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Nature in the laboratory – nature as a laboratory. Considerations about the ethics of release experiments

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Abstract. Field tests with genetically modified organisms go beyond the boundaries of the politically and morally neutralized space that normally surrounds scientific experiments. They enter public areas. As a social process of shaping nature they are political in a fundamental sense. Consequences of this observation concern the legitimacy of decisions and the legitimacy of deciding procedures. The political rights of citizens and their human rights can only be respected if these procedures are democratic. Without a more serious exploration of the specific circumstances of release tests – for example, the precise ecological context, the consequences for the future development of the affected ecosystem, the social consequences, and the possible institutional ways of establishing gene technology in agriculture – we do not really know what we are doing when we release transgenic organisms. Moral judgements today can therefore only be prima facie, not free from shortcomings. As responsible judges we must confess that we are still morally blind.
Key words. Philosophy of technology; release experiments; gene technology; technology assessment; risk assessment; transgenic organisms; ethics in genetic engineering; environmental ethics; bioethics; field tests.

Gene technology entangles us in a network of ethical problems. Only a minority of the questions that arise concern the possibilities of genetic engineering with human subjects. Nevertheless, it is these that have so far been treated in most detail in philosophical discussions. We have more arguments at our disposal to treat these questions because ethics has traditionally been occupied with activities that affect human beings. As far as applications in the 'extrahuman' field are concerned, the young discipline of bioethics is in a difficult plight. There are only a few points of contact with the existing history of ideas, and the concepts have to be newly developed. One is tempted to call for a "new ethics" – and the question is: if this new ethics scarcely exists as yet, how can it become sufficiently powerful soon enough to cope with the urgent problems resulting from the rapid progress in biotechnology?

In this essay, I want to point out that the novel issues of genetic engineering in microorganisms, animals and plants do nevertheless have a dimension which can be comprehended with the aid of the accepted concepts that build the moral foundations of our societies. The possibility of manipulating the central regions that control the essence of living beings with the techniques of genetic engineering is so dramatic, and the embarrassment of ethics in discussing these questions is so great, that it often seems to be forgotten that manipulations of non-human beings also affect people. The way society shapes the natural world by technology is a subject for a fundamentally political ethics.

In the present paper I do not even approach the question of the kind of moral respect we owe to manipulated living beings themselves. This does not mean that I think that this problem is of lesser importance. But it seems reasonable to me to describe first the clearly visible aspects of a situation, and to explore those hidden in the darker depths afterwards. I will concentrate on the discussion of release experiments with genetically modified plants.

In section I, I examine the recommendations given by proponents and opponents. Then some of the foundations of moral argumentation must be considered: how can moral judgements be adequate to a given situation? This allows conclusions to be drawn about responsibility in the assessment of the risks of release experiments (section II). An important step in the analysis of the situation can be achieved with the aid of the theory of scientific experimentation. It is necessary to examine whether release experiments, the so-called 'small-scale field tests', really are experiments in the classical sense of the word (section III). Another question that arises is: how far do field tests have a political dimension which can offer a starting-point for an ethical discussion? This must be preceded by some reflection on the terms 'politics' and 'technology' (section IV). Finally, in section V I consider what criteria could serve a society in planning its political decision-making procedures.

I

The conflict about releasing transgenic organisms essentially involves three parties. On the one side there are the protagonists, on the other the opponents and critics, and between these two we see a wide area of indecisive, doubtful, and in some cases also indifferent people. The boundary line between these groups passes right

through the scientific community. Scientific competence alone does not attach somebody to the group of proponents. Even among molecular biologists, and occasionally even among people working in chemical industries engaged in gene technology, all three groups are represented – albeit to different degrees, and possessing very different resources in terms of power. In this situation, a first conclusion can be drawn: that being for or against experimental release has nothing to do with scientific competence – unless someone is able to prove the assertion that it is only the less competent scientists who are pleading for a slower pace in realizing biotechnology.

What are the arguments usually offered by proponents? It is often said that gene technology is a great opportunity for mankind, because it could help to cover the food requirements of the exponentially-increasing population of the world. World food production will have to increase threefold during the next 40 years to meet the needs of an estimated nine billion people (Gasser and Fraley[9], p. 39; see also Gasser and Fraley[8] and Stiftung Gen Suisse[33]). Transgenic plants are often judged to be 'environmentally sound and commercially viable' (Gasser and Fraley[9], p. 34). Other, more cautious estimations do not exclude certain ecological risks, but vote nevertheless for small-scale field tests, in the course of risk assessment in a 'case-by-case' and 'step-by-step' procedure[35].

An analysis of this argument soon reveals its peculiarly dogmatic structure. It starts from objectives which are undoubtedly good – nourishing the future world population, and at the same time developing environmentally sustainable agricultural practices. Release tests are seen as a means of reaching these goals, and therefore they can be recommended on moral grounds. However, if this conclusion is to be valid, a series of premisses have to be accepted:

1) that world-wide farming with transgenic crops does not imply any seriously disadvantageous consequences which could offset the advantages of the higher yield-per-plant crops;

2) that the best way to solve the problem of famine in the world is indeed genetic improvement of crop plants; that the technological way ought to be taken, rather than the alternatives: a juster distribution of wealth and opulence between different nations and different strata within societies; the encouragement of the use of the manifold species and varieties of plants and cultivation methods, that have been used traditionally; 'biological' cultivation techniques, and so on;

3) that small-scale releases are a good means of experimentally assessing risks for large-scale applications, and

4) that the extent of possible ecological harm has a direct correlation with the quantity of land used, i.e., the experimental plantation does not *in itself* give rise to any serious perils.

Considered soberly, all four of these premisses are at least questionable. The other contributions in this volume, and also papers which have appeared elsewhere[1, 2, 12, 13, 21], can hardly support taking them for granted. The diagnosis allows for two different explanations. The first is that we are dealing not with moral propositions meant to be taken seriously, but with specious arguments made for the sake of appearances, designed to sustain the belief – both in the people presenting the arguments, and in the population at large – that the introduction of gene technology in agriculture is not merely a means of increasing the profits of the firms involved, but a kind of humanitarian and ecological engagement.

The second possible explanation is that there is still unbroken confidence in the fundamental equation of Francis Bacon's age: 'Every technological advance is an advance of humanity, or at least brings such an advance in its train' (see also Böhme[6]). However, the present ecological crisis forces us to question the universal validity of that equation. Technological progress has turned out to be a serious problem for humanity in several respects; often it has not resulted in improvement, or it has even produced consequences that are jeopardizing the life of humankind. Today, confidence in the Baconian equation is naive, at best. Behind it lies a belief that there is a 'reason' underlying history, and that science and technology are, as it were, the visible hand of that reason – a metaphysical view that should have been abandoned long ago in the face of the man-made catastrophes of our century.

The opponents of release experiments emphasize the negative ecological consequences of the developments in modern agriculture, and as far as gene technology is concerned, the generalized conclusion is drawn that it will almost inevitably aggravate these problems (see Bärlocher et al.[5]; also several essays in ref. 10). This is, according to the argument, because the release experiments are part of a programme of more and more sophisticated technical exploitation of nature, in the one-sided economic interest of the rich 'developed' countries and the multinational companies. The logic of chemistry, which until now could only manipulate the metabolism of plants from the outside, via artificial manures and pesticides, is now being applied to the manipulation of metabolic processes from the inside. Now the old consequences of that logic will come to light in a much more striking way. Release experiments should be forbidden not only because they conceal unforeseeable risks, but also because the corresponding developmental goals are not worth promoting.

However, the doctrine of these critics can only be supported by the presupposition of at least two premisses:

1) that there is not one single way of making use of genetic engineering techniques which is justifiable from

the point of view of both man and nature, and which will really bring general benefits, and

2) that there is no possibility of taking gene technology right out of the institutionalized programs for the exploitation of man and nature: of withholding gene technology from the economic system of the free market, where profit interests are naturally dominant, and putting it at the service of the people in the countries concerned.

This view implies that 'Scientific and technological progress can never be concomitant with human progress' – the converse of the Baconian equation. But refuting an equation in its universal form does not mean that it is totally invalid in special cases. It is true that technology does not automatically provide solutions to the problems of humanity, but may well produce even more serious problems. Nevertheless, this does not mean that no particular individual innovation could ever solve a problem. The collapse of the legitimation of scientific and technological progress in general cannot support the thesis of a general illegitimacy of new technologies. However, we must concede that none of the genetically engineered variants of crop plants produced (according to Gasser and Fraley[9]) up to now can promise such an incontestable general utility. They still remain ways of combating particular symptoms. For example, virus resistance, and protection against damages caused by insects, are becoming necessities in a monocultural mode of cultivation. 'Biological' cultivation methods and 'integrated' production have developed alternative protection strategies – which do, however, need more labor, and give to slightly lower yields per acre. (The rice fields in the nature gardens of René Haller in Kenya could perhaps be an example of an imaginative and successful method.) The introduction of herbicide resistance also has to be classified as symptomatic therapy. It can only reduce the need for chemicals in a thoroughly industrialized mode of cultivation and harvesting, and even this perhaps only in the mid-term, because resistance genes could soon appear in the weeds as well, as a result of the high selection pressure. Finally, the prolongation of the storage life of fruits and vegetables can only be an advantage if planting and consumption are not in the same region, and the products have to be transported over hundreds or even thousands of miles. Gene technology is being used to mitigate the negative effects of a highly industrialized agriculture, and thus to avoid the necessity of questioning this form of agriculture itself. Hence the critics are right in their insistence on the need to think critically about this developmental direction. Perhaps it was indeed the wrong way.

However, we must concede that within existent structures it is hard to imagine that gene technology could be carried out by non-profit organizations, which are committed to working for the general good. Much more probable is the world-wide spread of transgenic crops as a result of the forces generated by economic competition within the present market structures. As soon as one farming enterprise uses transgenic organisms, and because of the greater efficiency of that technology can sell its products more cheaply, its business rivals will also be forced to change to transgenic production. Higher yields per acre will set free areas now under cultivation. These will either return to their natural state or be used for the production of industrial raw materials[31]. The critics have performed a considerable service by calling our attention to such consequences of gene technology within the power structures of the real world. A technological innovation is never introduced into a social vacuum, but is played as a new card in a game of poker that has already begun. If no effective counter-measures are taken, a technological innovation will serve to strengthen the power of those who are already powerful, and to consolidate the powerlessness of those who are already being exploited[36].

Both the doctrine of the protagonists and that of the critics are based on premisses which are not self-evident. However, this does not mean that their positions are 'symmetrical'. The critics are calling for more prudence; they are following the 'heuristics of fear' that Hans Jonas has called for as an 'ethical basis for technological civilization'[14]. They take the worst possible consequences as the standard for decisions.

In contrast, the protagonists have to justify themselves as creators of new ecological and social risks. They do indeed claim that the critics are also producing a risk – the danger that the world will not have the possibility of profiting from the fruitful effects of the new technology. But this is a remarkably feeble argument. It does not refute the doubts of the opponents, but only claims once more that the aim of the protagonists is an honest one – to guarantee the sufficient nourishment of the future world population in a sustainable manner without jeopardizing the environment. It is not this goal that is called in question by critics, but the effectiveness of the means of reaching it.

In both perspectives we see a tendency to perceive the facts of the case only in a restricted way. In the perspective of the protagonists the problems of the world present themselves as tasks capable of being resolved by technological innovations. Their perceptions are limited – as a result of their situation – by a 'technicist reductionism'. In the perspective of the opponents, the problems of the world present themselves as burdens produced by technology, which cannot possibly be lightened by an even more cunning technology. Their perception suffers – as a result of their situation – from a 'critical reductionism' (I have introduced this terminology in ref. 25).

II

Moral claims derived from a limited view of the problem cannot be reliable. In the present state of knowl-

edge, both doctrines have to put up with this reproach. But we cannot content ourselves with that statement. We should enquire more deeply: which preconditions have to be fulfilled to make a moral claim reliable, so that it is correct for the situation? How can we reach moral certainty?

In principle, there are two possible answers to these questions. The first is that we have at our disposal a valid moral rule approved by all the persons concerned and affected, and with the aid of it we are able to solve the problem that we are confronted with. In many trivial daily situations we do find ourselves in this position. For example, I am obliged to compensate for harm I have caused, as far as I am able. This obligation is valid whether it concerns damage caused by a traffic accident or by irresponsible Stock Exchange transactions, by the emission of poisonous gases or by insulting somebody.

In such cases, we have at our disposal an approved norm, under which the situation in question can be subsumed unequivocally. Such norms represent approved rules for decision-making. Types of situations which are constantly being repeated do not have to be weighed-up afresh each time, as they do at the time of their first appearance. A norm is a piece of equipment, the 'outer casing'[23] of social everyday action. Moreover, norms are something to be handed down. Not every point of view, not every possible reason for an action has to be discovered each time totally anew. Norms make possible a 'reduction of complexity' in decision-making in recurring situations (Kuhlmann[19], p. 115).

The second possible answer is that we do not have at our disposal any valid moral norm approved by all the persons concerned and affected, under which the situation in question could be subsumed unequivocally. This can occur because the situation is totally new, or because its relationship to known paradigmatic cases is disputable. In this case ethics (a title for the kind of discussion that goes beyond existing morals and concerns itself with the rightness of norms and decisions) has to choose another, more complicated procedure.

Release experiments with transgenic organisms put us into a situation of this second kind. The intentional and well-defined transfer of genes beyond the boundaries of genus, class and kingdom is a fundamentally new technology. Man has never before confronted nature with any such products. It is difficult to relate this situation unambiguously to known paradigms. In certain respects it seems reasonable to look at it like the introduction of exotic plants into a foreign habitat[18, 34]. In other respects, genetically engineered organisms seem, to some extent, to be comparable with mutants produced by conventional means such as radiation treatment, or with hybrids. Or the organisms are simply products sui generis (see also Rehmann-Sutter[28]).

The primary task of ethics in these circumstances is the further exploration of the situation. As ethically interested persons we have to see quite clearly *what it is* that we are doing, or what we are planning to do, so that as a second step we can judge what we *ought to do*. What does this mean?

Our 'moral system' consists of a more or less individual selection of rules about what we ought to do, that concerns the actions of ourselves and of the people we interact with in any given situation. When we are confronted with a new situation in which a decision is needed, some of these rules can be linked with some characteristic features of the situation we perceive. By making this connection, we first of all define *what type of action* it is, about which the decision must be made. The classification of actions into types already implies a moral qualification. For that reason, the protagonists of genetic engineering try to treat transgenics as though they are new mutations obtained by classical breeding methods, whereas critics favor the model of exotic species, or reject any association at all with known ecological situations.

Determining precisely what the action is, about which a decision has to be made, is not only a matter of the selection of a comparable paradigm, but also of knowledge about the individual, concrete *circumstances*. A wrong assessment of circumstances, or the possession of only fragmentary knowledge, can lead to a moral error. In classical moral philosophy, the relevance of circumstances was appreciated and discussed in detail. Aquinas went so far as to say that an act is established by the circumstances as a particular species of good or bad (see Aquinas[4], I II q. 18 aa. 10 11; also Jonsen and Toulmin[15], p. 135). According to a 'memory rhyme' the particular circumstances comprise at least the following dimensions, 'quis, quid, ubi, quibus auxillis, cur, quomodo, quando (who, what, where, by what means, why, in what manner, when) (see Jonsen and Toulmin[15], p. 132).

Following this list, to judge a concrete release project with transgenic organisms we would have to take the following into account.

1) Who is carrying out the trial? A firm which is only seeking profit or, for example, a cooperative society of future users? Questions arise as to whether the results will remain in the hands of the rich, or whether they can be utilized by the poor.

2) What is being released? General statements about release projects are not reliable, because the risks involved in a new genetic arrangement of a plant are highly dependent on the specific *kind* of gene alteration introduced, and on the precise nature of the resulting changes in the phenotype.

3) Where? Not every ecosystem reacts to disturbance in a similar manner. What can be permitted in one place can become a problem in another. Today, we have only

a very fragmentary knowledge of the relevant ecological relationships. It would also be relevant to know about those ecosystems that will come into contact with the transgenic plants in the future, after many generations. Also the economic utility will be site-specific, as will economic damage. Whom a new technology serves, how it serves them, and how much they benefit, depends on the social structure in which the technology is embedded.

4) The means used for implementation become relevant. Are, for example, the marker genes which are usually used for the selection of recombinants in fact ecologically neutral? They are, after all, genes for antibiotic resistance, which could potentially also get into other living organisms via horizontal gene transfer.

5) The motives leading to a release experiment will also be relevant to the judgement. Is it merely the inherent automatism of research; is it the interest of an already powerful economy in gaining yet more advantages; or is it the unselfish intention of helping people to be better nourished?

6) In what manner is the experiment carried through? How are the persons affected dealt with when permission is applied for? How open are the proceedings to the public?

7) When? An experiment has to be considered differently, depending on the date for which it is planned. How much patience will the researchers have to wait for reliable results from accompanying risk-assessment studies, or from basic ecological research? A totally new branch of ecology – the horizontal exchange of DNA – has been discovered only recently[20].

The questions discussed above are not intended as a complete list, but are only illustrations of the seven points in the old rhyme. They do, however, illustrate clearly how much the concrete, specific circumstances can influence the moral qualities of release experiments about which a judgement must be made.

It can now be appreciated that a more detailed analysis of the situation can lead to the necessity of revoking those norms which have been held prima facie to be applicable. This can happen either because we see other norms that fit the situation better than those we considered appropriate after a superficial analysis, or because the available norms do not help us at all. The second situation presents a real moral 'hard case'. Our discussion of the doctrines of both protagonists and antagonists of release experiments has shown that both must be applying a prima facie moral system, because in fact the relevant circumstances have not yet been clarified or explored to their full extent.

It would be a mistake to argue in a dogmatic way and to form judgements on the basis of characteristics that are not an inherent part of the case, but are external to it. An example of such a dogmatic judgement is the radical condemnation of genetic engineering for the reason that technology in general has led to environmental problems and to injustice. But no less dogmatic is the corresponding but opposite judgement of the progress-fundamentalists, according to which genetic engineering is exactly the technology most suitable for solving the problems of our time.

Gene technology has not been developed because there is an environmental problem, or because there are injustices in our world. Its development resulted from a logic of scientific progress that is quite independent of such considerations. But neither is gene technology always the even-harsher, more ingenious exploitation of nature that its opponents often consider it to be.

In my view, ethics – in the sense of a debate about morals – has to be a perceptive activity. This holds true generally; I practise ethics when I exert myself to perceive more precisely the needs of those who are affected by my action (or by the actions controlled by a moral norm). I have to explore the circumstances surrounding my actions to see clearly what I will *cause* by doing this or that. Often, a more precise analysis of the circumstances and contexts can throw so much light on a situation that it becomes clear to me *through the situation itself* what is morally right and what is wrong. In every case, the perception of the situation involves the inclusion of both the people taking part in the action, and the people affected by it, in the process of reaching an agreement. If this is successful, we do not need to bring into the situation moral claims that are legitimated anywhere outside. The value criteria are verifiable within the situation itself (for more discussion on this see Rehmann-Sutter[30]).

Up to now, the conflict about gene technology has been a quarrel about dogmas. We have the chance of letting it mature into a dispute about 'Vernunft' – reason. The German word 'Vernunft' is derived from 'vernehmen, wahrnehmen' – to learn, to perceive! A situation contains, so to speak, traces ('Spuren') indicating the direction that moral decisions should take. These we have to trace out ('aufspüren').

One can ask whether it is also something evident that I ought to love my fellow-humans and be good to them, rather than being indifferent or even malicious towards them. In reply, I should like to say that an appeal to me to do something in favor of someone here and now, or to abstain from doing something injurious, is an appeal directed towards me by the affected persons themselves. It is not my calculating rationality which calls for me to act in a particular way, but my ability to perceive the structure of relationships. I show respect for other people insofar as I accept the responsibility involved in my relationship with them. When I neglect the responsibility, and when I miss the moment when I should act, I am acting without sense, and without 'Vernunft' in its true meaning, because 'Vernunft' is the capacity to perceive. To act reasonably, I have to perceive who and

what there is around me, what relationships I am involved in, and what relationships I will be participating in as a result of this or that action. Since the development of pluralistic societies, and the collapse of the universal value-systems that bound the different sections of a society together to form a unity, the relationships between one person and another have come to form the only possible basis for morality.

In the case of releasing manipulated organisms, we are confronted with a difficult practical problem with many possible consequences. We must get rid of the prima facie moral judgements that originated from a restricted view of the problem. To reach a judgement which truly does justice to the situation, we must do away with the reductionism of both the technologists and the critics. This can only succeed in a communicative process involving both parties, because both have to bring in their particular insights and concerns. In such a discourse we can hope that it will finally become clear whether, where, when, how and which release experiments deserve our support.

We have to know much more about what we are really doing when we carry out releases of transgenic organisms, before we can reach moral clarity. This includes, especially, knowing about both the ecological and social contexts, and the possible alternative strategies for meeting the same challenges. Without that knowledge, we cannot really know what we plan to do. It is not possible to take responsibility for an act when we do not really know what it is we are doing, because we lack knowledge about the relevant circumstances. We are simply not yet able to take a moral position. Aristotle formulated this argument even more radically, when he said that if the relevant special circumstances are not all known to the actor, an action cannot be attributed to free will but is in fact involuntary, and the actor is not accountable for it. (see Aristotle[3], 1110 b 27 – 1111 a). But we are responsible for the fact that we choose to carry out an action despite the fact that we are not accountable for it. With respect to release experiments we are still morally blind; they cannot be supported responsibly.

III

A scientific experiment is a controlled manipulation of one part of nature. It differs from other manipulations mainly in two respects. First of all, it is a manipulation with the goal of gaining knowledge. Secondly, the object of the experiment is isolated by artificial measures from its natural environment. This means that the influence of a multitude of factors that might affect the outcome is eliminated, in order not to adulterate the purity of the results. By varying a few individual parameters in a controlled way, we study the behavior of a few other isolated parameters. Thus in an experiment a relationship that exists in nature is removed from its context as systematically as possible. One sole natural relationship should appear in a pure form, and it should be possible to describe it in exact terms[17].

This strategy is basic for the conception of scientific experiments and therefore for modern science. Starting from a theory, precisely-defined questions are formulated, and the experiment is designed to extort from nature answers to these, and only these, questions. As experimenters we are striving for the exclusion of all other questions; the experiment should be designed so that it is as sensitive as possible to one question, but as insensitive as possible to all other questions in the field (see Popper[24], § 30).

Kant described this with the aid of his famous image of the tribunal. Galileo and Torricelli begin, with the principle of reason in one hand and that of experimentation in the other, to 'go to Nature in order to take her advice, but not in the position of a scholar, who lets the teacher tell him anything he wants to, but rather in the position of a judge in court, who is forcing the witnesses to answer the questions he presents them with .... Hereby natural science finally began to move ahead steadily, instead of merely fumbling about as it had done for so many centuries (Kant[16], B XIII f.). The shutting out of all possible sources of mistakes is not a subordinate criterion, but belongs to the idea of experimentation itself. It has become one of the central characteristics of exact natural sciences in their modern sense.

This isolation is normally guaranteed by the laboratory. We go out and fetch a natural relationship and install it in our laboratories, as it were. In the laboratory, nature is decontextualized; screened from an infinite number of disturbing factors. By doing that, we attempt to guarantee that the effects of the manipulation can be controlled and measured within the laboratory. Once the experimental containment becomes leaky – because of an explosion or a fire, for example – we talk about an 'accident', not an 'experiment'. So the classical scientific experiment is not simply a matter of trying out and documenting how nature reacts to a certain manipulation; it is a procedure that is methodically disciplined in a high degree. It is not without good reason that we speak of the 'art' of experimentation.

For that reason, the expression 'release experiment' (or 'field test'), used in this sense of an 'experiment' is actually a contradiction in terms. If it is an experiment in the sense of the art of experimentation as understood by modern science, it cannot have the release of something into open nature as its subject. Otherwise, we have to accept that the term 'experiment' (or 'test') is being used here in a looser way, in the everyday sense of a 'trial'. We want to 'try out' what will happen in nature when certain genetically modified organisms are introduced. In this case, in contrast to the classical theory of scientific experimentation, nature is not partially repro-

duced in the laboratory, but rather nature itself is used as a laboratory. It would be a misuse of terminology to call this an 'experiment' or a 'test' in the classic sense. In principle, it is simply a technical intervention in a natural process, with possible effects on nature as a whole. The fact that the effects and side-effects of an intervention are going to be documented is not sufficient to turn this intervention into a scientific experiment.

A second point concerns the consequences of a failure of the experiment. At least in Popper's view, experiments are in the best case designed as a sophisticated way to refute a theory, or to 'falsify' a hypothesis, as he puts it (see Popper[24], e.g. in footnote *3 to § 30). This happens in the interest of finding true propositions about nature, not as a vexation for the theorists. Experiments should not be designed in order to confirm our expectations, but rather in order to expose our hypotheses to the hardest possible test. Experiments should thus be able to fail, if 'failure' means that an expectation is not fulfilled. The real-life consequences of the failure of an experiment are negligible in the classic concept: either the result of a measurement is different from what was expected, or the experimental system is reacting in an unforeseen way, and we can clear everything off the laboratory bench.

This is different in so-called 'field tests'. They must not fail – or at least, some kinds of failure must not happen, because they could endanger a whole ecosystem. The hypothesis that states that the introduction of transgenic plants carries no risk could no doubt be falsified in a field test. However, the falsification of the hypothesis would not only have effects at the level of the theory (to enable the theory to be improved), but also at the level of the real natural world, where they could cause far greater problems than the correction of some theoretical propositions. In other words: an experimental release is a *real* release, though only on a small scale and under rigorous observation. We can only claim that field tests are not dangerous if we pretend that we already know a lot about the results of the test. The experimental character of small-scale field tests logically cancels itself out: if we were already certain that they are quite safe, we would have no need to carry them out. They can only be tests in the sense of being *real trials*. Interventions in nature on this scale are manipulations in a public area. With that statement, we enter the area of political considerations.

IV

What is the meaning of the term 'political'? The word stems from the Greek 'polis', the city-state. The notion of the state refers to 'the status of people organized in a closed territory' (Schmitt[32], p. 20). Hence we could consider that all those matters are political which are connected in any way with the state, its form of organization, its constitutional interpretation in a system of law and its relationship to other states. A contrasting idea is that of the 'private', a word derived from the Latin 'privare', to rob. 'Private' covers all those activities and concerns that remain beyond the public, political grasp. But in modern societies we clearly see that political affairs can no longer be strictly identified with state affairs, because by no means everything that is not organized by the state is only a private and individual concern.

The equation 'state affairs = political affairs' becomes misleading in the same measure as the spheres of the state and of the society interpenetrate each other (see Schmitt[32], p. 24). Sociologists talk about 'intermediary powers': superindividual, quasi-public forces that can only be controlled to a limited extent by the laws of the state, but that nevertheless make decisions that are relevant and binding for the public. Examples are various kinds of associations, multinational firms, or the 'scientific community'. Politics goes beyond the state, and includes the very matter we are concerned with here: the shaping of nature as a public area.

If I had to give a definition of the word, I would start with a formulation like this: 'political', in a fundamental sense, are all the conditions that human beings have established for human coexistence, which go beyond the bounds of individual affairs[26]. The social shaping of the common environment, the imposition of risks by one group upon another, the establishment of economic systems, of public order, and technology in general are, therefore, political topics in the principal sense of the word. It goes without saying that field-tests of recombinant organisms belong in the political area.

Carl Schmitt, state-theorist of the Third Reich, acknowledged the political relevance of technology already in 1932. He emphasized one aspect of it: 'Technology is always only an instrument and a weapon, and because it will serve everybody, it is not neutral ... If, today, many people are still expecting that technological improvement will also bring the progress of humanity and morality, they are connecting technology and morality in a completely magical way, and besides, they are presupposing in a somewhat naive way that the magnificent instruments of today's technology will only be used in the way they want them to be: i.e., sociologically, that they themselves will become the masters of these terrible weapons, and will be able to claim for their own purposes the immense power that this mastery gives' (Schmitt[32], p. 90 f.). Schmitt's paper ends with a plea for a struggle for the control of technology. In his view, whenever an area becomes political, people inevitably divide themselves into two groups, friends and enemies.

I should like to distance myself from this idea. In my view, a system for ordering human life does not only become political when people begin to fight about it,

but rather it is already inherently political. Man-made systems of order are imposed upon other men. That is politically relevant, in the sense that is transgresses privacy, even when those on whom the system is imposed are not actually rebelling against it.

Technology is, as Schmitt saw correctly, a means of obtaining power. Often this power is not directed immediately against men, but only against nature. However, power over nature is at the same time relevant to the conditions of human coexistence. It dissociates people into two groups – the powerful and the powerless. The question of who is in control of a technology becomes extremely important. A technology can be used to consolidate the existing order, or to bring about revolutionary change. This is the first sense in which technology in general, including gene technology – and especially gene technology in agriculture – is political.

A second sense in which technology is political becomes apparent if we consider the *material presence* of technology in the world in which we have to live. Technology affects the conditions of human coexistence not only as a result of the way it can be employed as a means to particular ends, but also simply because it exists. It restricts our freedom of movement and our opportunity to develop the world as we want to, just as much as it creates new freedoms and new possibilities.

To Langdon Winner, this is a reason for developing a political philosophy of technology: 'The things we call "technologies" are ways of building order in our world. . . . In that sense technological innovations are similar to legislative acts or political foundings that establish a framework for public order that will endure over many generations. . . . The issues that divide or unite people in society are settled not only in the institutions and practices of politics proper, but also, and less obviously, in tangible arrangements of steel and concrete, wires and semiconductors, nuts and bolts' (Winner[38], p. 28 f.). We can add to this list, 'also in arrangements of genes and chromosomes'.

The manner in which technology is used, and the material presence of technical installations and equipment – which are not easy to get rid of – embody answers to the age-old political questions, in a quite material form: 'questions about membership, power, authority, order, freedom, and justice' (Winner[38], p. 47).

Winner enumerates five politically relevant characteristics of technological systems:

1) the centralization of social control;

2) the increase in the most efficient or effective size of organized human associations;

3) the production of distinctive forms of hierarchical authority;

4) the tendency to crowd out and eliminate other varieties of human activity, and

5) large socio-technical institutions exercise power to control the social and political influences that ostensibly control them (Winner[38], p. 47 f.).

I have a further point to add:

6) the restriction of the available possibilities for the future cultural development of human beings. The galloping annihilation of biodiversity which is a consequence of the agro-technologies (among other things) is part of this limitation, and so is the burden of ecological and genetic instabilities which future generations will have to bear.

The 'risks' of genetic engineering – as they are called euphemistically – are really a manipulation of the chances of our children and grandchildren to live and to develop in new ways. They may well have to eke out a living as administrators of old legacies from the 20th and 21st centuries. Compared with this, our naïveté in wanting to realize all possible technological possibilities begins to look absurd. Technology is not only a means to an end, but also an institution. It does not only contain within itself the possibility of exercising power, but is already itself a power, by its mere presence. The order of the world we live in is only partially constituted by rules, laws and norms; another part is controlled by technology put into practice. Technological structures can influence behavior even more rigorously than laws and social norms. Since they have a material existence they often exercise direct physical power: they force people to behave in one particular way and in no other. Only today are we beginning to recognize how far the rationality of politics in general is affected when the political dimensions of technology are forgotten. If the public conditions of human coexistence are largely determined not by laws and social norms, but by socio-technical institutions whose decision-making procedures are not under adequate political control, then politics must suffer. Politics has only come halfway to self-realization; in other words, it is inherently split. The other half of politics remains repressed at the level of the unconscious mind – and operates out of the subconscious. In the process of putting technology into action we are constantly entering into social contracts, the terms of which we read only after signing them (see Winner[38], pp. 47–58) – provided that we see that we are signing a contract at all. The tragedy of technological civilization is that the contracts are binding, despite the fact that the people who signed them did not know what was their content.

V

When we have recognized this, we can begin to see how a procedure for making legitimate decisions about open field tests of transgenic organisms could be designed. It must be a *democratic* procedure. The essence of democracy is the right of the affected persons themselves to

control the forces which affect them[27]. In societies which have begun to organize their states – the sphere of explicitly political affairs – in a democratic manner, no paternalistic procedure can be legitimate any more in the sphere of technology, since this sphere is implicitly political. Legitimacy, here, means only partly that the decisions made have an ethical basis. It also includes simply the acceptance of the decision by the affected persons; an agreement with the mode in which power is exercised over them, which holds not only for the short- but also for the longer-term, and which cannot be quickly broken if conflict should arise. I use the term 'legitimacy' both in its ethical and in its sociological sense (see Weber[37], pp. 16–20). Concretely, this means that resistance against the quick realization of gene technologies, as it appears both in Europe and in the USA, does not have its real foundations in an irrational fear, or in a fundamentalistic hostility to technology in general or at least to new technologies. Resistance arises rather out of the neglect of the political relevance of the projects by their protagonists and sponsors. Whenever political decisions are made, the mechanism of rebellion against illegitimate exercise of power begins to operate; civil rights are sued for, even when they are not guaranteed explicitly in the law. An individual's right to participate in the control of the power that affects him belongs to the very core of the idea of human rights. A right to participate must include the right to refuse, if the right is not to remain a mere farce.

To provide grounds for our claim for democratic decision-making procedures we do not even have to prove that field tests include severe risks to human beings and to nature. If they include risks, the argument given above holds even more strongly: there is no way of affording legitimacy to technological risks other than the democratic way. I must not expose anybody to a peril unless he or she has agreed explicitly. The exceptions are special cases, for example in medical practice where the patient is not able to agree, and where he or she is exposed to a danger for the purpose of his or her rescue. It is not possible to replace factual consent by a sort of rational calculation to find the right decision; a vicarious procedure cannot take over the role of consent[29].

Technology begins to behave paternalistically when the owners of technological power claim to know better what is good or bad for the people affected than they can know it themselves. To enlightened people who are affected by such a paternalism, it looks like nothing better than simple force, the 'right' of the stronger, and it lacks any legitimacy. In clinical research we demand free and informed consent from the affected patients for that very reason. We consider that experiments done without this free and informed consent are a violation of human dignity.

Every discussion about the tolerability of risks must be preceded by an assessment of the dimensions of the risks being discussed. Release experiments pose particular problems also in this respect. There is a consensus that the future effects in ecosystems are, in a strict sense, unpredictable – that is, they can only be experienced empirically. The controversy concerns the evaluation of this prognostic insecurity. Does the insecurity remain within the normal range that we accept in our every day life and in our dealings with nature – and indeed, cannot avoid if we are to live at all? Or must we at least start with the supposition that the insecurity could be beyond this range? This assessment can certainly only be made case by case, and needs very careful investigations – not only about the genetically modified plant, its habitus and its behaviour, but also about the particular ecological environments it will come into contact with. This is the task of scientific risk-assessment studies. Up to now, such assessments have rarely been made. But without a doubt, they must be carried out *before* organisms are released into the environment, even for experimental purposes. In any event, it would be very difficult to convince a population that is alerted to what is happening that any other sequence of events could be reasonable.

The assessment of the risks involved in a technology not only concerns questions that can be answered scientifically, but also value-judgements. A first one is: 'How much knowledge about the potential consequences do we consider to be sufficient?' The more we learn about the relevant contexts, the more we shall become aware of possible consequences of an intervention. The search for consequences is a search that can never be completed, along tracks that are constantly dividing and going in new directions. The more we know, the more questions about consequences arise. This leads to still greater knowledge, and even more questions. . . . On the other side, risk assessment contains a kind of diabolic logic: the less we know, the less we are conscious of the possible consequences, and the more secure we fancy ourselves to be. The correlation between the security we perceive and the amount of knowledge we have is negative, and not, as the situation really demands, positive.

A second question about values concerns the precariousness of every single possible consequence. What does 'dangerous' really mean in a particular instance? What consequences for an ecosystem do we define as 'not desirable'? An answer must presume ideas about the desirable state of the natural environment. This depends again on the life-projects that we consider worth of living, and on our concepts of unhappiness and suffering. Thirdly, risks are not only risks to nature as a resource for life, but also risks of disadvantageous changes in the structure of human society. To talk about social risks implies having ideas about social health.

The question about the risks of gene technology has no scientific answer, although there will be scientific partial answers. For that reason it is indispensable that any risk-assessment research worth of the name must be established as an interdisciplinary project that embraces all the variously involved sections of society. It must not remain merely a scientific project. This will only succeed when a social-critical intelligence is already applied at the planning stage of the research projects concerned. Risk assessment is already a constituent part of political decision-making processes.

Democracies have quite a large collection of decision-making procedures at their disposal. Asking everybody to vote on a question is only one of these. Ideally, the procedure chosen should fit the particular kind of problem to be decided. However, in every case where the citizens themselves do not make decisions directly, but authorize appropriate bodies to do so on their behalf, the procedural rules of these bodies must be supported explicitly by the citizens. These include rules that authorize a committee or a parliament to discharge a particular, defined task, and rules that prescribe the composition and the election procedure of the representatives. Such rules have to be parts of the constitutional law.

Concretely, this means that committees like the Swiss Commission for Biological Safety (SKBS), which are deeply involved in making decisions about release experiments, should be elected by the citizens themselves, if they are to be capable of producing legitimate decisions. If this cannot be achieved, or is not considered to be suitable, the least that should be done is to set up another committee, which would be authorized by the citizens to select the members of the specialist committees according to strictly-defined rules. Neither of these procedures exists in Switzerland[7]. In the Federal Republic of Germany the situation with the 'Zentrale Kommission für biologische Sicherheit, ZKBS' (see also Gill[11]) is similar. Out of necessity, and in a situation where legal rules were still lacking, the local scientific community selected for itself a committee of the most successful scientists. The fact that committees do exist, at least in this form, is to be welcomed. But this mode of organization cannot suffice for a democratic legitimation of decisions.

To be able to do justice to the subject on which a decision must be made, a committee would have to be composed in a more pluralistic way. In particular, it would have to include people able to exercise a social-critical intelligence, and also members of the social groups likely to be affected, in order to prevent 'technicist reductionism' influencing the judgements. Furthermore, representatives of interested parties should not be in the majority, so that the better argument, and not the predominant interest, will be decisive.

It is one of the irrational features of the present conflict that public discussions have revolved for years exclusively around a moratorium – a stop to gene technology in general – or around material limitations to the projects that can be permitted. I do not want to say that these discussions were not necessary, but they have led to the neglect of another important aspect: the working out of proposals for a good constitutional law that could regulate the decision-making procedures. For such a discussion case studies like that reported in Naimon[22], about applications for permission that have actually been considered, their difficulties, faults, and distortions, could be eminently important. Up to now, we were asked to vote on laws concerning prohibition and permission, although good procedural rules are still lacking.

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