from such protoplast cultures.

From the above descriptions of the various techniques it becomes clear that the development from conventional breeding to biotechnological methods and from there to genetic engineering has proceeded by numerous steps and gradations. When one knows the details of the various methods the question arises: where does one draw the line when rejecting genetic engineering and on which grounds!

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2.2 Where do we draw the line?

At present, in Germany, Switzerland (and most other European countries?), the regulations for organic produce forbid the insertion of 'materials of any sort obtained by means of genetic engineering'. I question whether this is a sufficiently clear formulation and whether in all cases the boundary between 'genetic engineering' and 'biotechnology' is clear. I also question whether the boundaries will be correctly drawn. According to our opinion about the above transitions, we might come to the conclusion that everything should be permissible or everything forbidden...

I would like to discuss four 'possible propositions for organic guidelines.

1. All techniques whereby isolated DNA is incorporated in cells, regardless of which vectors or other techniques are used, are to be rejected.

One possible reason would be that at least the cell must remain as the fundamental unit of life and be preserved from biotechnological interference. According to the EU definition, this marks the boundary between genetic engineering and traditional biotechnology.29 One might also say that DNA as the fundamental information of life should not be isolated for manipulative purposes from this ultimate component of a regulating organism, namely the cell. – A reasoned formulation for this proposal is not so easy to give. In my case it arises immediately from feeling. Perhaps I (and probably others too) have intensified and made my own a 'thinking in terms of cells' (Zelldenken) which already is very reductionist and I am also a follower of the 'sacrosanct DNA’. – In any case when I propound this reasoning I remain largely on the level and way of thinking that has led to genetic technology. (See Section 1.1.4)

Thus protoplast fusion (without genetically inserted marker genes) would still be allowed because in this case two entire cells are fused. Likewise anther culture, in vitro selection and selection aided by markers would be permitted.

2. All techniques requiring the application of plant cell and tissue cultures are to be rejected.

A possible reason for this would be that tissue culture creates an artificial environment in which plants or cells: a) have optimal care like soil-free greenhouse plants in a nutritive solution, b) are intensively manipulated with hormones during their development, c) are torn away for long periods when physiologically active from their natural development and seasonal rhythm, a procedure which does not accord with what plants are. Such interferences are unnatural.

This objection arises from a different picture of the plant from the one above. It sees the plant as intimately connected with its habitat and the seasons, (we might also call this 'cosmos') and its contact and sympathetic resonance with this cosmos as inseparable. The severance of this contact for plants intended for human nourishment cannot be accepted.

A further reason for this second proposition would be that during culture, which can last many months, a selection at first unnoticed could take place based on the laboratory-fitness of genotypes. Important traits could be lost that are needed by the plant in natural surroundings.30 To date I have not been able to find any confirmation in print of this proposition.

In practice this borderline would prohibit something that today, on the whole, is not questioned, often because it is hardly known. One should, on this account, be opposed to in vitro maintenance of potato gene banks and meristem cultures the purpose of which is the elimination of viruses from potatoes and berry fruit. Up till now I do not know of any reliable alternative. Probably every potato fruit and vegetable grower and many grain producers are using varieties that are obtained or maintained with the aid of cell cultures. For this reason such a regulation is hardly feasible. Apart from this a clear distinction must be made between tissue culture and multiplication by cuttings.

It could however be included in the guide lines that such methods should not be encouraged and that efforts should be made, especially within the organic movement, to further breeding without these methods.

3. Species barriers should not be crossed.

In the course of the anti-genetic engineering discussions a certain vague unclear fear repeatedly surfaces when it comes to the mixing of genes from different species. This can arise from various motives: a quasi religious reverence for the single 'species' as a unit of creation or a more secular respect for the species as an entity that is an active factor in evolution.31

Such a guideline would be defensible against the background of a much deeper grasp of what a plant is. Evolution would be taken into consideration and the question as to the basis of the feeling of reverence that is taken so seriously would have to be addressed. And it is not clear whether refraining from any crossing of different species is the only possible way of expressing such a reverence. Is it evolutionarily justifiable or reasonable?

The consequence of such a guideline would entail a complete upheaval of organic agriculture. One would have to prohibit Triticale which exemplifies a modern crossing of species. Many of our cultivated plants would be questionable: rape, soft wheat, hard wheat and spelt (Dinkel) often considered to be ‘primeval grain’ (Urgetreide). As far as is known today, all are species crosses and occur only under the care of man. Moreover, all sorts of plants would have to be prohibited which, by conventional crossing and back crossing, incorporate resistances crossed into them from other species. This would affect practically all commercial varieties of grain, also many vegetables and, for instance, the new scab resistant apples.

Or one could set a time limit. Everything that happened 'early' will be accepted as 'natural', everything that has happened since 1850 or 1900 or 1950 will be rejected as 'manipulated'. (see the view described above under the heading 'The older the better'). Varieties with particular resistances from other species would be permitted but incorporation of whole genomes would be rejected. Thus as regards genetic engineering, one is landed in a really paradoxical situation. (see protoplast fusion Section 2.1)

To put in place such regulations one would have to live in quite another world than that of today.

4. Crossing should not take place beyond the limits of the family.

This is a variant of the previous proposition which allows somewhat more room for manoeuvre and fewer problems of definition. (Boundaries of species can be defined in different ways). But even so, many resistant varieties as well as Triticale would have to be forbidden.

Triticale is however already a widely established crop. This species of grain originated as described above (Point 7) from thoroughly 'unnatural manipulations' but it has many agronomic characteristics that are very desirable in organic agriculture. Regarding the nutritive quality of Triticale I know little at present, but certainly it would be rewarding to do some research on this, rather than reject Triticale from the outset.

We must therefore ask ourselves, would regulations such as the last two close the door on the future of organic agriculture? Would this apply too to all the propositions discussed above? Naturally this would support the advocates of genetic engineering – given the example of Triticale we must face this question.

I hope that the above presentation has made clear the following:

That discussion of genetic engineering also requires examination of long established practices in conventional plant breeding.

Various broadly or narrowly held guiding principles reflect the picture of the plant that the author has in mind. A discussion of guiding principles would therefore have to take account of the aspect of 'world outlook' (Weltanschauung).

It could happen in the future that various organic guidelines will exist side by side, as accepted as a scenario in the 'BATS' study.32 All the more important would be the question of the common denominator which all the participating groups would represent. Differentiation would not necessarily lead to a split in the organic movement.

Critics of modern technology are very often, without knowing it, already benefactors of this technology. This is not meant as a reproof but is necessary for clarifying our position at this moment.

Critics of modern biotechnology should realise that their criticism can only continue in the future if alternatives can be developed. This requires finance and indeed a constant supply of it for many years.

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## 2.3 Further questions

Breeding seeks on the one hand, to produce or find a certain diversity (variation) in plants and on the other hand, to select from this diversity the most suitable plants (selection). Thus it works with a continual alternation between broadening and narrowing of the genetic spectrum of the plant. This is putting it only a very generally. How broad or how narrow the spectrum is after selection depends very much on the breeder’s judgement and the methods employed. Criticism of modern methods is directed mostly at the processes of creating diversity (insofar as we may include gene transfer here). Little fuss is made about the methods of selection. This imbalance seems to me to be one-sided, since only the combination of both aspects leads to present day successful results. Producing diversity must reckon with an element of chance, even in the case of gene transfer! Selection then produces the new variety. Both taken together reflect the aim of the breeding, the motive. One could conclude that the methods should not be judged on their own merits alone but that the desired aim of the breeding should be included.

Allied to this is the question of 'good' genetic engineering. Is a gene technique with genuine ecological and good nutritional aims a possible option to be kept open for the future of organic agriculture? Or may one find, on closer examination of the various procedures, that such a goal, by its very nature, cannot be realised by genetic engineering?

The development towards working with isolated DNA (isolated 'genes') follows hand in hand with the corresponding conceptual model of the 'foundations of life'. One can hardly be separated from the other and, as I see it, the thinking that has led to this model must be examined. The deeds of today arise from the thoughts of yesterday and if we want other deeds we must think differently. Otherwise all the boundaries that are set and the prohibitions will remain only as a battle against symptoms without looking at the cause of the unease.

If the conceptual model from which genetic engineering originated presented the whole truth about life, no reasonable cause would exist to oppose genetic engineering. Ever since the Neolithic revolution, mankind has manipulated nature according to his means and has presumably practised plant breeding, even though we know little of the details. He has thus actively participated in the evolution of the other living organisms. This can be seen negatively (destroyed wild nature, over-civilisation of mankind) but it can just as well be seen positively (artistically cultivated landscape, freedom of natural limitations, improving wild plants) and even as a duty of man within evolution.

Conceptual models, however, do not reflect the whole truth but only a section of the whole and they are objectifications which reveal at least as much about the model builders as about the phenomena and connections which they are supposed to represent. Model builders have a mechanistic not an organic picture of the world. Critics of genetic engineering must bear this in mind! If they remain on the level of thinking that has led to genetic engineering, they will not stop it. A broadening at the level of what is taken into consideration would lead to wider reaching consequences than mere criticism of genetic engineering (compare with the above propositions re. guidelines).

If the causes of health and illness, resistance and quality, lodging resistance, nutritive properties and size of grain all lie together in the molecules, it would indeed be appropriate to combine the right molecules correctly. But the conceptual models provide no explanation of how the organism, at the right moment, makes the right choice from the abundance of genetic information and then translates it into RNA and finally into protein.33 For this it needs an entity - an organism. An organism like a plant for instance, is something that constantly develops. It changes its form in the course of time (seed, seedling, flowering plant) and according to the environment (moisture, light, warmth, soil). The totality of the plant can only be grasped when surroundings and seasons are included. A plant breeding system that wants to proceed holistically will not try to produce a plant genotype in artificially created surroundings (laboratory) which can be sold throughout the whole world; but it will direct itself to regional needs and conditions. It will take account of the development of type over many years, a process during which the influence of the habitat and inherited characteristics of the plant interact. Here we come to the third question mentioned above. What alternatives to genetic engineering (as the result of the stepwise development described earlier) exist which could be developed?

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## 3.0 Alternative approaches

### 3.1 Beginning with nature

In the above I have endeavoured to show how genetic engineering has resulted as a logical consequence of the present day way of thinking about life. How has biology developed into genetic engineering? In earlier times research was based on sense perceptions. What the senses experienced was extended and refined beyond the human scale – in biology and especially in microbiology. The smallest particle discovered often took on the role of a primal cause. This development concerns specifically the sense of sight (via the microscope) and the realm of chemistry (which one can perhaps take as scientific processing of impressions which as naive humans are given to us in the sense of taste). Extension and refining of one of the senses was usually accompanied by renunciation of qualities encountered in the other senses. Finally, the actual realm of the senses itself was abandoned and what remained were purely mechanical concepts of bodies and forces interacting spatially on one another.

What I have here described appears to me to be what Steiner described as 'descent into subnature'.34 As a counterbalance to this 'descent' of our culture due to technical civilisation, Steiner called for an 'ascent' to knowledge of 'super nature' which mankind must achieve in order that the 'descent into subnature' may not act destructively.

Such an 'ascent', i.e. a knowledge of the supersensible forces and ideas present in nature should be analogous to the 'descent into sub nature'. In this context I understand 'nature' as:

What is perceptible to the senses

What stays within the bounds of our senses

What is provided by the whole concert of our senses.

It goes without saying that 'nature' in this sense is also grasped, described and penetrated with the activity of thinking. Thus one can fundamentally dispense with recourse to mechanistic explanations, as Maier (1986) has already shown for questions arising in the study of inorganic nature.35 Rather should an effort be made to train aesthetic appreciation of the sense perceptible world as an approach to a ‘supersensible perception’. Here aesthetics is to be understood in its original sense, which extends far beyond the realm of art.36

The following presents examples of a beginning of a hypothesis-free experiential approach to plant cultivation.

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### 3.2 Attempting to see holistically: simple beginnings

We notice that in many respects plants are intimately involved with their environment. They are rooted in the soil with which they are engaged in an active exchange of substances. They grow upwards in the light where the same applies. They are bound to the spot and thus completely interwoven with their locality. They partly prepare this place themselves with root secretions, rotting leaves, shading of the root area. They reflect the place. Anyone familiar with such things can see whether a plant removed from its environment has grown in sun or shade. If, for comparison, there is another plant grown under different conditions, even an inexperienced person can see immediately the effect on its growth.37 We have a fine – if often untrained – perceptive capacity for such connections. Just by comparing observations of different plant types in different surroundings we can train ourselves.

The interconnection of plant and habitat is not only of a material nature. It is also to be found in the whole form of the plant. If I see only the ripe wheat plant and say 'this is the plant', I ignore much that is important and give the name of the whole to only a part and even forget that I have done this.

If we want to see the whole, it is important to activate our capacity to form pictorial concepts. With a picture one can grasp a totality. It can be carried inwardly and enriched with more details and differentiations as new discoveries are added. This is far more difficult to achieve by pure 'if - then' correlations, by chains of cause and effect, and it leads more quickly away from the phenomenon into abstraction which always wants to know 'how it really is'. We are far too strongly conditioned to mistrust our senses and too ready to replace observation with explanatory thinking.

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3.2.1 Example: strains of wheat in different environments

As an example of such a pictorial procedure, I would like to present a few pictures that always recur in the work of a wheat breeding project. The first concerns an experiment with varying plant population densities

Wheat stalks from a dense stand were thinner, taller, began to flower earlier, ripened earlier and did not resist lodging as well as single plants.

From this correlation I can draw all sorts of conclusions. The mutual shade engendered by the plants makes them grow quicker towards the light, whereby the lower sections of the stalks are longer and often subject to lodging. In a dense stand, less nutritive material is available so plant development is hastened and a sort of premature ripening occurs. Such explanations help to bring differentiation into the picture and make it comprehensible. Nevertheless it is helpful repeatedly to bring to mind the picture as such.

Now I would like to describe a picture from an experiment with manuring. There are correspondences with the first picture, but also differences.

Plants on nitrogen-poor soil also ripened earlier. However, their spring development was delayed! They easily resisted lodging and the relatively short stems stood up stiffly in the field.

Now I would like to present a third picture with a geographical connotation.

I was amazed when I saw varieties which I was familiar with in Switzerland, in an experimental trial on good soil in Norway. The plants ripened too early, had thin short stems and on the whole gave a rather grass-like impression. It was as if they were grown on very poor soil.

To this Norwegian picture belongs the corresponding Swiss one.

The Norwegian varieties grown in Switzerland developed slowly, were strong, dark green and had very large leaves. They ripened slowly and late - as if there had been no high summer.

Now I will try to place the different pictures in relation to each other. The plants in the Norwegian trial looked as if they were not properly supplied with nutrients and water. The effect of the soil was reduced by the effect of light. The excess of light due to the long days of the northern summer led to a displacement of the plant's characteristic equilibrium.

In Switzerland the lack of light for the Norwegian varieties led to a reversed displacement. For them the effects of nutrients and water reached their full expression. Ripening was delayed; they 'waited for more light', they lacked their normally predominant influence.

Here one would probably distinguish two themes: firstly, 'long day plants - short day plants' and secondly the 'physiology of yield'. However I would like to consider further the two aspects together.

Observations such as the above are particularly fruitful for comparisons because they concern matters of relation, of displaced force relationships. I can set up 'models' for wheat plants grown in environments dominated by one of these aspects.

Shade plants - tall, thin and delicate, pale, lodging easily, late, immature and ripening stages are mixed up.38

Light plants - short, thin (but tough), dark green, sturdy, early, stages of development clearly separated from each other.

Nutrient and water plants - tall, thick-stalked (but not tough), dark green, lodging easily, late, ripening stage strongly influenced by immaturity.

Deprived plants - short, thin and tough, pale green, sturdy, early, immature stage already noticeably marked by symptoms of ripening.

On poor ground the influence of the soil gives way to the influence of light. The balance is displaced. To a certain extent one can consider a nitrogen-poor site as one where the influence of light predominates. But only to a certain extent, for though the influence of light and poor conditions do indeed go in a similar direction, they are not the same.

Could the resemblance of effects provide guidance for cultivation and breeding? Could one offset the lack of light with poverty of the soil? Yes, this approach is confirmed by experience. Under poor light conditions (for instance declining daylight and Autumn mists) meadows should not be dressed with nitrogen, otherwise nitrogen will be found in the fodder. The same precaution is recommended for Spring vegetables (lettuce, spinach). Nitrate is an indicator of light deficiency.

On the other hand could one mitigate nitrate deficiency by shading? This strange sounding proposition is confirmed by observation. On poor soil, tall wheat plants which mutually shade each other produce better stands than short ones.39 This may also be due to the fact that usually length of stem is correlated with length of root40 and thus the tall plants have better access to nutrients. What is important is that such a way of thinking in balances, relationships, and pictures can more readily lead me to ideas than the mere thoughts: nitrogen deficiency? -

therefore manure with nitrogen! shortage of nutrients? - therefore grow short plants which require less!

Deal with lack of shade by treating with manure? For this there are also practical experiences. Plants well supplied from the soil can manage the water situation better and will not ripen so prematurely.

This should demonstrate that observation of plants in their interaction with their locality is relevant and rewarding. Such observations can and should be pursued further and more thoroughly and lead to a different emphasis on breeding goals.

Present day breeding is mostly aimed at providing plants with the desired characteristics independent as far as possible from their environment (i.e. reliable yield). Up to now this has been successfully achieved. But the question must be addressed: how much of the evident interactive dependence of the plant on its environment is necessary to preserve intact the agricultural ecosystem? Do we want to eliminate all the deficiencies of a locality by supplying the missing elements from outside, or do we want to take seriously the observations that plants themselves have many possibilities for adjusting to extreme conditions, if they are allowed to adapt themselves to the locality?

(This does not mean that a farm which obviously suffers from lack of nutrients should not do everything possible to optimise the nutrient cycle and remedy defects that contribute to the impoverishment of the soil. Leaking slurry tanks and washed out compost heaps do not correspond to ecological thinking.)

In my opinion, ecological plant breeding requires the following:

formulating location-related breeding goals

site-oriented action and including the effect of the location in the selection process

carrying out comparisons and studies between locations

comparing and picturing, i.e. taking seriously the context as we perceive it from direct observation of the phenomena.41

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3.2.2 Example: developmental dynamics of a strain of spelt wheat (Triticum spelta Dinkel)

As in section 3.1, the spatial and location relationships of the plant were emphasised, so can I take a closer look at the temporal relationships, for instance, the developmental dynamics of the plant. This has already been touched on when we dealt with the theme of long versus short days.

A variety of spelt, which in April was growing vigorously and cheerfully in May suddenly caused us great concern. It was one of the first strains to get the white fungal mildew pustules at the base of the stems. Even more instructive was the fact that at the next inspection the attack had hardly increased at all. Many of the previously healthy plants were now also infected and in some cases the fungus had already reached the upper leaves and would soon reach the glumes and the ears.

Our spelt variety 'grew out' of the mildew and was not much the worse for it. With the increasing shading of the lower leaves, these became yellow. It was important that the fungus should restrict itself to the organs which in any case were on the way to decomposition, but that the developing upper leaves and the ears should not be infected.

This is a typical example where a problem can be associated with the temporal developmental dynamics of the plant and where an appropriate growth dynamics can offer a solution to the problem. But in phytopathology and breeding for resistance, more weight is laid on other 'strategies' of the plant in its dealing with the fungus. Especially the 'mechanism of the hypersensitive reaction' is to be mentioned here: the plant allows the infected cells to die very rapidly, thus removing the very source of life of the fungus and protecting the still healthy cells. In extreme cases a plant which thus resists an acute infection can appear to be sprinkled with small pure white flecks.

This example is only a small introduction to the whole complex of ‘developmental dynamics'.

Because of the foregoing I see further important goals for a breeding project as being:

dealing with the temporal dynamics of disease outbreaks

in the matter of plant nutrition, paying attention to the nutrient and transformation dynamics of the soil

observing the germination and ripening processes and giving attention to them in the breeding process.

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3.3 Further methodological steps

Breeding is always closely connected with fundamental biological research. It is thus necessary that a breeder who wishes to advance ecological and holistic methods, should train him/herself in supersensible perceptions in order to experience, learn to describe and try to guide the forces which are active in living nature in addition to the chemical and physical ones. By this I mean the upbuilding forces which do not act in the direction of a general entropy (equalisation of forces and energies, disorder), but on the contrary, lead to form, order, non-equilibrium and tension, and thus make life possible. These forces integrate ideas into the material world that do not themselves originate in it. The cell as 'archetypal unit of life' is such an idea realised in the material world.

(The idea that life has developed by chance also expresses this from another angle: it is certainly extremely unlikely that matter developed into life, because life is not prescribed in the laws of matter. Seen from the standpoint of matter, life can only arise by accident; for from this point of view no other cause is to be seen.)

From experience I know that I have the capacity to perceive living forces. Actually I am as much aware of them as I am of what I see and taste. But these perceptions have a different character from the usual sense perceptions. Rather are they like a taking part in a life process. Only, normally I am hardly aware of this. I normally do not account to myself for the fact that by participating in repeated observations of the sprouting plant over a few days or weeks I make inner progress, noticeably extend myself, and that I can describe such reactions as initial undifferentiated supersensible perceptions, which can with further participatory observation be differentiated and extended and actually have something to do with the wheat plant.

I can notice that some plants in the way they ripen, tell me more than others. This is more than a question of 'mere aesthetics'. It is not only an appreciation of beauty (though this is by no means unimportant).

As examples I will describe a couple more pictures:

In July the tall red-eared varieties of wheat with strong stalks went through a whole palette of colour changes. At first the ears were a pale olive green, then they became more brown, while at the same time the stalks began to glow a salmon pink, as if they were painted with a fluorescent marker pen. It was not so much the colour as the glow that appeared with it. The stalk appeared permeated with light as if it was illuminated from behind or from within. The effect was strong. It conveyed an impression of summer warmth and sunshine which however, was not without a touch of melancholy. It was not the beauty of blossoming, but rather an autumn beauty of release, of letting go. Gradually the glow disappeared and the dense, reddish brown straw colour remained.

There were other white-eared varieties which glowed in their own way. With some only the upper section of the stalk lit up. Others were suffused with light up to the leaves. This depended on how many leaves were already completely withered. The glowing varieties had still a few green leaves which, together with the stalks, shone with a golden colour and then withered. Some varieties did not glow at all. The stalks remained green for a long time while the leaves often withered as colourless straw. Often the transition to ripeness occurred quite quickly. In a few days they were suddenly straw-like and ripe, but the ripe colour was matt, no glow appeared, the transition from green to straw colour followed rather more like a drying process than a transformation of colour.

These last varieties have of course their advantages. With green stalks the plant continues to assimilate, while the leaves may already be withered. Such varieties have a higher yield potential, hence nearly all the newer, high-yielding varieties belong to this category.

Even if we do not want to make bouquets with our plants it seems to me that the intensity with which the ripeness colouring expresses itself is an indicator of quality. It shows that the plant is involved in a process of transformation which can last from a few days to a fortnight. This is an additional process after the flowering, formation and filling of the grain and it is conceivable that one puts up with a loss of inner quality if one selects plants that extend the filling out phase at the cost of the ripening phase.

As already stated at the outset, I do not consider it a waste of time to study such questions and to systematise and deepen the corresponding sensory and supersensible observations. Rather is it a necessity. When something looks appetising, I can take it as a message from my organism to follow it up.

For this, much work and observation is necessary. We need all our human faculties if we are to comprehend growth, creation of form, health and ecology. If we want to work holistically we also need our capacity to experience with our own instincts, our aesthetic sense and our inner feeling to experience something of the quality of plants. In this way the knowledge supplied by traditional natural science will be extended.

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Notes

1. Any gender-specific references to persons in this text should be taken as including both men and women unless it is obvious from the context that one or the other applies.

2. See Appendix.

3. See for example the BATS-Studie (Schulte & Käppeli, 1996), or Ifgene (1997).

4. e.g. in macrobiotics, c.f. the section 'Makrobiotische Grundklassifikation' in Beckmann (1993).

5. From a conversation with Johannes Wirz in May 1997.

6. BMT (1994), p.9.

7. It could be for instance that the chance processes of mutation and recombination, that genetic engineering depends upon, are not the only processes which bring about variation. The possibility of directed or adaptive mutations, as postulated by Lamarck, is since 1988 once again increasingly discussed (Wirz 1996). One can picture evolution as a symphony of a (Darwinian) microevolution and a (goal-directed) macroevolution, cf. Kipp (1991).

8. cf. e.g. Balzer et al. (1997)

9. Lindee (1996)

10. Koechlin (1998)

11. c.f. the project overview on the home page of the Instituts für Pflanzenwissenschaft: http://ipw.agrl.ethz.ch

12. Ackermeier et al. (1993), p.25.

13. cf. e.g. the SWISSAID book on this theme (SWISSAID, 1991)

14. Ho (1996); Holdrege (1996); Rist (1997); Wirz (1992).

15. Wilson (1992)

16. Steiner (1924)

17. Kunz & Karutz (1991)

18. Becker (1993).

19. Becker (1993) p.186.

20. For a description of the colchisinising process see for instance Schmid (1985).

21. e.g. the winter wheat variety Tambo, c.f. Fossati et al. (1986).

22. Schmid 1985).

23. Wicki (1998).

24. Solanum tuberosum L= domestic potato. The potato has many wild relatives in the Solanacae with interesting resistances, cf. Fischbeck et al. (1985).

25. EU (1990).

26. EU (1991), BLW (1997).

27. c.f. e.g. Karutz (1997).

28. There are very many different varieties of B.t.

29. EU (1990).

30. This argument goes in the opposite direction from the usual fear of the uncontrolled spread of GMO's. It suggests that there is reduced 'fitness' in plants originating from tissue culture.

31. Rist (1997)

32. Schultze and Käppli (1996), p. 499

33. Lodish et.al. (1995)

34, Steiner (1954), p. 255ff.

35. Maier (1986)

36. Schweizer (1976)

37. Bockemühl (1980), p. 22/23

38. cf. Kunz (1986), p. 51

39. Müller (1996)

40. Fischbeck et al. (1985), p. 53

41. This claim is based on Steiner's theory of knowledge. 'The thought content of the world comes to us from outside, analogous to sense impressions, though from an outer world which we are only able to grasp inwardly.' (Steiner 1886).

42. BLW (1997), p.2

43. New, enlarged paragraph 1.8 of DEMETER (1996).

44. BioSuisse (1997) Point 2.2.1.

45. Current guidelines: Migros Organic Production (1996). New draft: unpublished, as of April 1998.

46. EU (1998)

47. IFOAM (1995), Section 4.3.5

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4. Appendix

The wording of guidelines for various agricultural systems:

Switzerland

‘Bio-Verordnung’ (organic regulations): (dated 22.9.97)

Art. 3c: Use is not made of GMOs or their products.42

DEMETER guidelines: (Passed at the AGM of 26.11.97)

The following are deliberately not used in biodynamic agriculture: genetically modified plants and animals, GMOs and their products and organisms which are produced with the aid of genetic engineering.43

BioSuisse guidelines: (version of 1.1.97)

The use of genetically modified seeds and transgenic plants is forbidden in organic agriculture.44

Migros organic guidelines: (not in force in April 1998, issued March 1996)

Migros organic production was so far the only organic brand known to me that did not expressly forbid genetic engineering of plants in the guidelines. (Genetic engineering of animals was banned at the outset by Migros.) At present (April 1998) there is a new draft of the guidelines in preparation which will accord with the Swiss organic regulations. It will say:

Genetic engineering: The use of seeds and seedlings that have been genetically modified is not permitted.45

Europe

So far genetic engineering is not expressly mentioned in the EU regulations on organic agriculture. Currently a new proposal is before the Commission..

New supplementary proposal of the EU Commission for the EU organic regulations: (as of Jan. 1998)

Whereas genetically modified organisms (GMOs) and products derived therefrom are not compatible with organic production methods; whereas, in order to maintain consumer confidence in organic production, genetically modified organisms, parts therefrom and products derived therefrom must not be used in products labelled as from organic production.46

Worldwide

All organic agriculture organisations (i.e. e.g. Demeter, Bioland etc) are part of the International Federation of Organic Agriculture Movements (IFOAM). Independently of statutory instruments they hold voluntarily to the basic guidelines, the corporate 'lowest common denominator'.

IFOAM basic guidelines: (passed on 15.12.94)

The use of genetically modified seed and transgenic plants is not permitted.47

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