WHY GENETIC MODIFICATION AROUSES CONCERNS: SOCIAL, CULTURAL AND POLITICAL IMPACTS

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Summary

Genetic modification opens up a whole new world of possibilities. These range from breeding methods to improve plants, animals or microorganisms, to maintenance of the

environment as well as production of food fibers or drugs. Medical applications of genetic modification have been well accepted by the general public all around the world. Many new pharmaceuticals, vaccines, and diagnostics have become available and more will be forthcoming. On the other hand food from GMOs has raised concerns, principally in Europe. Many people are worried about the impact of GM–food on human health and the environment. This despite the fact that a great deal of research has been done on the subject and no evidence has been found that GM–food is less healthy for humans than other food or that transgenic crops, cultivated on 90 million hectares world–wide, cause any environmental damage. In fact GM crops will increase sustainability in farming, when judiciously applied.

Apart from these practical concerns, GMOs have become the scapegoat for other problems: globalization, the power of multinational companies, US economic dominance, loss of traditional patterns of farming, and loss of cultural values associated with eating and drinking, etc. In several street demonstrations against the WTO the GMO opponents have been highly visible. These concerns need to be taken seriously, but they are not uniquely related to genetic modification. Some consider GM "unnatural".

Particularly in Europe, modern biotechnology has become the playground of diverse political forces. Green political parties, some NGOs (particularly Greenpeace), and environmental agencies sometimes even those of governments are vocal opponents of GMOs. The public's concern is used to build up their political influence.

To get out of the present impasse there is an urgent need for more transparent dialogue. This will have to include scientists, industry, NGOs, policy makers, and the media. Industry needs products with clear consumer benefits and scientists need to communicate better. In the long run, better education is required, in science generally. Those likely to suffer most from the Europeans' scepticism about GM–food are poor farmers in the developing countries who in the coming decades should increase their production to create wealth and to meet increasing local demand for food. Increased productivity will help conserve biodiversity by preventing ever more land, in particular tropical rain forests, being cleared to provide more space for cultivation.

1. Introduction

In the public debate on science and technology, genetic modification and biotechnology (including GM food and the use of human embryonic stem cell lines) have recently become more visible than any other technology. Why has this happened only now, although the first products of modern biotechnology - pharmaceuticals - appeared on the market nearly 20 years ago? Are the costs and benefits of food from transgenic crops so different from those of medical products or is it primarily the public perception that differs?

1.1. The public perception of new technologies

In the past two centuries many scientific discoveries have lead to new technologies. These technologies have helped solve problems of everyday life whilst often disrupting traditional ways of doing things. The advent of the railway allowed for inexpensive transport of goods over long distances and was at the same time, however, the knell of horse-drawn transport with its entire infrastructure.

The acceptance of new technologies by the public has varied a great deal (see also - *Public Policy Responses to Biotechnology*)**.** The factors affecting acceptance include the perceived benefits and costs, the historical setting as well as the segments of society seen to benefit or lose. Even with technologies that have generally been well accepted, as for example aeroplanes, telephones, vaccinations and microwave ovens, there are people unwilling to use them. Examples of technologies that are poorly accepted today, at least in Europe, are nuclear power for electricity generation and food irradiation. These technologies raise concerns, or outright rejection, by a substantial fraction of the population. It is, perhaps, worth looking at these examples in order to draw some conclusions for the discussion on agricultural biotechnology and genetic modification. Nuclear energy faces huge potential environmental problems: there has to date been no solution found and enacted for the long term storage of spent fuel elements. The second obvious problem is the fear of radioactive contamination resulting from the malfunction of the reactor, such as experienced at Chernobyl, Three Mile Island etc. Despite many countries' decision to shut down nuclear power plants, there is, nevertheless, the belief that once fossil fuel becomes much more expensive, nuclear power will be a major part of global energy resources, as recently argued by Starr.

The second, far less pervasive and relatively unimportant technology that has virtually not been accepted in Europe is food irradiation. Although this sort of hygienic measure causes no harm to consumer health, it is allowed for only very few specialized applications, such as for dried herbs. The aversion against the technology presumably derives from its perceived closeness to nuclear energy. It is feared that some harmful residue of the radiation may be left in the treated food, although there is no scientific basis for this perception. In nearly all applications, food irradiation can be replaced by heat, high pressure or chemical treatments making food irradiation not of vital importance for consumers or industry.

Other problematic technologies have included the textile machine, the introduction of which led to riots in Great Britain around 1815, but turned out to be centrally important for the industrialization of the country and its wealth generation. The Luddites feared it would lead to more rural poverty. More recent innovations such as computers and mobile phones are in daily use while still facing vociferous opposition from a small segment of the public.

1.2. The status of applications of genetic modification

Many applications of biotechnology, including genetic modification, have become well accepted by the general public in the last ten years. This holds particularly for many medical uses. Through the transfer of human genes to micro-organisms it has become possible to manufacture many human proteins in large amounts in single cell organisms, while before such proteins could only be extracted with a huge effort from human tissues or other native biological materials. This holds particularly for over 100 pharmaceuticals and vaccines that are now on the market. The number of products used in diagnostics is even larger, but the amounts finally used are small, since they are only laboratory reagents and not drugs. The annual turnover of the whole biotechnology industry is estimated by Ernst & Young at $ 63 billion for 2005. With the completion of the human genome project many new pharmaceuticals will be developed in the coming years: some estimates speak of many hundred new compounds that will be discovered and developed.

Somatic gene therapy, xenotransplantation and tissue regeneration from stem cells (also called therapeutic cloning) are applications of biotechnology that have been evolving more slowly than expected. Yet the potential of these procedures is huge and may have a large impact on medical treatment and perhaps on disease prevention. The public's concerns are quite different for these three future medical treatments.

For gene therapy (see also - *Gene therapy*) the cost-benefit debate is in the fore: in several hundred clinical trials to introduce beneficial genes or to eliminate defective ones, hardly any positive results have been obtained. The consensus of the specialists is that appropriate gene vectors are not yet available, but will be developed in the coming years. For replacing defective human organs, xenotransplantation is promising: pigs have been modified by genetic modification so that their organs - kidney, heart and perhaps liver - may be transplanted to patients, without organ rejection. In the public perception, xenotransplantation raises both ethical and medical questions. Is it right to use animals as reservoirs for human body parts? What ethical difference does it make if pigs are raised to produce organs or to provide meat? From a medical point of view it is not yet clear whether such organs can be prevented from being rejected in the human body and furthermore whether pig organs transferred to humans might release dangerous viruses into the human population. In view of what catastrophe HIV has brought about, this concern appears highly justified. Finally, human stem cell research is only in its infancy: its potential is huge, but quite untested. Human embryonic stem cells or somatic stem cells from the human body are polyvalent cells, from which many or even all human adult cell types arise. Stem cells may be induced to transform into cells for organ and tissue regeneration. Whether there is a broad, safe and efficient application for this technology will only be seen in many years from now. In the meanwhile, the main ethical concern is whether human embryos should be "consumed" for therapeutic purposes. Are two week old human embryos to be considered as human beings, whose lives may not be touched? The issues raised are similar to the ones in the debate on abortion and in vitro fertilisation and raise strong emotions both in the pro and anti camps.

In contrast to these future medical uses, biotechnology is already broadly employed in agriculture and food production (see also - *Agricultural Biotechnology*)**.** Here genetic modification is a new method of breeding crops **(**see also - *Application of Biotechnology to enhance resistance of vegetables and crops to insects, viruses and fungi in transgenic* plants**)** and farm animals, complementing the traditional breeding methods **(**see also - *Conventional Plant Breeding for Higher Yields and Pest Resistance*)**.** The advantage of genetic modification is that DNA from virtually any organism can be used as a starting material and that one or very few well defined genetic traits can be transferred to the recipient. This means that crops can be specifically made resistant to one particular pathogen or pest. Also other traits can be modified, such as nutrient contents, drought or herbicide tolerance etc. At an experimental level, all important crops have been successfully modified and about a dozen transgenic crops **(**see also - *Transgenic plants***)** are widely planted commercially. The turnover of the industry is thought to be about $ 5 billion, with transgenic crops planted on 90 million hectares in 2005. The most important transgenic crops are corn, soybeans, cotton and canola. Technically it is quite possible that in the next 20 years a majority of crops will be transgenic **(**see also - *Farmers and Plant Genetic Resources***)**, but whether this will happen or not, will depend to a considerable degree on public perception **(**see also - *Biotechnology in the environment: potential effects on biodiversity***).** For the two most important crops in world farming, wheat and rice, transgenic varieties are ready to be commercialised. The reasons for the public's concern about transgenic crops will be discussed later.

So far there have been very few applications of transgenic micro-organisms or plants to protect or improve the environment, although the potential for both damage prevention and for bioremediation is large. Prevention means for example replacing chemical processes in industry with biological processes using transgenic micro-organisms. By doing so, aggressive chemicals and processes run at high temperature may be replaced by biological processes run at ambient temperatures, using enzymes or whole micro-organisms in an aqueous system instead of aggressive chemicals in organic solvents. Bioremediation involves breaking down recalcitrant toxic chemicals like polyphenols or removing cadmium from soil **(**see also - *Microorganisms as catalysts for the decontamination of ecosystems and detoxification of chemicals*; **-** *Biodegradation of xenobiotics; - Bioremediation in marine environment*)**.** Plants designed to take up cadmium, for instance, have been developed by genetic engineering and these plants can be used in the field to remove a substantial portion of the unwanted cadmium left behind by industry for many years. The degree of implementation of such biological processes for the benefit of the environment depends both on the technicalities and economics of each specific application and particularly on the political will.

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Biographical Sketch

Richard Braun is a microbiologist / molecular biologist. After working in basic cancer research from 1962 he became professor of microbiology in 1972 and taught at the University of Bern (Switzerland) until 1998. He is now involved in communication on biotechnology through BIOLINK (a one man consulting company) and diverse academic organisations such as the European Federation of Biotechnology