



## **The gene is out of the bottle The menace of genetic engineering**

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As I write, today's newspaper reports that thousands demonstrated, and twenty were injured, in Genoa yesterday in protests against genetically manipulated foods. No less than 5,000 policemen were deployed in a tiny area of Genoa to ensure that a "Biotechnical Fair", sponsored by sixty companies in this sector, passed off without incident. The same reporter tells us that although one out of every two Italians hasn't an iota as to what biotechnology signifies, a majority would express itself as being "cautious" regarding the application of such knowledge to the creation of new agricultural products. Isn't that what spokespersons for the genetic engineering sector tell us: that opposition to their project and consumer rejection of their products is based on romanticism, groundless fears and irrational technophobic attitudes—sad anachronisms, as more and more areas of social life submit to the dictates of technological rationality, the ideological bedrock of the coming millenium?

A range of transgenic supercrops to solve the world's nutritional problems is one of the many tempting prospects held out by genetical engineers—and yet the transgenic crop field trials are destroyed by ecoprotesters. Biotech partisans hold that genetically altered animals and micro-organisms hold the key to the cost-efficient production of many substances of crucial medical and nutritional importance. Opponents hold that methods used to achieve these goals pose unacceptable risks to the health of this and future generations. Worried consumers pressurise for the removal of transgenic products from supermarket shelves. Genetic ID, a US company, reports that more than half of the maize samples analysed in its laboratories contain transgenic contamination (today's newspaper again!). Transgenic seed stocks are destroyed as biotech share prices plummet. The Human Genome Project offers the prospect both of the elimination of hereditary disease, and of eugenic planning. The O J Simpson trial put DNA tests firmly in the public domain. The ethical debate around the issue of human clonation runs and runs...

No wonder the average punter, and not only in Italy, is confused! The gut feeling of socialists would be that they are 'agin' field trials and commercial release of transgenic crops and seeds, for example, if only because of the enormous economic leverage and power over (especially) Third World farmers that exploitation of genetic engineering technology places in the hands of a handful of multinationals. This is, of course, a point worth reiterating, although many may feel, subliminally, that this is a price worth paying in view of the alleged fabulous benefits genetic manipulation can bestow on humankind.

The now well established scientific Achilles heel of the whole genetic engineering enterprise is seldom stressed, leaving the propaganda initiative with 'experts' who assure us soothingly that their meticulous trials and tests ensure that all possible risks are identified and eliminated before transgenic organisms are released for commercial exploitation. So the industry can respond to critics by presenting them as latter-day Luddites, born-again Flat-Earthers etc., straining Canute-like in their attempts to stem the tides of (inevitable) scientific progress. After all, they reason, genetic modification is simply the latest in a continuum of biotechnological innovation that has been going on since the year dot. Its possible benefits to mankind are limitless.

Food, for example. Today 800 million people go hungry and 82 countries neither grow enough food nor can afford to import it. In India alone, 85% of children under five suffer from malnutrition. The global population now needs to consume over two billion tonnes a

year of cereals and other crops, according to the 1996 World Food Summit in Rome (World Bank Report) and, with current demographic trends, this production will need to be doubled over the next thirty years. Given the limited technical and other resources of the Third World, how is this goal to be achieved? Plainly high-yield disease- and pest-resistant crops with high nutritional value and zero environmental impact would be a highly desirable step in the right direction.

And that's where genetic engineering comes in.

By that is meant a set of techniques for isolating, modifying, multiplying and re-combining units of genetic information, known as genes, from different organisms. Genes play a key role in the determination of the form of organisms, each gene being associated with the expression of one particular characteristic. The uniqueness of each organism is a reflection, then, of its own unique gene pool or genome. Using biotechniques, a gene from one organism can be attached, for example, to a virus with its pathogenic genes removed, which can then be made to infect other organisms, inserting the foreign gene into the host organism genome. So by cutting and joining bits of viruses or other genetic entities that can move from cell to cell or organism to organism, appropriate vectors, or carriers, are made which can transfer genes from a donor species even to recipient species that do not naturally interbreed with it. Thus, fish genes could be incorporated into sugar beet genomes, for example, or human genes into those of pigs or plants. Or – to return to the less exotic – using these techniques, crop plants can be genetically modified to increase yield and nutritional value and to enable their cultivation in currently inhospitable environments. Such crops can be tailormade to resist pests and diseases and, moreover, to thrive on reduced inputs of pesticides, herbicides and fertilisers.

The root of the problem is that certain assumptions of pre-1970 molecular genetics, on which genetic engineering practice is based, have been invalidated and superseded by advances in the science over the last ten to twenty years. And evidence accumulating over the same period leads to the inevitable conclusion that the methods used to genetically manipulate organisms not only subject public health to unacceptable and, in practice, unknowable long term risks, but are bound to cause incalculable damage to the delicate fabric of existing ecosystems on which all human life ultimately depends. To better understand this position, look at the invisible terrain of DNA, the gene, the chromosome and the vector, as seen by the commercial genetical engineer!

You and me, for example, are made up of billions of such units. Ultimate control of cell activity and form is located in their organising centres, or 'nuclei', in structures known as chromosomes. The nuclei of human body cells, for example, contain 46 chromosomes. Each individual cell trait is determined by a specific section of a chromosome called a gene, as defined above. The gene is made of DNA, whose chemistry encodes instructions needed to enable the gene to carry out its specific role. The chromosomes of a cell are thus seen as long linear sequences of genes, which constitute a comprehensive set of commands that determine precisely the chemical nature and form of the cell environment and, by extension, that of the whole organism.

One of the main functions of genes is to organise the synthesis of protein molecules, enzymes, each one of which catalyses specifically one of the many thousand chemical reactions in the body that, in summation (the metabolism), make up the life process. More specifically, DNA (deoxyribonucleic acid), the genic substance, 'makes' RNA (a chemical relative of DNA) and that RNA in its turn 'makes' enzyme proteins, each of which, by virtue of its chemistry, enables a specific chemical reaction in the cell which would not otherwise occur. Enzymes are the agents of DNA policy, as it were. Thus, the story goes, by determining the enzyme complement of a cell, nuclear DNA controls its chemical/metabolic activity in a rigidly deterministic way and, thence, its form, which is the visible expression of its chemical activity. This model postulates strictly one-way information (or command)

flows outwards from chromosomal DNA. Reverse flow is not envisaged: i.e. proteins cannot alter RNA, nor can RNA alter the information encoded in DNA.

A basic assumption underlying this picture is that genes are stable, apart from random mutations, and are passed on unchanged to succeeding generations (hence the constancy of species form across the generations). Another is that each gene expresses itself independently of the others: a gene transferred from one genome into another will behave in its new environment exactly as it behaved in its original one.

Each of these assumptions has been invalidated. For example, reverse information flow has been demonstrated to occur in many different ways, and indeed, current research would identify it as being the norm. And it is a matter of recorded observation that not only can genes be altered by environmental stimuli, but such altered genes have been transmitted to offspring.

But, most alarmingly, genes in nature are now known not only to hop from chromosome to chromosome within their own genome and migrate across generations within their own species, but have been shown to roam throughout the biosphere across species and even kingdom (the animal, plant and microbial domains) boundaries. Thus genes for pathogen or herbicide resistance introduced by genetic engineering techniques into crop plants, say, can be expected, and indeed have been shown, to migrate both into the genotypes of relatives and even non-relatives—creating ‘superweeds’, for example, with inevitable disruption of nutritional webs that underlie the delicate balance of the ecosystems within which they are located. Field trials have shown, for example, that such gene migration has taken place from herbicide-resistant transgenic *Brassica napa* to a number of its wild relatives, rendering the latter herbicide-resistant also. A very recent German report based on a four-year study of a herbicide-resistant gene in rape detected this gene in the intestinal bacteria of bees. The zoologist who headed the study, Hans-Heinrich Kaatz, warns that his finding could have grave implications for human health. And indeed, an earlier German report indicates clearly that genes for antibiotic resistance in pig gut have wound up in humans. We will return below to the significance of such gene transfers.

Furthermore, scientific observation showing us that the expression of a given gene can be various, depending on the particular genome in which it is located, has invalidated the assumption that genes express themselves independently of each other. In fact, it is becoming increasingly difficult to define and delimit a gene, as the expression of each gene is ultimately connected to that of every other within an organism’s gene pool or genome. The old idea of one-to-one relatedness between gene and specific function in all circumstances is oversimplistic, and hence, exact prediction of the full effects of introducing a foreign gene into a genome is impossible.

Thence, single gene transfers have inevitably led to unexpected changes in host organisms. Toxins and allergens have arisen unexpectedly as ‘side-effects’ in transgenic plants and microbes. Hideously deformed animals have resulted, again unexpectedly, from single gene transfer, underlining the oversimplicity of the ‘one gene:one character’ postulate and the unpredictability of this procedure. Not surprisingly, a human death has been recently reported in the US following ‘gene therapy’, among allegations that other such occurrences may have been subject to cover-up.

In short, the tenets on which commercial genetic engineering is based have been invalidated by a wealth of scientific observation and experiment that has been accumulating with gathering momentum over the last couple of decades, data that are conveniently—and irresponsibly—ignored by proponents of ‘easi-fix’ genetic cure-alls. The claim that gene manipulation can solve our food, medical and even social problems can only be true if by identifying a gene we can with certainty relate it to a corresponding trait: by changing the gene we change that trait only, and by transferring the gene we transfer that trait only. Such assumptions are no longer valid, but they still inform genetic engineering—which explains

not only why this practice cannot fulfil its promises, but why it creates such unacceptable health and ecological hazards.

Failure to recognise that genes migrate promiscuously across species and even kingdom boundaries is the basis for probably the greatest hazard that genetic engineering poses for the biosphere, including the human component of it. Geneticists have linked the emergence of pathogenic bacteria and of antibiotic resistance to such transfer of genes to other bacteria and even to unrelated species.

For example, the bacterium *Escherichia coli* is a normally harmless inhabitant of the intestine of all human beings and many other mammals. In 1982 a new pathogenic strain, *E.coli* 0157:H7, emerged, which causes severe haemorrhages of the colon, bowel and kidneys in human beings. Since then many outbreaks have occurred all over the world with increasing frequency. An outbreak in Japan in 1996 affected 9,000 and claimed the lives of twelve children. A series of outbreaks in Scotland in 1997 claimed twenty lives and made hundreds ill. Scientific evidence indicates that *E.coli* 0157:H7 arose recently and appears to have acquired the ability to manufacture toxins associated with the pathogenic bacterium *Shigella*, most probably by gene transfer from the latter organism. Antibiotic resistance genes have been shown in nature to cross species, genera and kingdoms.

The last ten to fifteen years have seen a dramatic increase in virulent infections and antibiotic resistance in Europe and America, some of which can be undoubtedly attributed to overuse of antibiotics in medicine and intensive farming: antibiotics not only stimulate target organisms to develop resistance to them, but can actually increase gene transfer ten- to a hundred-fold. For example, some countries in Europe have suffered a twenty-fold increase in salmonella infections over the last ten to fifteen years – and since the early 1990s, resistance to a wide range of antibiotics has evolved in one of the strains of the bacterium responsible for the infections. The fact that such alarming increases have coincided with the development of commercial-scale genetic engineering serves to focus attention on the fact that artificial gene transfer vectors or carriers, by their very nature, are bound to accelerate gene transfer across species boundaries.

The most common vectors used in genetic engineering to infect target organisms are a recombination of natural genetic parasites from a variety of sources, including cancer-causing viruses and other diseases in plants and animals, with their pathogenic functions neutralised. These are routinely attached to antibiotic genes so that cells transformed by the vector can be harvested. Exposure to the relevant antibiotic in a mixed culture simply zaps untransformed cells that have failed to incorporate the vector, leaving the genetic engineer with a pure culture of vector-infected cells. Released into the biosphere, these cells – apart from carrying out their designated functions – can serve as a source of antibiotic resistance genes for other organisms.

Furthermore, many such vectors are specifically designed, and used, to break down species barriers and to neutralise cellular mechanisms that attack foreign DNA so that they are enabled to broadcast genes across a wide spectrum of organisms. More simply, these artificially created vectors smuggle foreign genes into cells that would reject them in the normal course of events. Thus, they can infect many animals and plants, and in the process pick up genes from viruses of all these species to create new pathogens – and bestow their antibiotic resistance genes randomly on a wide range of other species, including pathogenic ones, when current antibiotic resistance levels in the biosphere are already the cause of serious medical concern.

Would that the story of the migrating gene were science fiction! According to a German report published in 1996, and referred to above, the antibiotic streptothricin was administered to pigs in 1982. By 1983, streptothricin resistance genes were found in pig gut bacteria. This had spread to the gut bacteria of farm workers and their families by 1984, and to the general public and pathological strains of the bacterium the following year. The

antibiotic had to be withdrawn in 1990, yet prevalence in soil of the vector carrying streptothricin resistance genes remained high in 1993, pointing to the tenacious survival of gene-carrying vectors in the environment. A 1996 report shows that a mobile genetic element, mariner, originally found in the fruit fly, is now found in humans, where it leads to a neurological wasting disease, the Charcot-Marie-Tooth syndrome. The same element has been incorporated by genetic engineers into 'anti-malarial' mosquitoes, holding out the real possibility that the disease has spread from transgenic mosquitoes to human beings.

The dangers posed by vector-mediated gene migrations don't stop there. The nuclei of higher organisms contains much more DNA – up to 99 per cent in some genomes – than is necessary to code for all the proteins their cells need. Part of this excess or 'junk' DNA is known to contain endogenous proviruses, the partial genomes of viral pathogens of the recent or distant past, that became permanently incorporated into host species genomes, having lost the genes that would enable them to undertake autonomous action. However, they may be reactivated by combination with appropriate gene sequences carried by the 'benign', i.e. non-pathogenic, vectors of genetic engineering technology. Thence, the real possibility of the re-emergence of major diseases of the past and the creation of new highly virulent pathogens with high levels of antibiotic resistance.

In fact, as provirus sequences are found in all genomes, recombinations between the genetic material of introduced vectors and endogenous proviruses are bound to occur. 'Murphy's Law', that says that the disaster that can happen will, pithily encapsulates this very unfunny statistical inevitability. So, not surprisingly, there are now a number of reports of observations that directly relate such recombination to pathogenesis – though not, as yet, to human pathogens... so far! However, some, at the very least, of the thirty new diseases, including AIDS, Ebola and Hepatitis C, that have appeared over the past twenty years, according to the 1996 WHO Report, along with the worldwide re-emergence of diphtheria, cholera, tuberculosis and other old infectious diseases, will have been caused undoubtedly by gene transfers and recombinations. Accelerated development and dissemination of supervectors on the part of the genetic engineering industry can only serve to further facilitate a process whose potential for undermining public health and destroying the stability of the biosphere on which we depend is limitless.

Scaremongering? Continually accumulating scientific evidence shows us that the dissemination of genetically modified organisms gives us the best of reasons to be scared. And the best of reasons for all who share a concern for the environment and for the health of this and future generations to battle against the reckless irresponsibility of profit-driven biotech multinationals who would pollute the biosphere, the patrimony of all, with deadly genetic litter for centuries to come.

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