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(The two following talks were given at workshops during the Conference of the Parties on Biosafety, UN Convention on Sustainable Development, Madrid July 23-28, 1995)

The Cairo Report is Scientifically Flawed

The Cairo Expert Panel Report is scientifically flawed, on the following grounds,

1. It is based on assumptions of genetic engineering that are scientifically unsound

- notably in failing to distinguish between rDNA and traditional technologies.

I shall show how the technologies are radically different, and how rDNA technology gives rise to entirely new hazards.

2. It adopts a posture of complacency and permissiveness with regard to biosafety which is dangerous given the current knowledge of the dynamic genome. This is reflected in the Panel's report

- projecting a false sense of security based on gross inadequacy in design and monitoring in field trials,
- failing to apply the precautionary principle, and
- proposing relaxation of existing guidelines without recognizing that existing measures are already inadequate, as Elaine Ingham has demonstrated more clearly with respect to genetically engineered microorganisms.

The situation is very serious because the Experts Panel has not taken up-to-date knowledge in genomic fluidity on board, and are still guided by an out-moded, and discredited set of assumptions of the old genetic paradigm. I shall go into some details on that.

3. It fails to recognize many applications as useless and commercially non-viable, in the light of current knowledge, that are also hazardous for health, biodiversity and sustainability.

We really need to reassess all current applications of gene biotechnology in view of the work of Elaine Ingham's group and others showing unexpected adverse effects of the genetically modified microorganisms on soil ecology and the growth of crop-plants. I shall only dealt with two major kinds of applications in crop plants which are especially misguided right from the start: herbicide resistance and insect resistance.

Recombinant DNA technology differs radically from conventional breeding techniques and carries new hazards

First of all, genetic engineering uses a combination of enzymes to cut and join, and therefore recombine genetic material in the laboratory, totally bypassing natural barriers that prevent species from cross-breeding. That means **genes can be transferred between species that would have had little or no probability of exchanging genes otherwise**, say, between the pig and a pea plant.

Conventional breeding methods cross-breed closely related species so that different forms of the same genes (alleles) are shuffled, **rDNA tecnology enables completely new genes to be transferred from one species to another which has no equivalents to those genes in its genome**. This often means that there is no control as to where the transferred gene is integrated into the genome.

The integration of new genetic material into the host genome is known to have many harmful and fatal effects including cancer.[1] These effects arise from mutations. gene inactivation/activation, gene deletions/amplifications, and even major rearrangements of the genome.

Another major feature of rDNA technology which distinguishes it from conventional breeding methods is that the **gene transfer is mediated by vectors. These vectors have three undesirable characteristics:**

- they are derived from disease causing viruses and plasmids - parasitic DNA that have the ability to invade cells and integrate themselves into the cell's genome. For example, in plant genetic engineering, the vector most widely used is originally derived from a tumour inducing plasmid carried by the bacterium *Agrobacterium tumefaciens*. In animals, vectors are constructed from retroviruses which are known to cause cancers and other diseases. Even though they have been "crippled", they can still be helped by other viruses or recombine with them to regenerate disease-causing viruses.

- **the vectors are designed to breakdown species barriers** so that they can shuttle genes between a wide number of species. Thus, a vector currently used in fish[2] has a framework

from the Moloney murine leukemic virus, which causes leukemia in mice, but can infect all mammalian cells. It has bits from The Rous Sarcoma virus, causing sarcomas in chickens, and from the vesicular stomatitis virus, causing oral lesions in cattle, horses, pigs and humans. Can such vectors be safe for health? Their wide host range means that they can infect many animal cells and in the process pick up genes from viruses of all these species to create new pathogens.

- **the vectors carry genes for antibiotic resistance** so that cells with integrated vectors can be selected for. This is bound to speed up the evolution of antibiotic resistance which is already a big public health problem.

Gene transfers produce massive fatalities; and even organisms that survive often suffer many ill and bizzare effects. This is because they constitute major disturbances to the natural checks and balances that exist in the developmental process. This much is predictable from what we already know about living systems. They are complex, nonlinear systems maintained in a dynamic equilibrium by a combination of positive and negative feedback interactions. It is characteristics of such systems that they are stable to perturbations below a certain threshold. However, when perturbed beyond that threshold, they will break down, without prior warning, in a catastrophic manner. This should serve to warn us against largescale commercial releases of transgenics into the environment.

Sustainable ecological communitiess are also complex, nonlinear systems, with positive and negative feedback interactions that keep them in dynamic equilibrium. When subject to perturbations of the scale currently contemplated in the commercial releases of transgenic organisms, these communities may also breakdown catastrophically without warning. Ecological timescales, are much longer than the developmental timescales of individual organisms, but the effects will be similar.

As repeatedly stated by critics of gene biotechnology, **genetic pollution, unlike chemical pollution** - which is bad enough - **is self-perpetuating, and self-amplifying. Once let loose, they are impossible to control or recall.**

The New Genetics and Gene Biotechnology

One of the major stumbling blocks to formulating a rational biosafety protocol as well as policies and applications on gene biotechnology based firmly on the most up-todate knowledge, is that the practicianers, the proponents as well as the public are all generally unaware of developments in the knowledge of the *New Genetics* since the 1970s, which constitutes a radical break with the old genetics. Instead, people are still guided by the old, discredited genetic paradigm, and that is where the danger lies.

In order to see why the new genetics is diametrically opposed to the old. Let me begin with the three major assumptions of the old genetic paradigm:

1. Genes determine characters of organisms in a linear, additive (noninteractive) way.
2. Genes and genomes are stable, and except for rare random mutations, are passed on unchanged to the next generation.
3. Genes and genomes cannot be changed directly in response to the environment.

The genetic paradigm is very powerful indeed, it perpetrates a view of the organism as nothing but the sum of its genes, its genes being the most important, unchanging essences of the organism. So it is supposed that once the gene is transferred, the desired character follows. This has already been falsified in numerous instances. Although it is generally recognized that genes interact with one another and with the environment, it is assumed that those interactions can be neatly sorted out and separated. This leads to the reductionist targetting of single-gene effects, with the assumption that nothing else will be affected. Again this has been shown to be false, even without the studies that should have been done to characterize the physiological and biochemical changes in the organism consequent on gene transfer, which is particularly worrying in transgenic foods. Finally, the false assumptions that genes and genome are stable and constant led people to believe that once the genes are transferred, they will stay in the genome forever, regardless of changes in the environment. Again, this has been shown to be false.

The new genetics - by which I mean the picture that has been revealed by the application of rDNA technology to investigate genomes since the 1970s - has overturned all three assumptions.[3] Actually, assumption 1 has been known to be false for at least 40 years - long before rDNA research got underway. Let me deal with each in turn.

The action of genes are inextricably interlinked in a complex, nonlinear network with feedback interrelationships at every level. Organisms including human beings have tens of

thousands of genes in their genome. Each gene exists in multiple variants. One of the main functions of genes is to code for the thousands of enzymes catalyzing thousands of metabolic reactions in our body that provide us energy to do everything that constitutes being alive. These metabolic reactions form an immensely complicated network in which the product of one enzyme is processed by one or more other enzymes. Thus, no enzyme (or gene) ever works in isolation. Consequently, the same gene will have different effects from individual to individual because the other genes (in the 'genetic background') are different. So-called "single-gene defects" - which account for less than 2% of all human diseases - are now proving to be very heterogeneous. Many different mutations of the same gene, or of different genes may give the same disease, or not, as the case may be. This has been known for sickle-cell anaemia, common in Africans and Afro-Americans, and more recently, for cystic fibrosis, common among Northern Europeans, and a conglomerate of "craniofacial syndromes" which includes achondroplastic dwarfism. It has provoked the geneticist reporting in *Nature News and Views* to declare that there is "no such thing as a single gene disease"[4].

The extent to which the effect of single genes is entangled with that of all the other genes really comes home to us in the findings of the new genetics. These findings not only further discredits assumption 1 of the genetic paradigm, but also fatally undermines assumptions 2 and 3 - that genes or genomes are unchanging and do not respond directly to the environment.

The picture unveiled by the new genetics is an incredibly complex and dynamic catenation of cellular and genic processes, many of which serve to destablize and alter genomes within the lifetime of the organism. This is in direct contrast to the static linear conception of the "Central Dogma" of molecular biology that previously held sway. The Central Dogma states that the genetic material, DNA makes RNA in a faithful copying process called *transcription*. The RNA then makes a protein by a process of decoding called *translation*. There is strictly a one-way "information flow" from the genetic message coded in the DNA to RNA to protein, and no reverse information flow is possible. In other words, proteins cannot determine or alter the DNA or the transcribed message in RNA, and RNA cannot determine or alter the genetic message in DNA. We shall see that such reverse information flow not only occurs and in a wide variety of forms, and is, furthermore, a necessary part of how genes function within a metabolic-epigenetic supernetwork.

The fluid genome and the new genetics[5]

A complicated network of feed-forward and feedback processes has to be traversed just to express one gene or to make a single protein. Genes, especially of 'higher' organisms, are found to exist in bits, and the bits must be correctly joined together to make the 'messenger' RNA. Numerous other proteins take part in making every single protein, in chopping and changing, editing and recoding in a complicated *epigenetic* network, which interposes between the genes and the metabolic net, and interlocks with it, forming an epigenetic-metabolic supernetwork. *It becomes increasingly difficult to define and delimit a gene, as the metabolic-epigenetic supernet ultimately connects the expression of each gene with that of every other.*

The genome, embedded as it is, within the epigenetic-metabolic supernet, is far from stable or insulated from environmental exigencies. A large number of processes appear to be designed especially to destablize and alter genomes during the life-time of all organisms, so much so that molecular geneticists have been inspired to coin the descriptive phrase, "the fluid genome". Genes can be marked and inactivated by chemical modifications, or by proteins binding to them, base sequences can mutate, stretches of DNA can be inserted, deleted, or amplified thousands, and tens of thousands of times. The sequences can be rearranged or recombined with other sequences, genes can jump from one site to another in the genome, and some genes can convert other genes to their own DNA sequences. These processes keep genomes in a constant state of flux in evolutionary time. Genes are found to have jumped between species that do not interbreed, being carried by mobile genetic elements, viruses or microorganisms, which can exchange genes at a prolific rate, as witnessed by the rapid horizontal spread of antibiotic resistance in bacteria. Parasites that infect more than one species are also vectors for horizontal gene transfer. A particular genetic element - the *P*-element - has spread to all species of fruitflies in the wild within the span of less than 50 years, probably carried by a parasitic mite.

Jumping genes, viruses and vectors for gene transfers are all related genetic parasites. They can help one another jump or mobilize, mutate, exchange parts and infect each other's hosts as a result. As I have already indicated, the vectors used to transfer genes are designed especially to overcome species barriers and to be used for a wide range of hosts, which would speed up and amplify the process of genetic exchange enormously. The genetic perturbations from largescale environmental releases of transgenic organisms are orders of magnitude greater than those

normally experienced in ecological communities. As I have also said, ecological communities are stabilized by a complex of natural checks and balances, of positive and negative feedback interactions, which, when sufficiently perturbed, will break down in catastrophic manner.

The fluid genome processes in the living system are likewise subject to physiological and cellular regulation, which can also be severely disrupted by the gene transfers, leading to highly unpredictable and lethal effects, as we have seen with transgenic plants and animals. Gene jumping, recombination and other alterations of the genome are consequences of gene transfer. they are also greatly enhanced by environmental stress or starvation.[6] Thus, transgenic organisms will be much more prone to mobilize their transferred genes in the event of drought and other environmental stress, increasingly the likelihood that the genes will spread to nontarget species.

Most provocative of all, there is now abundant evidence of (previously forbidden) reverse information flow in the genomes of all higher organisms, i.e., information flow from the environment back to the genes. Predictable and repeatable genetic changes have been found to occur simultaneously and uniformly in all the cells of the growing parts in plants exposed to different fertilizers, and these changes are inherited in subsequent generations.

Of particular relevance to the major applications in gene biotechnology is that, plants exposed to herbicides, insects to insecticides and cultured cells to drugs, are all capable of changing their genomes repeatably by mutations or gene amplifications that render them resistant to the noxious agent, which is why resistance evolves so rapidly, *even in the absence of introduced resistance genes*. And so long as high levels of herbicides are used with the herbicide-resistant transgenic plants - as clearly intended, otherwise the transgenic plants would lose their competitiveness - or high levels of insecticides are expressed by the insect-resistant crops, then some weeds and some insects will be bound to evolve the appropriate resistance, rendering the transgenic plants useless, and with disastrous ecological consequences besides.

As a final blow to the genetic paradigm, starving bacteria and yeast cells are now known to respond directly to the presence of (initially) non-metabolizable substrates by mutating the genes required to use the substrate. The genetic responses are so specific that they are referred to as "directed mutations". In summary, genes are neither stable nor immune to environmental influence. On the contrary, they mobilize and mutate as part of the physiological response of the organism to environmental change.

Implications of the new genetics for organic wholeness

The genetic paradigm has collapsed under the weight of its own momentum in the findings of the burgeoning new genetics. The genes are far from being the constant essences of organisms, whose effects can be neatly separated from one another or from the environment. There is furthermore, no constant genetic programme or blueprint for making the organism, for the genome can also change even as the organism is developing.

How should we see heredity in the light of the new genetics? If the genome itself is dynamic and fluid, where does heredity reside? It is clear that heredity does not reside solely in the DNA of the genome. In the first instance, it resides in an epigenetic cellular state - a dynamic equilibrium between interlinked genic and cellular processes. But even that is an oversimplification. It cannot be assumed that heredity is exhausted at the boundary of cells or organisms. For as organisms engage their environments in a web of mutual feedback interrelationships, they transform and maintain their environments which are also passed on to subsequent generations as home ranges, cultural traditions and artefacts. It is this whole complex of dynamical interrelationships that gives rise to the stability and repeatability of the developmental process, which we recognize as heredity. The fluidity of the genome contributes to the dynamic stability of the whole, just as it is the entire complex of sustainable feedback interrelationships that stabilizes genes and genomes.

The new genetics that underpins gene biotechnology belongs within a paradigm of organic wholeness and complexity emerging in many areas of contemporary research in the west, which is reaffirming the traditional indigenous wisdom common to many cultures all over the world.[7] However, the new genetics can give no justification to *simplistic* ideas on the capacity of organisms or ecosystems to adapt to any and all new circumstances. Organisms and ecosystems, I repeat, are complex dynamical systems with positive and negative feedback mechanisms that make them resiliant as well as a resistant to change. However, these same mechanisms will also cause them to breakdown when the disturbance is large enough, and in a catastrophic, spectacular fashion. The appearance of novelties and of mass extinctions alike in evolutionary history are but two sides of the same coin, we cannot be complacent about the capacity of organisms or ecosystems to

adapt to any and all environmental insults that are perpetrated. The challenge is to chart the safe and sustainable uses of gene biotechnology within the new holistic paradigm.

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2. Lin, S., Gaiano, N., Culp, P., Burns, J.C., Friedmann, T., Yee, J.-K. and Hopkins, N. (1994). Integration and germ-line transmission of a pseudotyped retroviral vector in zebrafish. *Science* **265,** 666-669.
3. The issue of the new genetics versus the old genetic paradigm is dealt with in detail in Ho, M.W. (1995). Unravelling gene biotechnology. *Soundings* vol.1 No. 1 (in press); also Ho, M.W. (1995). Evolution. In *Encyclopedia of Comparative Psychology* (G. Greenberg and M. Haraway, eds.), Garland Publishing, New York.
4. Mulvihill, J.J. (1994). Craniofacial syndromes: no such thing as a single gene disease. *Nature Genetics* **9**, 101-103.
5. First reviewed by Pollard, J. W. (1988). The fluid genome and evolution. In Evolutionary Processes and Metaphors (M.W. Ho and S.W. Fox, eds.), Wiley, London; and Ho, M.W. (1987). Evolution by process, not by consequence: implications of the new molecular genetics for development and evolution. *Int. J. comp. Psychol*. **1**, 3-27. See also Rennie, J. (1993). DNA's new twists. Scientific American March, 88-96.; Jablonka, E. and Lamb, M. (1995). *Epigenetic Inheritance and Evolution. The Lamarckian Dimension*, Oxford University Press, Oxford.
6. This was really discovered fifty years ago by Barbara McClintock - see McClintock, B. (1984). The significance of responses of the genome to challenge. *Science* **226**, 792-801 - for which she was awarded, much belatedly, a nobel prize.
7. See Ho, M.W. (1993). *The Rainbow and the Worm - The Physics of Organisms*, World Scientific, Singapore; also, Ho, M.W., ed. (1995). *Bioenergtics, S327 Living Processes Book 2*, Open University Press, Milton Keynes.

The Hazards of Genetically Engineered Foods

(Talk presented to The National Council of Women of Great Britain Symposium on Food: Facts, Fallacies and Fears, 22 March, 1996, Darlington, U.K.)

I was, for some time, a molecular geneticist and taught the subject for the Open University until seven years ago when I changed my field of research, just as commercial gene biotechnology was taking over the subject. I began to review the literature again in 1994 as a member of an international group of scientists helping the Non-Government Organization, Third World Network, assess UN policy on gene biotechology. We produced a Scientists' Statement on what we perceived to be the ecological, socioeconomic and health hazards of gene biotechnology, calling for a moratorium on commercial releases of transgenic organisms and immediate action on establishing legally binding international biosafety regulation. A number of us also put together an independent experts report on biosafety last year after we lost confidence in the official UN experts report [1]. Apart from the hazards, there are also many global ethical issues, including the patenting of life and the intellectual property rights of indigenous peoples which are dealt with elsewhere [2]. Today, I shall concentrate on genetically engineered foods. By that, I include both food produced with genetically engineered additives, and transgenic food plants and animals such as the Flavr Savr tomato and Zeneca's tomato puree which is now on the shelves in Safeway and Sainsbury, and animals such as the transgenic salmon produced in Canada and now reared in Scotland. I am particularly concerned about transgenic foods though genetically engineered food additives are already problems by themselves, like Bst milk featured in the last issue of The Splice of Life [3].

My thesis is that the hazards of transgenic foods are built into the technology, and that new evidence confirms this, suggesting that transgenic foods are neither safe to grow nor safe to eat. Therefore, there is no case for relaxing existing, already inadequate, guidelines for environmental releases of transgenic organisms, and for marketing transgenic foods. On the contrary, a moratorium on both environmental releases of transgenic organisms and marketing of transgenic foods should be imposed as a precautionary measure until the evidence can be fully assessed, and appropriate legally binding biosafety regulations firmly established.

Genetic engineering bypasses conventional breeding by using artificially constructed parasitic genetic elements as vectors to carry and smuggle genes into cells. Once inside cells, these vector slot themselves into the host genome. In this way, transgenic organisms are made carrying the desired transgenes. The most common vectors are a mosaic recombination of natural

genetic parasites from different sources, including viruses causing cancers and other diseases in animals and plants, and tagged with one or more antibiotic resistance 'marker' genes. Unlike natural parasitic genetic elements which have various degrees of host specificity, vectors used in genetic engineering are designed to overcome species barriers, and can therefore infect a wide range of species. Critics have warned that these vectors in the transgenic organisms constitute major sources of genetic pollution with drastic ecological and public health hazards that cannot be contained, once the transgenic organisms are released into the environment.

Genetic engineering is also known as recombinant DNA or rDNA technology, as it uses enzymes to cut and join, and therefore recombine genetic material from different sources. Let me summarize why rDNA technology differs radically from conventional breeding methods

rDNA technology differs radically from conventional breeding techniques

1. rDNA technology recombines genetic material in the laboratory between species that have very little probability of exchanging genes otherwise.

2. While conventional breeding methods shuffle different forms (alleles) of the same genes, rDNA technology enables completely new (exotic) genes to be introduced with unpredictable effects on the physiology and biochemistry of the transgenic organism. The insertion of foreign genes into the host genome is known to have many harmful and fatal effects including cancer [4].

3. Gene transfers are mediated by vectors which have three undesirable characteristics:

a. they are derived from disease causing viruses, plasmids and mobile genetic elements - parasitic DNA that have the ability to invade cells and insert themselves into the cell's genome. In plant genetic engineering, the vector most widely used is derived from a tumour inducing plasmid carried by the bacterium *Agrobacterium tumefaciens*. In animals, the most common vectors are constructed from retroviruses which are known to cause cancers and other diseases.

b. they are designed to breakdown species barriers so that they can shuttle genes between a wide range of species. Their wide host range means that they can infect many animals and plants, and in the process pick up genes from viruses of all these species to create new pathogens. Thus, a vector currently used in fish has a framework from the Moloney murine leukemic virus, which causes leukemia in mice, but can infect all mammalian cells. It has bits from The Rous Sarcoma virus, causing sarcomas in chickens, and from the vesicular stomatitis virus, causing oral lesions in cattle, horses, pigs and humans [5].

c. they carry genes for antibiotic resistance. This will speed up the evolution of antibiotic resistance which is already a big public health problem.

The vectors for gene transfer are where most of the dangers lie. Unlike ordinary pieces of DNA, they are resistant to enzymic degration, and can survive indefinitely and independently in the environment where they infect cells, multiply in them, and jump in and out of their genomes.

Much of the current concern regarding the health hazard of transgenic foods center on toxicity or allergies from the exotic gene, while the ecological hazards are focussed on secondary gene transfer by conventional hybridization of transgenic plants with weedy relatives. The role of vector-mediated horizontal gene transfer by infection have been down-played or ignored in current guidelines, and is not generally monitored in field releases. This is most unfortunate in view of the rapid advances in genetics within the past 20 years, which so radically alters the subject that it is legitimate to contrast the old, pre-rDNA genetics with the new post-rDNA genetics.

The New Genetics *Versus* the Old Genetics

Old genetics	New Genetics
1. Genes determine characters in a linear, additive way.	**Genes function in a *complex nonlinear network - the action of each gene inextricably linked with that of every other.***
2. Genes and genomes are stable,	**Genes and genomes are *dynamic*,**

and except for rare random mutations, are passed on un-changed to the next generation.	**and *fluid*, they can change in the course of development subject to feedback metabolic regulation**
3. Genes and genomes cannot be changed directly in response to the environment	**Genes and genomes *can change* in direct response to the environment, *these changes being inherited in subsequent generations.***
4. Genes are passed on *vertically*, i.e., as the resulting of inter-breeding within the species, each species constituting an isolated gene pool.	**Genes are also exchanged *horizontally* between unrelated species, so that any gene in any species have a finite probability of being transferred to any other species.**

These findings have been extensively reviewed by a number of people including myself, beginning more than 10 years ago [6]. In the light of this new knowledge, it is most appropriate to ask the question,

Are Transgenic Foods Safe to Grow?

I shall focus on the last feature, horizontal gene transfer, which was known to be widespread among bacteria and viruses for at least 20 years. Microbes are completely promiscuous in their mating (*conjugation)*, Moreover, a host of parasitic DNA can ferry genes across during the mating process, or independently of conjugation by a process called*transduction,* and bits of DNA can also be directly taken up by bacteria from the environment in a process referred to as *transformation*. The parasitic genetic elements can jump between cells, slot in and out of the genome, multiply in cells, and exist in a dormant state almost indefinitely in the environment. As they slot in and out of genomes, they disrupt gene function and also take with them genes of the cell or leave other previously acquired genes behind. There are three kinds of parasitic elements - viruses, plasmids and mobile genetic elements - mosaics of all of them currently employed to transfer genes in transgenic technology. Viruses are probably the most infectious as they do not require cell to cell contact for infection and can persist in the environment indefinitely. Plasmids and mobile genetic elements are generally exchanged by cell to cell contact during conjugation or when one cell ingests (or *phagocytoses*) another.

For a long time, geneticists supposed that horizontal gene transfers did not involve higher organisms, and certainly not organisms like ourselves, because there are genetic barriers between species and viruses and other genetic parasites are species-specific. After all, genetic engineering involves constructing mosaic vectors to overcome those barriers so that genes can be ferried across Kingdoms of organisms.

Within the past two years, however, the full scope of horizontal gene transfer is slowly coming to light. I have done a computer search under "horizontal gene transfer" and came up with 68 references published in prestigious Journals between 1993 and 1996, all but one giving direct or indirect evidence of horizontal gene transfers. Transfers occur between very different bacteria, between fungi, between bacteria and protozoa, between bacteria and higher plants and animals, between fungi and plants, between insects... in short, as one paper states [7] " The threat of horizontal gene transfer from recombinant organisms to indigenous ones is..very real and mechanisms exist whereby, at least theoretically, any genetically engineered trait can be transferred to any prokaryotic organism and many eukaryotic ones." I have presented the current state of our understanding in Fig. 1, where the arrows indicate transfers for which direct or circumstantial evidence already exists. If you follow those arrows, you will realize how a gene transferred to any species in a vector can reach every other species on earth, the microbial/viral pool providing the main genetic thoroughfare.

It must be stressed that although horizontal gene transfers have occurred in our evolutionary past, they were relatively rare events among multicellular plants and animals. **However, horizontal gene transfer is now made much more likely because the vectors constructed for genetic engineering are designed to infect a wide range of host cells**.

Among those 68 references are documentations for the rapid spread of antibiotic resistance genes carried on plasmids among bacterial populations [8-11]. As you know, multi-drug antibiotic

resistance is already endemic in many U.K. hospitals. The transgenic tomatoes currently marketed here and the U.S. both carry genes for kanamycin resistance. Kanamycin is widely used to treat tuberculosis which is coming back all over the world including Europe. The single reference which dismisses horizontal gene transfer is a review produced by the staff of Calgene, assuring us that the kanamycin resistance gene used in the Calgene transgenic tomato is completely safe [12].

As pathogens become antibiotic resistant they also exchange and recombine virulence genes by horizontal gene transfer thereby generating new virulent strains of bacteria and mycoplasm. This has been shown for *Vibrio cholerae* [13-15] involved in the new pandemic cholera outbreak in India, *Streptococcus* [16-20] involved in the world-wide increase in frequency of severe infections including the epidemic in Tayside Scotland in 1993, and *Mycoplasma-genitalium* [21], implicated in urethritis, pneumonia, arthritis, and AIDS progression.

Horizontal gene transfers have been directly demonstrated between bacteria in the marine environment [22], in the freshwater environment [23] and in the soil [24]. The aquatic environments are known to contain some 10^8 or more virus particles per millilitre, all capable of transferring genes, of helping endogenous 'crippled' vectors move and recombining with them to generate new viruses. Transfer of transgenes have been experimentally demonstrated from transgenic potato to a bacterial pathogen [25], and between transgenic plants and soil fungi [26].

Transgenic organisms now include all major crop-plants, engineered to be resistant to herbicides, or to insect pests with transgenes producing a bacterial poison, the Bt toxin, which unfortunately, also attacks many non-pest species. Field trials have shown that herbicide resistance transgenes can spread to weedy relatives within a single growing season [28.29], while Bt resistance evolved rapidly among major insect pests due to the continuous presence of Bt toxin in the transgenic plants [30, 31]. Ecologists such as Jane Rissler and Margaret Mellon who have opposed the release of transgenic organisms since the 1980s, have predicted those ecological effects .

A potentially even greater danger lies in the vector-mediated gene transfer, as recent evidence suggests. An obvious route for the vectors to spread - which is not adequately taken into account in existing guidelines - is by infecting the teeming microbial populations in the soil, where transgenic plants are grown, and in aquatic environments, where transgenic fish and shellfish are currently being developed for marketing. These microbial populations form large reservoirs supporting the multiplication of the vectors, enabling them to spread to all other species. There will also be ample opportunity for the genetic elements to recombine with other viruses and bacteria to generate new genetic elements and pathogenic strains of bacteria and viruses, which will, at the same time, be antibiotic resistant.

Another major class of transgenic plants are now engineered for resistance to viral diseases by incorporating the gene for the virus' coat protein. Viruses are notoriously rapid in their mutation rate. They play a large role in horizontal gene transfer between bacteria [13, 23] and also exchange genes among themselves thus increasing their host range [32]. Molecular geneticists have expressed concerns that transgenic crops engineered to be resistant to viral diseases might generate new diseases by recombination. In a study to test this possibility, *Nicotiana benthamiana* plants expressing a segment of a cowpea chlorotic mottle virus (CCMV) gene was inoculated with a mutant CCMV missing that gene [33]. The infectious virus was indeed regenerated by recombination. As plant cells are frequently infected with several viruses, recombination events will occur and new and more virulent strains can be generated.

Are transgenic foods safe to eat?

In the light of our new knowledge, one must also ask whether transgenic foods are safe to eat. Although natural viruses and other parasitic genetic elements are to varying degrees specific in the range of host cells they will infect or multiply in, current transgenic vectors are designed to overcome species barriers so that they are much more likely to infect a wide range of hosts. In a study to test for the ability of bacterial viruses and plasmids to infect mammalian cells, it was found that plasmids of *E. coli* carrying the complete poliovirus can be transferred to mamalian cells and the polioviruses recovered from the cells, even though no eukaryotic signals for reading the genes are contained in the plasmid [35]. In the same paper, the authors review experimental observations made since the 1970s that the lambda phage of bacteria, and the baculovirus, supposedly specific for insect cells, are also efficiently taken up by mammalian cells; and in the case of the baculovirus, transported to the cell nucleus. Similarly, *E.coli* plasmids carrying the complete Simian virus (SV40) genome were also taken up simply by exposing the cell culture to a bacterial suspension. Mammalian cells accept these foreign DNA parasites so well because they phagocytose bacteria and viral particles directly.

It has long been assumed that our gut is full of enzymes which can digest DNA. However, genes carried by vectors are especially resistant to enzyme action, and are much more infectious than ordinary bits of DNA. In a study designed to test the survival of viral DNA in the gut, mice were fed DNA from a bacterial virus, and large fragments were found to survive passage through the gut and to enter the bloodstream [36]. Within the gut, vectors carrying antibiotic resistance will be taken up by the gut bacteria, which would then serve as a reservoir of antibiotic resistance for invading pathogenic bacteria.

The rapid spread of antibiotic resistance markers has been documented in a long term study carried out in Eastern Germany. In 1982, streptothricin was administered to pigs. By 1983, plasmids encoding streptothricin resistance was found in the pig gut bacteria. This has spread to the gut bacteria of farmworkers and their family members by 1984, and to the general public and pathological strains of bacteria the following year. The antibiotic was withdrawn in 1990. Yet the prevalence of the resistance plasmid has remained high when monitored in 1993 [37], confirming the ability of microbial populations to serve as stable reservoirs for horizontral gene transfer and recombination. Bacteria and viruses are also known to survive indefinitely in dormant form as biofilms in the body and in the environment [38, 39], when they can accumulate new mutations to come back with a vengeance.

Let me end by summarizing the hazards from transgenic foods.

Hazards of Transgenic Foods

1. **Toxic or allergenic effects due to transgene products or products from interactions with host genes.** I just got news via the network that a study published in the latest *New England J. of Medicine* found that genes transplanted from Brazil nuts to soybeans include the allergenic protein, and the biotech company involved had to drop the project.
2. **Spread of transgenes to related weed species, creating superweeds (e.g. herbicide resistance.** [28,29]
3. **Vector- mediated horizontal gene transfer to unrelated species, creating many weed species.** [25,26]
4. **Vector-mediated horizontal gene transfer and recombination to create new pathogenic bacteria.** {13-24]
5. **Vector recombination to generate new virulent strains of viruses, expecially in transgenic plants engineered for viral resistance with viral genes.** [33]
6. **Vector mediated spread of antibiotic resistance to bacteria in the environment, greatly exacerbating an already existing public health problem.** [7-11]
7. **Vector-mediated spread of antibiotic resistance to gut bacteria and to pathogens.** [37]
8. **Vector-mediated infection of cells after ingestion of transgenic foods.** [35] **The vector can regenerate disease viruses or insert itself into the cell's genome, disrupting gene function and causing cancer.** [4]
9. **The vectors carrying the transgene, unlike chemical pollution, are self-perpetuating, and self-amplifying. Once let loose, they are impossible to control or recall.** [37-39]

I hope this helps to convince you that **there is no case for relaxing existing, already inadequate, guidelines for environmental releases of transgenic organisms, and for marketing transgenic foods. On the contrary, a moratorium on both environmental releases of transgenic organisms and marketing of transgenic foods should be imposed on the precautionary principle, until the possibility of vector-mediated horizontal gene transfer and its consequence on biodiversity, agriculture and human health can be fully assessed, and appropriate legally binding biosafety regulations firmly established.**

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Are Current Transgenic Technologies Safe?
Capacity Building in Biosafety Urgently Needed for Developed Countries*

(Paper prepared for Workshop on Capacity Building in Biosafety for Developing Countries, Stockholm Environment Institute, May 22-23, 1996)

Capacity building in biosafety must be based on a thorough understanding of science

Capacity building in biosafety is not the same as capacity building for gene biotechnology. However, the two cannot be divorced. A biosafety capacity for objective risk assessment of gene biotechnology must depend on a thorough understanding of the scientific basis of gene biotechnology. Paragraph 13 of the latest UNEP Report of the Global Consultation on Biosafety [1] states: "To be credible, safety mechanisms need to be based on up-to-date knowledge." Here is where I see the present biosafety capacity in the Developed World itself as far from adequate. It is not based on up-to-date knowledge, but on considerable ignorance of existing knowledge, and in many cases on insufficient knowledge because there has been little support for the necessary research.

I was, for some time, a molecular geneticist and taught the subject for the Open University until seven years ago when I changed my field of research, just as commercial gene biotechnology was taking over the subject. I began to review the literature again in 1994 as a member of an international group of scientists helping the Third World Network assess UN policy on gene biotechology. We produced a Scientists' Statement on what we perceived to be the ecological, socioeconomic and health hazards of gene biotechnology, calling for a moratorium on commercial releases of transgenic organisms and immediate action on establishing legally binding international

biosafety regulation. A number of us also put together an independent experts report on biosafety last year after we lost confidence in the official UN experts report [2]. Apart from the hazards, there are also many global ethical issues, including the patenting of life and the intellectual property rights of indigenous peoples [3] which I won't have time to go into. I want to concentrate on current transgenic technologies in the light of what we already know as well as new findings reported within the past 2-3 years. This will help identify some major gaps in biosafety capacity in the Developed World, which makes it premature and unethical to export transgenic technologies to the Third World.

I shall show how the hazards are *inherent* in current transgenic technologies. Therefore, there is no case for relaxing existing, already inadequate, guidelines. On the contrary, one should seriously consider a moratorium on both environmental releases and marketing of transgenic products until the evidence can be fully assessed, and appropriate legally binding biosafety regulations firmly established.

Transgenic organisms are not the same as conventional breeds

Genetic engineering bypasses conventional breeding by using artificially constructed parasitic genetic elements as *vectors* to carry and smuggle genes into cells. Once inside cells, these vectors slot themselves into the host genome. In this way, transgenic organisms are made carrying the desired *transgenes*. The insertion of foreign genes into the host genome has long been known to have many harmful and fatal effects including cancer [4], and this is borne out by the low success rate of creating desired transgenic organisms. Typically, a large number of eggs or embryos have to be injected or infected with the vector to obtain a few organisms that successfully express the transgene.

The most common vectors used in gene biotechnology are a mosaic recombination of natural genetic parasites from different sources, including viruses causing cancers and other diseases in animals and plants, with their pathogenic functions 'crippled' and tagged with one or more antibiotic resistance 'marker' genes. For example, the vector most widely used in plant genetic engineering is derived from a tumour-inducing plasmid carried by the bacterium *Agrobacterium tumefaciens*. In animals, vectors are constructed from retroviruses known to cause cancers and other diseases. Unlike natural parasitic genetic elements which have various degrees of host specificity, vectors used in genetic engineering are designed to overcome species barriers, and can therefore infect a wide range of species. Thus, a vector currently used in fish has a framework from the Moloney murine leukemic virus, which causes leukemia in mice, but can infect all mammalian cells. It has bits from The Rous Sarcoma virus, causing sarcomas in chickens, and from the vesicular stomatitis virus, causing oral lesions in cattle, horses, pigs and humans [5]. Genetic engineering is also known as recombinant DNA or rDNA technology, as it uses enzymes to cut and join, and therefore recombine genetic material from different sources. Let me summarize why rDNA technology differs radically from conventional breeding methods (Box 1).

Box 1

rDNA technology differs radically from conventional breeding techniques

1. rDNA technology recombines genetic material in the laboratory between species that have very little probability of exchanging genes otherwise.

2. While conventional breeding methods shuffle different forms (alleles) of the same genes, rDNA technology enables completely new (exotic) genes to be introduced with unpredictable effects on the physiology and biochemistry of the transgenic organism.

3. Gene transfers are mediated by vectors which have three undesirable characteristics:

a. they are derived from disease causing viruses, plasmids and mobile genetic elements - parasitic DNA that have the ability to invade cells and insert themselves into the cell's genome causing genetic damages.

b. they are designed to breakdown species barriers so that they can shuttle genes between a wide range of species. Their wide host range means that they can infect many animals and plants, and in the process pick up genes from viruses of all these species to create new pathogens.

c. they carry genes for antibiotic resistance, which is already a big public health problem.

Transgenic technologies carry new hazards

The unpredictable effects of transferred genes on transgenic organisms already raise concerns regarding transgenic food toxicity and allergy. This fear has materialized in the recent discovery of a brazil-nut allergen in a transgenic soybean [6], and of a highly toxic mutagen which accumulates in a transgenic yeast engineered for increased glycolytic activity [7]. The second example is particularly instructive, as the transgenes were derived from the yeast themselves, but amplified into multiple copies; and would have escaped current novel foods regulation if the tests had not been carried out. Transgenic microorganisms can have unexpected and devastating ecological effects as Holmes and Ingham [8] discovered: a transgenic soil bacterium, *Klebsiella planticola*, engineered to produce ethanol from crop waste, completely inhibited the growth of wheat seedlings. Again, the bacterium did not require risk assessment by the Environmental Protection Agency (EPA) in the United States. The EPA's own scientists have been publicly critical of the Agency's failure in risk analysis of transgenic organisms prior to authorizing environmental releases [9]. Transgenic organisms now include all major crop-plants, engineered to be resistant to herbicides, or to insect pests with transgenes producing a bacterial poison, the Bt toxin, which unfortunately, also attacks many non-pest species [10]. Field trials have shown that herbicide resistance transgenes in transgenic potato and transgenic oilseed rape have spread to weedy relatives within a single growing season [11,12], while Bt resistance evolved rapidly among major insect pests due to the continuous presence of Bt toxin in the transgenic plants [13,14]. Ecologists Jane Rissler and Margaret Mellon who have opposed the release of transgenic organisms since the 1980s, have predicted those ecological effects [15].

A fundamental source of hazard is inherent to current transgenic technologies

I now draw your attention to a more fundamental source of hazard that is inherent to current transgenic technologies. This source of hazard is in the vectors used for gene transfer and amplification, which has been down-played or ignored in current guidelines. In order to appreciate why the vectors are dangerous, I have to summarize the rapid advances in genetics within the past 20 years, which, unfortunately, have yet to reach most genetics text books [16]. But it so radically alters the subject that it is legitimate to contrast the old, pre-rDNA genetics with the new post-rDNA genetics (Box 2).

Box 2

The New Genetics *Versus* the Old Genetics

Old genetics	New Genetics
1. Genes determine characters in a linear, additive way.	**Genes function in a *complex nonlinear network - the action of each gene inextricably linked with that of every other.***
2. Genes and genomes are stable, and except for rare random mutations, are passed on un-changed to the next generation.	**Genes and genomes are *dynamic*, and *fluid*, they can change in the course of development subject to feedback metabolic regulation**
3. Genes and genomes cannot be changed directly in response to the environment	**Genes and genomes *can change* in direct response to the environment, *these changes being inherited in subsequent generations.***
4. Genes are passed on *vertically*, i.e., as the resulting of inter-breeding within the species, each species constituting an isolated gene pool.	**Genes are also exchanged *horizontally* between unrelated species, so that any gene in any species has a finite probability of being transferred to any other species.**

These findings have been extensively reviewed by a number of people including myself, beginning more than 10 years ago [17].

The vectors for gene transfer are a major source of genetic pollution

I shall focus on the last feature, horizontal gene transfer, which makes the vectors for gene transfer a major source of genetic pollution. Horizontal gene transfer was known to be widespread among bacteria and viruses for at least 20 years. Microbes are completely promiscuous in their mating (*conjugation)*, Moreover, many parasitic DNA can ferry genes across during the mating process, or independently of conjugation by a process called *transduction,* and bits of DNA can also be directly taken up by bacteria from the environment in a process referred to as *transformation*. The parasitic genetic elements can jump between cells, slot in and out of the genome, multiply in cells, and exist in a dormant state almost indefinitely in the environment. As they slot in and out of genomes, they disrupt gene function and also take with them genes of the cell or leave other previously acquired genes behind. There are three kinds of parasitic elements - *viruses*, *plasmids* and *mobile genetic elements*. Mosaic recombinations of all classes are currently employed to transfer genes in transgenic technology. Viruses are probably the most infectious as they do not require cell to cell contact for infection and can persist in the environment indefinitely. Plasmids and mobile genetic elements are generally exchanged by cell to cell contact during conjugation or when one cell ingests (or *phagocytoses*) another.

For a long time, geneticists supposed that horizontal gene transfers did not involve higher organisms, and certainly not organisms like ourselves, because there are genetic barriers between species and viruses and other genetic parasites are species-specific. After all, genetic engineering involves constructing mosaic vectors to overcome those barriers so that genes can be ferried across Kingdoms of organisms.

Within the past two years, however, the full scope of horizontal gene transfer is slowly coming to light. I have done a computer search under "horizontal gene transfer" and came up with 75 references published in prestigious Journals between 1993 and 1996, all but 2 giving direct or indirect evidence of horizontal gene transfers. Transfers occur between very different bacteria, between fungi, between bacteria and protozoa, between bacteria and higher plants and animals, between fungi and plants, between insects... in short, as one paper states [18] " The threat of horizontal gene transfer from recombinant organisms to indigenous ones is..very real and mechanisms exist whereby, at least theoretically, any genetically engineered trait can be transferred to any prokaryotic organism and many eukaryotic ones." The current state of our understanding is presented in Fig. 1, where the arrows indicate transfers for which direct or circumstantial evidence already exists. If you follow those arrows, you will realize how a gene transferred to any species in a vector can reach every other species on earth, the microbial/viral pool providing the main genetic thoroughfare and reservoir. A mobile genetic element, called *mariner*, first discovered in *Drosophila*, has jumped into the genomes of primates including humans, where it causes a neurological wasting disease [19]. Geneticists suspect the *Drosophila* gene might have got into a viral pathogen which infected the primates.

Although horizontal gene transfers have occurred in our evolutionary past, they were relatively rare events among multicellular plants and animals. **However, horizontal gene transfer is now made much more likely because the vectors constructed for genetic engineering are chimaeras of many different natural vectors, designed to infect a wide range of host cells and have the potential of recombining with a wide range of natural pathogens**. **That they have been'crippled' should not lull us into a false sense of security, because it is well-known that they can be helped by endogenous viruses and mobilze genetic elements to jump in and out of genomes. Otherwise, it would have been impossible to construct any transgenic organisms at all.**

Vectors can cause severe immune reactions by themselves

I cannot overemphasize how dangerous these vectors are. Direct health hazard from the adenovirus vector, used in attempted gene therapy for Parkinson's disease, Alzheimer's disease and Cystic Fibrosis, has been reported in the May 11 issue of the *New Scientist* [20]. It caused such severe immune reaction that one patient almost died. Rats receiving injections of the virus directly into the brain and then into the foot 2 months later developed severe inflammation in the brain. These findings have to be seen against the fact that not a single successful gene therapy has been documented. Geneticists are now looking into even more aggressive gene transfer vectors: the latest one constructed from the AIDS virus [21] even though it has been pointed out that the disabled virus could recombine into a virulent form and cause AIDS.

Vectors mediate horizontal transfer of antibiotic resistance genes

Among the 75 references on horizontal gene transfer are documentations for the rapid spread of antibiotic resistance genes carried on plasmids among bacterial populations [22-26]. Multi-drug antibiotic resistance is already reported to be endemic in many U.K. hospitals. The transgenic tomatoes currently marketed here and the U.S. both carry genes for kanamycin resistance. Kanamycin is used to treat tuberculosis, which is coming back all over the world including Europe, and the TB bacteria are already multi-drug resistant [27]. One of the two out of 75 references which reported 'negative' for horizontal gene transfer is a review produced by the staff of Calgene, assuring us that the kanamycin resistance gene used in the Calgene transgenic tomato is completely safe [28].

Vectors mediate genetic recombination to generate new pathogens

As pathogens become antibiotic resistant they also exchange and recombine virulence genes by horizontal gene transfer thereby generating new virulent strains of bacteria and mycoplasm. This has been shown for *Vibrio cholerae* [29-31] involved in the new pandemic cholera outbreak in India, *Streptococcus* [32-36] involved in the world-wide increase in frequency of severe infections including the epidemic in Tayside Scotland in 1993, and *Mycoplasma-genitalium* [37], implicated in urethritis, pneumonia, arthritis, and AIDS progression.

The dangers of generating pathogens by vector mobilization and recombination are real. Over a period of ten years, 6 scientists working with the genetic engineering of cancer-related oncogenes at the Pasteur Institute have contracted cancer [38]. This reminds us of the hazards of so-called "contained use". Jäger and Tappeser [39] have reviewed numerous publications documenting the long term viability, in the general environment, of GMOs supposedly 'disabled' for contained use in the laboratory. This highlights the need to include contained use in biosafety capacity building and in the legally binding biosafety protocol.

The natural microbial populations form a major thoroughfare and reservoir for horizontal gene transfer

Horizontal gene transfers have been directly demonstrated between bacteria in the marine environment [40], in the freshwater environment [41] and in the soil [42]. Aquatic environments are known to contain some 10^8 or more virus particles per millilitre, all capable of transferring genes, of helping endogenous 'crippled' vectors move and recombining with them to generate new viruses.

An obvious route for the vectors containing transgenes in transgenic higher plants and animals as well as microorganisms to spread is via the teeming microbial populations in the soil, where transgenic plants are grown, and in aquatic environments, where transgenic fish and shellfish are currently being developed for marketing. These microbial populations form large reservoirs supporting the multiplication of the vectors, enabling them to spread to all other species. There will also be opportunity for the genetic elements to recombine with other viruses and bacteria to generate new genetic elements and pathogenic strains of bacteria and viruses, which will, at the same time, be antibiotic resistant. Transfer of transgenes have actually been experimentally demonstrated from transgenic potato to a bacterial pathogen [43], and between transgenic plants and soil fungi [44].

Viral resistance transgenes can generate live viruses by recombination

A major class of transgenic plants are now engineered for resistance to viral diseases by incorporating the gene for the virus' coat protein. Viruses are notoriously rapid in their mutation rate. They play a large role in horizontal gene transfer between bacteria [29, 41] and also exchange genes among themselves thus increasing their host range [45]. Molecular geneticists have expressed concerns that transgenic crops engineered to be resistant to viral diseases might generate new diseases by recombination. In a study to test this possibility, *Nicotiana benthamiana* plants expressing a segment of a cowpea chlorotic mottle virus (CCMV) gene was inoculated with a mutant CCMV missing that gene [46]. The infectious virus was indeed regenerated by recombination. Moreover, the transgenic coat protein can even help defective viruses multiply [47]. As plant cells are frequently infected with several viruses, recombination events will occur and new and virulent strains can be generated.

Vectors resist breakdown in gut and can infect mammalian cells

In the light of the new evidence that vector-mediated horizontal gene transfer is so widespread, it is clear that current transgenic foods are not safe to grow. Are transgenic foods safe to eat? Although natural viruses and other parasitic genetic elements are to varying degrees specific in the range of

host cells they will infect or multiply in, current transgenic vectors, I repeat, are complex genetic chimaeras designed to overcome species barriers so that they are much more likely to infect a wide range of hosts. In a study to test for the ability of bacterial viruses and plasmids to infect mammalian cells, it was found that plasmids of *E. coli* carrying the complete poliovirus can be transferred to mammalian cells and the polioviruses recovered from the cells, even though no eukaryotic signals for reading the genes are contained in the plasmid [48]. In the same paper, the authors review experimental observations made since the 1970s that the lambda phage of bacteria, and the baculovirus, supposedly specific for insect cells, are also efficiently taken up by mammalian cells; and in the case of the baculovirus, transported to the cell nucleus. Similarly, *E.coli* plasmids carrying the complete Simian virus (SV40) genome were also taken up simply by exposing the cell culture to a bacterial suspension. These mammalian cells accept foreign DNA parasites so well because they phagocytose bacteria and viral particles directly. Transgenic medaka and mummichog fish have even been constructed by injecting fish embryos with a bacteriophage fX174 vector carrying an oncogene, which is integrated into the fish chromosome [49].

It has long been assumed that our gut is full of enzymes which can digest DNA. However, genes carried by vectors may be especially resistant to enzyme action, and are much more infectious than ordinary bits of DNA. In a study designed to test the survival of viral DNA in the gut, mice were fed DNA from a bacterial virus, and large fragments were found to survive passage through the gut and to enter the bloodstream [50]. Within the gut, vectors carrying antibiotic resistance may be taken up by the gut bacteria, which would then serve as a reservoir of antibiotic resistance for invading pathogenic bacteria.

Antibiotic resistance genes carried by vectors can persist indefinitely in the environment

The rapid spread of antibiotic resistance markers has been documented in a long term study carried out in Eastern Germany. In 1982, streptothricin was administered to pigs. By 1983, plasmids encoding streptothricin resistance was found in the pig gut bacteria. This has spread to the gut bacteria of farmworkers and their family members by 1984, and to the general public and pathological strains of bacteria the following year. The antibiotic was withdrawn in 1990. Yet the prevalence of the resistance plasmid has remained high when monitored in 1993 [51], confirming the ability of microbial populations to serve as stable reservoirs for horizontral gene transfer and recombination. Bacteria and viruses are also known to survive indefinitely in dormant form as biofilms in the body and in the environment [52, 53], when they can accumulate new mutations to come back with a vengeance.

According to the 1996 WHO report [54], old and new infectious diseases are coming back worldwide, claiming the lives of 50000 men, women and children every day. Antibiotic resistance of the pathogens is identified as a major contributing factor.

Box 3

Hazards of Transgenic Technologies

1. **Toxic or allergenic effects due to transgene products or products from interactions with host genes.** [6,7]
2. **Spread of transgenes to related weed species, creating superweeds (e.g. herbicide resistance.** [11,12]
3. **Accelerating the evolution of biopesticide resistance in insect pests.** [13,14]
4. **Adverse immune reactions caused by gene transfer vectors.** [20]
5. **Vector - mediated horizontal gene transfer to unrelated species via bacteria and viruses, with the potential of creating many other weed species.** [39, 43,44]
6. **Potential for vector-mediated horizontal gene transfer and recombination to create new pathogenic bacteria and viruses.** {29-39]
7. **Vector recombination to generate new virulent strains of viruses, expecially in transgenic plants engineered for viral resistance with viral genes.** [46,47]
8. **Potential for vector mediated spread of antibiotic resistance to bacteria in the environment, exacerbating an existing public health problem.** [22-26, 39]
9. **Vector-mediated spread of antibiotic resistance to gut bacteria and to pathogens.** [51]
10. **Potential of vector-mediated infection of cells after ingestion of transgenic foods, to regenerate disease viruses or insert itself into the cell's genome.** [39, 48-50]
11. **The vectors carrying the transgene, unlike chemical pollution, are self-**

perpetuating, and self-amplifying. Once let loose, they are impossible to control or recall. [39, 51-53]

Identifiable gaps in biosafety capacity

An objective scientific risk assessment must address these hazards, both actual and potential, which are based on the most up-to-date findings. There are, furthermore, major identifiable gaps in our knowledge that are relevant for risk assessment. We do not yet have answers for such basic questions as (Box 4),

Box 4

Some Gaps in Information for Risk Assessment

1. What is the stability of the vector-mediated integration of the transgene and associated marker genes?
2. What is the probability of secondary mobilization and recombination with endogenous viruses and mobile elements which are ubiquitous in all genomes?
3. What is the frequency of horizontal gene transfer to microbes, fungi and other organisms capable of acting as secondary vectors for transferring genes to other plants and animals?
4. What is the probability that transgenes and associated antibiotic resistance marker genes survive in the environmental microbial populations?
5. What is the probability that recombination events in the microbial populations can generate or regenerate pathogens from the disabled vectors?
6. What is the extent to which transgenes and associated marker-genes can survive passage through the gut, when ingested in transgenic foods, and remain in the sewage discharged into the environment?
7. What is the extent to which transgenes and associated marker genes in ingested transgenic foods are taken up by gut bacteria, and persist in the gut bacteria?
8. What is the extent to which transgenes and associated marker genes in ingested transgenic foods are taken up by gut cells.
9. What is the extent to which transgenes and associated marker genes in ingested transgenic foods are taken into the blood stream?
10. What is the extent to which transgenes and associated marker genes in ingested transgenic foods can form infectious particles or DNA to be phagocytosed by cells?

I have raised some of these questions with the UK Ministry of Agriculture, Fisheries and Food [55]. The answers to those questions are vital to a truly scientific and objective risk assessment. Meanwhile, we have to proceed with extreme caution. **There is certainly no case for relaxing existing, already inadequate, guidelines for biosafety. On the contrary, there is an urgent need to strengthen the guidelines.** Capacity building for biosafety must begin at home, with those countries that are already working in gene biotechnology. It is irresponsible and unethical to export gene biotechnology to any other country before appropriate risk assessment, based on the most up-to-date knowledge, can be implemented.

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Five Reasons for Rejecting Genetic Engineering Biotechnology

Global Genes Conference 29 November, 1997, Stoneleigh Park, Warwickshire

Thank you for coming to listen to me. I don't know much about farming and I am here to learn from you on that score. I do know something about genetic engineering however, and I shall give you 5 reasons why I think we should reject genetic engineering biotechnology. It is unethical, unwholesome, unsound, unsustainable and most of all, unsafe.

Genetic engineering biotechnology is a big industry built on genetic engineering. What is genetic engineering? It is a set of techniques for cutting, joining, modifying, and replicating genes, and, most of all, for transferring genes from one species to another bypassing reproduction. Thus, human genes are transferred to pig, mouse, fish, plants and bacteria. And genes of all species can be recombined, cloned and modified in any and every way.

Genetic engineering biotechnology is unethical

To me, genetic engineering biotechnology is inherently unethical because it denies the intrinsic value and integrity of species, subjecting species including human beings and their genes to arbitrary modification, and patenting them, turning them into commodities. Secondarily, genetic engineering biotechnology is promoting and legitimizing biopiracy against indigenous peoples of the Third World. who are robbed of their genetic as well as intellectual resources. It will increasingly marginalize small organic farmers everywhere due to intellectual property rights and other restrictive practices assoicated with seed certification. Medical genetics, similarly, raise many ethical issues that have hardly been debated in public: genetic discrimination, eugenics, and xenotransplantation - genetically engineering pigs to supply spare organs. We are now asked to seriously contemplate cloning, not just sheep and cows, but headless human embryos for harvesting tissues, cells and organs. This is a brave new world of rampant commercialism that stops at nothing for profit and fundamentalist science that says "scientific progress" must come before everything else. Professor Steve Jones of University College, London, stated in a Radio 4 debate not long ago that the role of ethics is to "lubricate science" and no one contradicted him. It is clear that genetic engineering biotechnology will radically transform human society, it will redefine our relationships with one another and with all of living nature, if we let it. This is the crucial time to decide whether that is the world for us and for our children and grandchildren.

But let me return to food and farming, for that is the main topic of our discussion. Here, the exploitative, instrumental relationship with nature that genetic engineering biotechnology entails is completely at odds with sustainable agriculture, especially as practised by many indigenous farmers. Peruvian farming communities, for example, are so integrated with the ecosystem that there is no separation between nature and culture. Peasants collect seeds from different places and grow them, adopting the plants as members of their family. The reciprocity between crop and human being is so strongly felt that farmers perceive themselves as being bred by the crop instead of the other way round. In one of the oldest rituals celebrating the harvest of the new crop, last year's potato "speaks" to the new potato: as I bred these human beings, now I pass [this power] on to you.[1] I tell this story not to perpetrate an excessively romantic view of indigenous peoples, but to remind us that food is more than just the number of calories, or the balance of carbohydrate, protein, fat and vitamins that we need to keep alive. It is more important than that. Food is pure quality. It is nurture, the gift of life given in love: from the earth to us, from the crop, from our mother to ud. And that is how we learn to love. That is why we take so much care to prepare food for our loved ones, and why we insist on animals and plants raised compassionately, organically, so they can be fully themselves, so we, in turn, can be fully ourselves. That is what wholesomeness is about. I might add that there are now biophysical methods to characterize such wholesomeness in

healthy organisms and discern differences which are beyond the capability of chemical and biochemical analyses.[2]

Genetic engineered organisms are unwholesome

They are made by stressing the developmental and metabolic system of the organism, by forcing it to accept and express foreign genes continuously,[3] producing excess amounts of the gene product and/or to be grown in the presence of poisons that would otherwise kill them. Let me give just a few indications of the unwholesomeness of genetically engineered foods.[4] Milk from cows fed genetically engineered bovine growth hormone - BST milk - is unfit for human consumption because the stress on the cows is so severe that they develop mastitis and other infections which have to be treated with drugs and antibiotics. Moreover, the cows burn out prematurely and stop producing milk altogether. Evidence now suggest that Monsanto's genetically engineered Round-up resistant soybean may contain increased amounts of phytoestrogens. Phytoestrogens are linked to reproductive abnormalities in children, so anyone feeding babies on soybean formulas should beware. Food crops engineered with the delta-endotoxin gene from the soil bacterium *Bacillus thuringiensis* - Bt-crops - are found to poison non-target species, and to harm beneficial species further down the food chain, such as aphids and lacewings feeding on insects that have eaten the Bt-plants. The aphids were found to live only half as long and to have a lower reproductive rate.

Genetic engineering biotechnology is unsound

Why? Because it is based on bad science that has already been invalidated by scientific findings accumulated over the past 20 years. In a publication which aims to "provide consumers with clear and comprehensible information about products of the new [bio]technology", we are told that,
"Research scientists can now precisely identify the individual gene that governs a desired trait, extract it, copy it and insert the copy into another organism. That organism (and its offspring) will then have the desired trait.."[5]

This encapsulates the reductionist mindset that misguides the practice of genetic engineering biotechnology and helps to sell it to the public as well. It is the genetic determinist idea that one gene controls one character trait in linear causal chains, as it were, and isolating and transferring the gene results in the transfer of the corresponding trait to the genetically modified organism, which can then pass it on indefinitely to future generations. It presents the process of genetic modification, furthermore, as a precise and simple operation. All of which are false.

The above account - so typical of that found in publications promoting "public understanding" - is based on simplistic assumption of genetics that both classical geneticists and plant breeders have rejected, and have indeed been thoroughly invalidated by all the research findings of the past twenty years using genetic engineering techniques.

There is a serious mismatch between the mindset of genetic engineering biotechnology (with the projected benefits and wealth to be gained thereof) and the reality of the scientific findings (see Box 1).[6] There are no linear causal chains between genes and characters, but a complex network of nonlinear, circular and multidimensional causation, so that ultimately, the function of each gene is dependent on all other genes. Genes and genomes are subject, therefore, to metabolic feedback regulation, and furthermore, they can change as the result of environmental challenges. Some of the changes are so specific that they are referred to as directed mutations. In essence, organism and environment are intimately interconnected, so that changing a single gene in one species can have drastic ecological effects, as demonstrated by soil ecologist Elaine Ingham and her student.[6] They tested a strain of *Klebsiella planticola* engineered with a gene to convert wood waste into alcohol in microcosms including soil from different environments plus a wheat seedling. In all the soils containing the transgenic microorganism, the wheat seedling failed to grow. Imagine the agricultural disaster if that transgenic microorganism were released as it might very well have been. Reciprocally, changes can propagate in reverse, from the ecological environment to the genes, as we shall see later. Finally, genes can travel horizontally by infection between species that do not interbreed.

To sum up the situation, the scientific findings support a radically holistic and dynamic view of organisms fully entangled with the ecological environment.

Box 1

Genetic Engineering Mindset	**Reality of Scientific Findings**

1. Genes determine characters in linear causal chain; one gene gives one function.	**Genes function in a complex network; causation is multidimensional, nonlinear and circular.**
2. Genes and genomes are not subject to environmental influence.	**Genes and genomes are subject to feedback regulation.**
3. Genes and genomes are stable and unchanging.	**Genes and genomes are dynamic and fluid, can change directly in response to the environment, and give "adaptive" mutations to order.**
4. Genes stay where they are put.	**Genes can jump horizontally between unrelated species and recombine.**

Unfortunately, the genetic engineering mindset remains genetic determinist through and through. Of course, genetic engineers will deny that when confronted. *But that is how the practice is guided, and the basis of the claims that are made.* In other words, genetic engineering biotechnology only makes sense if one believes in genetic determinism. No one would think it is a good investment if they do not believe in genetic determinism. More to the point, no one would think it is a good investment if they do not believe everybody else thinks genetic engineering works in the way it claims. The mismatch between mindset and reality is ultimately why genetic engineering biotechnology cannot deliver the promises, is unsustainable, and furthermore, poses great hazards. I shall refer to a few symptoms of unsustainability before I go on to the hazards.[7]

Mismatch number 1 leads to unrealistic assumptions about the efficacy of gene transfers. Single gene transfers have invariably led to "unexpected" changes in the recipient organism. "Unexpected" only because reductionists fail to take account of complexity and interconnectedness. Toxins and allergens have arisen as so-called, "side-effects" in transgenic plants and microorganisms, and very sick, monstrous transgenic animals have resulted from having a single gene introduced. The most notorius is the "superpig" engineered with a human growth hormone gene which turned out to be ulcerous, arthritic, partially blind and impotent. Consumers are in trouble, particularly as regulatory bodies share the same reductionist mindset in risk assessment. It is also morally unacceptable to increase animal suffering for which there is neither need nor good scientific justification.

Mismatch 2 leads to unrealistic neglect of physiological and environmental feedback regulation. Calgene's Flavr Savr tomato, genetically engineered to improve shelf-life, and the very first *live* transgenic food to be introduced to our supermarkets, has now been withdrawn. Apparently, because it was developed in California, it does not grow properly in Florida. Similarly, Monsanto's *Bt*-cotton crop - engineered with the delta endotoxin gene against insect pests - did not work properly when it was first planted commercially in Texas in 1996, because it was "too hot". Nor did it work properly in Australia, probably because it was "too cold". The instability of transgene expression due to *gene silencing* and, in some cases, loss of the transgene, is a big problem for the biotech industry, although they are not doing their best to communicate the failures to the public. In April this year, Monsanto pulled two varieties of genetically engineered canola seeds from the Canadian market when testing revealed that at least one of the patented herbicide-tolerant transgenic varieties contained an "unexpected" gene, after 60 000 bags of the seeds have already been sold throughout Western Canada. No explanation has been offered as to how that could have happened. Once again, it is the reductionist disregard for complexity and wholeness that is failing. It is unsafe and unsupportable as an investment in the long term. The industry has in fact produced little else than dreams. It is still living off the gullible in the stock-market shares.[8]

Mismatch 3 is particularly relevant to the large class of current transgenic plants engineered with the Bt toxin, Insects were found to develop resistance rapidly when exposed to the toxin. That was the other problem with the *Bt*-cotton crop in Texas. Classical neo-Darwinian theory puts this

down to natural selection of pre-existing, rare "random" mutations. However, the real story is that all cells and organisms have the physiological capability to develop resistance by a wide variety of mechanisms, from multiplying particular genes thousands of times to generating new genes by recombinations or mutations. Or, they can also acquire the genes needed from their friends, which include organisms from other species.

Genes and genomes are inherently fluid and dynamic and will change in response to the environment. It is the failure of reductionist science to recognize that genetic stability is a property, not of the gene transferred, but of the ecological whole in which the organism is entangled. Furthermore, the technology used in creating the transgenic varieties inherently generate instabilities. That is why there is no substitute for the stability and reliability of indigenous varieties that have adapted to local conditions for hundreds if not thousands of years.

Mismatch 4 is perhaps the most serious of all. It is the failure to recognize that genes do not remain static in the genome once and for all. They can also jump between species that do not normally interbreed, in particular, when the conditions are favourable: ecological disturbances and means whereby species barriers can be overcome. The instability of the genome is to a large extent due to genetic parasites including mobile genetic elements, plasmids and viruses, that can hop in and out of genomes, replicate themselves and infect other cells. It is these genetic parasites that have been pressed into the service of genetic engineering.

Genetic engineering biotechnology is unsafe

The unique hazards of genetic engineering are inherent to how it is done. It is not easy to transfer genes in nature, although it occurs naturally at a low rate. The reason is that there are barriers to such transfer. But genetic engineering is designed to overcome these barriers that destroy foreign genes or inactivate them, and can therefore enhance horizontal gene transfer, whether intended or not. That is why it is inherently hazardous. But let us go through the detail points below.

a. The technology transfers *exotic* genes to organisms - genes for which no equivalents (alleles) may exist in the genome of the recipient organism - and are, therefore, more likely to have unexpected physiological and metabolic effects.

b. Gene transfer involves *random* insertions of the gene(s) into the genome, causing correspondingly random genetic effects.

c. Special signals, *promoters* and sometimes *enhancers* (often from disease-causing viruses) are included with the introduced gene(s) to boost (continuous) expression, effectively to place the gene(s) outside regulation by the host cell. These promoters and enhancers are very strong, and are likely to affect the expression of neighbouring genes in the host genome.

On account of (a), (b) and (c), many unintended metabolic and genetic changes can result from the gene transfer, and grossly abnormal transgenic plants and animals have been generated, as well as toxins and allergens.

d. The technology depends on artificially constructed invasive *vectors* for carrying genes, which are mosaics of different genetic parasites with the ability to invade cells of different species, multiply in them, or insert themselves into the genome. These vectors are designed to deliver genes *into* cells and to overcome cellular mechanisms that destroy or inactivate foreign DNA. They are, therefore, expected to be particularly good at transferring genes horizontally between *unrelated* species, and will do so whether intended or not. Although their mobility function has been removed, they can be moved by "helper-functions" supplied by other parasitic genetic elements that are present in all genomes. *There is already direct evidence of secondary horizontal gene transfers from transgenic plants to a bacterial pathogen and to soil fungi.* And these are the only experiments that I know of, which have been carried out specifically to investigate horizontal gene transfer from transgenic plants.

e. Many gene-transfer vectors are derived from viruses that cause diseases or bacterial plasmids or transposons (mobile genetic elements) that carry antibiotic resistance and virulence genes, with their virulence functions removed. However, these gene-transfer vectors may recombine with viruses and plasmids in the host cells to generate new pathogens. *New superinfective viruses have indeed been generated by recombination between infecting viruses and the viral gene in a transgenic plant which is supposed to confer resistance to virus.* There is also evidence that while recombination between unmodified viruses may be negligible; modified, manipulated viral genomes are much more prone to undergo further recombination. This raises questions on the safety of gene-transfer vectors which are practically all modified hybrid genomes of viruses, plasmids and mobile genetic elements.[9] This topic alone, requires thorough investigations which have yet to be carried out.

f. Most of the gene-transfer vectors carry antibiotic resistance markers to enable transformed cells to be selected, and these marker genes are routinely left in the transgenic organisms constructed.

The main difference from varieties obtained by conventional breeding methods, is that, *they are constructed with invasive vectors that can insert at random into chromosomes and potentially undergo secondary movements, the vectors carry antibiotic resistance marker genes, and strong promoter or enhancer sequences that continuously switch on gene expression, placing the genes outside cellular control.*

The special characteristics inherent to genetic engineering biotechnology, (d), (e) and (f), have to be seen in the context of the current crisis in public health identified by 1996 WHO Report - the emergence of old and new infectious diseases which are resistant to treatment by drug and antibiotics. And, there is now abundant evidence that horizontal gene transfer and recombination have been responsible for the rapid spread of both virulence and antibiotic resistances.

Transgenic plants therefore have the additional hazard that they can not only transfer genes to nontransgenic varieties by cross hybridization but also spread genes horizontally to other organisms by infection. This source of hazard is real. I have already mentioned that horizontal transfer of transgenes and marker genes has been demonstrated to soil bacteria and fungi. No experiments have yet been done to find out if horizontal gene transfer can occur from transgenic foods to gut bacteria. But recent experiments have been carried out showing that large pieces of viral DNA can survive passage through the gut of mice, can pass into the blood stream and end up in many kinds of cells in the body. While in the cells the vector or bits of it may jump into the genome or recombine with endogenous dormant viral sequences that are in all genomes to regenerate infectious viruses. It had been previously assumed by genetic engineers and regulators alike that DNA released into the environment from live or dead cells are readily broken down and rendered harmless. But that is not so. Findings within the past 3 -4 years show that the released DNA is protected from breakdown by adsorbing to debris, to clay or sand particles, and retain the ability to infect cells.

The possibility for spreading genes especially antibiotic resistance genes to bacteria in all environment is surely there. Some European Governments such as Austria, Luxembourg and Norway are already taking horizontal gene transfer and recombination seriously enough to ban transgenic crops with antibiotic resistance marker genes. Norway, in particular, has banned 4 transgenic plants containing antibiotic resistance marker genes and is calling for antibiotic resistance markers to be phased out by the year 2004, They have also banned 2 transgenic rabies vaccines on grounds that there is no need for them and they may generate live infectious viruses,

What makes genetic engineering biotechnology especially unsafe is that there is practically no protection from the so-called food safety regulation we now have.

I don't have time to go into it in detail, but suffice it to say that, according to the Report of the FAO, jointly with WHO, whose Codex Alimentarius sets safety standards for the world, it is designed to expedite product approval with little or no regard for biosafety. It is a case of "don't need - don't look - don't see", effectively giving producers *carte blanche* to do as they please, while serving to diffuse and allay legitimate public fears and oppositions.[10]

The "principle of substantial equivalence" (SE), on which all safety assessment is based, is completely unscientific and arbitrary. A GE product assessed to be SE is regarded as safe and fit for human consumption. And, by the way, it will be illegal for any country to ban GE products that have been passed as safe by the Codex Alimentarius. But the principle is vague, ill-defined, flexible, malleable and open to interpretation. "Substantially equivalence" does *not* mean equivalence to the unengineerd plant or animal variety. The GE food could be compared to any and all varieties within the species. It could have the worst characteristics of all the varieties and still be considered SE. A GE product could even be compared to a product from a totally unrelated species. Worse still, there are no defined tests that products have to go through to establish SE. The tests are so undiscriminating that unintended changes, such as toxins and allergens could easily escape detection. A GE potato, grossly altered, with deformed tubers, was nevertheless tested and passed as SE.

The Report explicitly failed to assume responsibility for major areas of GE food safety, such as labelling and monitoring; impacts on biodiversity; and the control of traditional food crops engineered to produce pharmaceuticals and industrial chemicals. The latter will readily cross-pollinate with unmodified food plants and contaminate global food supply for years to come. Also left out are pesticide residues in food crops engineered to be resistant to herbicides, hormone residues and veterinary drugs in milk from cows fed GE bovine growth hormone (BST milk) which have to be treated for stress and infections.

Much more serious are a list of gruesome products that will appear on our dinner table, if the Report goes unchallenged: a range of "transgenic wastes" from GE plant residues after engineered industrial chemicals and pharmaceuticals have been extracted, meat from failed GE experimental animals or from animals engineered to produce drugs and human proteins in their milk (e.g. Tracy, the transgenic sheep), meat from pigs engineered with human genes for organ transplants, and crops sprayed with insecticidal GE baculovirus. Baculovirus is simultaneously engineered by medical geneticists to transfer genes into human liver cells because the virus is particularly good at invading those cells.

I repeat, the possibility of new viruses being generated, and of genes jumping (horizontally) across species barriers, *as the result of GE biotechnology itself*, are real, especially in the light of recent scientific findings. The FAO/WHO Report ignores those findings, and sidesteps the whole issue by still maintaining that there is no difference between genetic engineering and conventional breeding methods. The Report is openly partisan to the technology, making unsubstantiated claims for its benefits while omitting to mention the socioenomic impacts on small farmers, and the viable alternatives to the technology in all forms of sustainable agriculture already practiced worldwide.

Recommendations

In view of the gross inadequacies in food safety regulation and the scientific evidence pointing to serious hazards, my colleague Ricarda Steinbrecher and I have recommended a number of measures to safeguard the health of consumers and to protect biodiversity (see Box 2) The precautionary principle also demands that a moratorium on further releases should be imposed until those measures are implemented.

Box 2

Recommendations on Food Safety

1. **No food crops are to be engineered for producing pharmaceuticals and industrial chemicals, as the engineered crops could be mistaken for food, or cross-pollinate with non-engineered food crops. The onus must be on the producer to prove that any plant genetically engineered is not a food crop.**
2. **All projects involving genetic manipulation of baculovirus for insecticidal purposes should be discontinued, as this virus is being used in human gene therapy and invades human liver cells readily.**
3. **Complete characterization of inserted gene sequence(s) of the GE organism (GEO) must be provided in the application for market approval. This should include any antibiotic marker gene(s), promoter(s) and enhancer(s) and their effects on the expression of neighbouring genes. The presence of mobile genetic elements and other proviral sequences in the host genome likely to contribute to secondary mobility of inserts must also be stated.**
4. **No GEOs with uncharacterized foreign gene inserts are to be considered for release. No parts of such GEOs, nor of animals from failed GE experiments or xenotransplant animals are to be used as human food or animal feed.**
5. **No GEOs containing antibiotic resistant genes are to be considered for release or to be used as human food or animal feed.**
6. **A detailed record of the stability of the GEO over at least five successive generations of field conditions (including drought and heat) is a precondition for market approval. (Field conditions does not mean open field conditions). This must be supported by appropriate data indicating the stability of the insert as well as the level of gene expression under different conditions in successive generations.**
7. **Data on the frequency of unintended gene transfers, including horizontal gene transfer from the GEO under field conditions, must be included in application for market approval.**
8. **Data on the frequency of horizontal gene transfer from GEO to gut bacteria must be included in applications for market approval.**
9. **Data on the ability of transgenes and marker genes in the GEO to invade mammalian cells must be included in applications for market approval.**
10. **A specified set of tests must be carried out to establish "substantial equivalence", which are sufficiently discerning to reveal unintended as well as intended effects. The comparator must be the unmodified recipient organism itself, and results of repeated tests must be provided to support the stability of the characteristics over at least five successive generations.**

11. Safety assessment must include the GEO's potential to generate pathogens through genetic recombination.
12. Safety assessment must include pesticide residues where they are integral components of the product, as in herbicide-resistant transgenic plants.
13. Product segregation, labelling and post-market monitoring are non-negotiable conditions for market approval.

I urge you to adopt these recommendations and to put them to our own Government as soon as possible. I have already sent a copy of our detail report to Sir Colin Campbell and Michael Meacher, among others.

At the 1997 State of the World Forum in November, in San Franscisco, a number of scientists - Fritjof Capra, Brian Goodwin, Ervin Laszlo and myself - drafted a statement rejecting patents on life and calling for a moratorium on commercial releases of genetically engineered products (see Box 3). I have copies here for anyone to sign on and to collect more signatures. We hope to present it to the next State of the World Forum, to the UN Convention on Biological Diversity and to the World Health Organization, to ask them to initiate a major enquiry into genetic engineering biotechnology and the resurgence of infectious diseases.

Box 3
1997 State of the World Forum Statement on Life and Evolution

Life is an intimate web of relations that evolves in its own right, interfacing and integrating its myriad diverse elements. The complexity and interdependence of all forms of life have the consequence that the process of evolution cannot be controlled, though it can be influenced. It involves an unpredictable creative unfolding that calls for sensitive participation from all the players, particularly from the youngest, most recent arrivals, human beings.

Life must not be treated as a commodity that can be owned, in whole or in part, by anyone, including those who wish to manipulate it in order to design new life forms for human convenience and profit. There should be no patents on organisms or their parts. We must also recognize the potential dangers of genetic engineering to health and biodiversity, and the ethical problems it poses for our responsibilities to life. We propose a moratorium on commercial releases of genetically engineered products and a comprehensive public enquiry into the legitimate and safe uses of genetic engineering. This enquiry should take account of the precautionary principle as a criterion of sensitive participation in living processes. Species should be respected for their intrinsic natures and valued for their unique qualities, on which the whole intricate network of life depends.

We recognize the validity of the different ways of knowing that have been developed in different cultures, and the equivalent value of the knowledge gained within these traditions. These add substantially to the set of alternative technologies that can be used for the sustainable use of natural resources that will allow us to preserve the diversity of species and to pass the precious gift of life in all its beauty and creativity to our children and their children, to the next century and beyond.

Notes

1. Rengifo Vasquez's presentation in Workshop on Protecting people's rights to productive resources, 22nd World Conference, SID, May, 1997.
2. See F.A. Popp K.H. Li and Q. Gu Advances in Biophoton Research, World Scientific Singapore, 1992; also Mae-Wan Ho *The Rainbow and The Worm, The Physics of Organisms,* World Scientific, Singapore, 1993; 1998.
3. See Mae-Wan Ho and Ricarda A. Steinbrecher's *Fatal Flaws in Food Safety Assessment*, Third World Network, Penang, 1998.
4. See Mae-Wan Ho's *Genetic Engineering Dream or Nightmare? The Brave New World of Bad Science and Big Business*, Gateway Books, 1998; also Ho and Steinbrecher (Note 3).
5. *Food for Our Future, Food and Biotechnology,* Food and Drink Federation, London, 1995, p.5
6. Michael Holmes and Elaine Ingham first reported their results at the 79th annual meeting of the Ecological Society of America, 2-7 August, 1994.
7. The details and references are given in M.W. Ho's book cited in Note 4.
8. I have referred to genetic engineering biotechnology as the contemporary equivalent of the South Sea Bubble in M.W. Ho. *Third WorldResurgence* 53/54, 28-29,1995.

9. See *Genetic Engineering and the Resurgence of Infectious Diseases*, M.W. Ho, B. Tappeser. V. Howard, C. von Weizsacker, (in preparation).
10. See Ho and Steinbrecher, cited in Note 3.

Gene Technology and Gene Ecology

Conference in European Parliament, Brussels, March 5-6, 1998
(Published in Proceedings afterwards)

Proponents of gene technology claim to be on the side of science, often referring to critics as greens or luddites who reject all things new on emotional, irrational grounds. They further accuse critics of "impeding scientific progress". Actually, it is the other way round. Proponents of gene technology are adhering to an outmoded mindset which is contrary to all the scientific evidence accumulated especially over the past 20 years. *They* are the ones left behind by scientific progress. The science motivating genetic engineering cast aside all moral considerations, ignores scientific evidence, doesn't work the way it claims, and is oblivious of the grave dangers posed by the technology. This bad science, working hand in hand as it is with big business corporations driven solely by profit, may well ruin our food supply, destroy biodiversity and unleash pandemics of drug and antibiotic resistant infectious diseases. I have just published a book which makes a detailed case for a moratorium and a comprehensive public enquiry.[1] Of course, I would like everyone to read it, as I can only rough out the argument here.

Let's see what the public is told:

(transparency 1)

"Research scientists can now precisely identify the individual gene that governs a desired trait, extract it, copy it and insert the copy into another organism. That organism (and its offspring) will then have the desired trait..".[2] This description, typical of literature supposedly "promoting public understanding", neatly encapsulates the bad science of genetic determinism.

It gives the highly misleading impression of a precise technology, implying that,

1. Genes determine characters in linear causal chains, one gene giving rise to one character;
2. Gene are not subject to influence from the environment;
3. Genes remain stable and constant;
4. Genes remain in organisms and stay where they are put.

So, by manipulating genes, all the problems of the world can be solved, as simple as that! Except that it goes counter to all the scientific evidence telling us what the new genetics of the present day is really like.

(transparency 2)

- No gene ever works in isolation, but in an extremely complicated genetic network, the function of each gene is dependent on the context of all the other genes in the genome. So, if the gene is transferred to a different genome, it is very likely to have totally new and unpredictable effects.
- The genetic network, in turn, is subject to layers of feedback regulation from the physiology of the organism and its relationship to the external environment.
- These layers of feedback regulation not only change the function of genes but can mutate genes to order, rearrange them, multiply copies of them, or make them move around.
- And, genes can even travel outside the original organism to infect another - this is called horizontal gene transfer. I shall come back to it later.

The new picture of the gene is diametrically opposite to the old static, reductionist view. The gene has a very complicated ecology consisting of the interconnected levels of the genome, the physiology of the organism and its external environment.[1,3] If you put a gene into an organism, the disturbance will propagate out to the environment. Conversely, changes in the environment will be transmitted inwards and may alter the genes themselves.

Genetic engineering profoundly disturbs the ecology of genes at all levels, and that is where the problems and dangers arise.

First of all, I must dispel the myth that genetic engineering organisms is a precise operation. It is not. The insertion of foreign genes into the host cell genome is a random process, not under the control of the genetic engineer.[4,5] This gives rise to correspondingly random genetic effects: inappropriate gene activation, or inactivation and even cancer. Furthermore, the foreign genes are equipped with very strong promoters and enhancers from viruses that force the organism to express the foreign genes at rates 10 to 100 times greater than its own genes. In other words, the genetic engineering process, both by design and otherwise, completely upsets the first two levels in the ecology of genes - the genome and the physiology - with dire consequences.

It is disastrous for animal welfare, creates unwholesome foods, and endangers our very food supply. For every product that reaches the market, there are perhaps 20 or more that fail.

- The superpig engineered with human growth hormone gene turned out arthritic, ulcerous, blind and impotent.[6]
- The supersalmon engineered, again, to grow as fast as possible has big monstrous heads and died from not being able to breathe or feed properly.[7,8]
- The latest clones of the sheep Polly are abnormal and 8 times as likely to die at birth compared with ordinary lambs.[9]

And, incidentally, watch out for carcasses of failed transgenic experiments and xenotransplant pigs turning up as meat on our dinner table. They will all pass as "substantially equivalent". And if not, then GRAS, generally regarded as safe, by present regulatory regimes, as we have shown in a critique of the FAO/WHO food safety report.[5]
(Transparency 3)

Even products that reach the market have a high failure rate.

- The Flavr Savr tomato was a commercial disaster and has disappeared.[10] Monsanto's Roundup Ready cotton balls drop off and farmers in seven states in the US are seeking compensation for crop losses.[11]
- The transgenic "Innovator" herbicide tolerant canola does not perform consistently in Canada.[12]
- There is widespread instability of transgenic lines, which do not breed true.[1,5]

The technology is hit or miss and completely haphazard. The food created is unwholesome, because it is based on stressing the developmental and metabolic system. There are bound to be a host of so-called unintended effects including toxins and allergens, which current risk assessments are designed to conceal rather than reveal. The risk assessment in the FAO/WHO food safety report is little more than, no need, don't look, don't see.[5]
(Transparency 4)

The stresses on the developmental and metabolic system may be partly responsible for the widespread instability of transgenic lines, which is a big problem for the industry, and will surely also ruin our agriculture and food supply.

Genetic engineering food and agriculture destroys biodiversity, not surprisingly, because ecological relationships are ignored.

-The broad-spectrum herbicides used with herbicide-resistant transgenic crops, such as glufosinate[13] (Novartis; Basta) and glyphosate[14] (Monsanto's Roundup) destroy plants indiscriminately, many of which are habitats for wild-life. They are toxic to animals and human beings. Glufosinate also causes birth defects and glyposate is mutagenic.[15]

- Resistant transgenic plants can become weeds as volunteers or cross-pollinate with wild-relatives, creating resistant weeds.[16]
- Food plants are now being engineered to produce industrial chemicals and pharmaceuticals. These will surely cross-pollinate and contaminate our food supply for years to come.[5]
- Transgenic plants with insecticidal transgenes not only harm beneficial species directly, but also indirectly down the food chain.[17,18]
- Transgenic crops favours evolution of resistance.[1]

I want to comment on pesticide resistance, a major and persistent problem in intensive agriculture, which has become a textbook example of the supposed power of natural selection to increase the frequency of "rare random mutations" that conferred resistance. Actually, insecticide resistance turns out to be a pardigmatic example of feedback regulation in the ecology of genes that I mentioned earlier. It is due to genetic changes that can occur in most, if not all of the individuals in insect populations, including mosquitoes, houseflies, aphids, in response to the ecological condition of sublethal levels of insecticide. They do not have to wait for rare random mutations to arise. This has been known more than 10 years ago. Resistance often involves amplification of genes encoding enzymes that detoxify the chemical, and is part and parcel of the physiological mechanisms common to *all* cells challenged with toxic substances, including anti-cancer drugs in mammalian cells or antibiotics in bacteria, as described in detail in my book.[19] Similarly, resistance to glyphosate readily arises in plant cells lines exposed to the herbicide, and

involves amplifications of detoxifying genes.[20] So the use of herbicide resistant transgenic plants will also hasten the wide-spread evolution of herbicide tolerance among weeds.

Bt sprays have been used for 40 years previously as an environmentally friendly biopesticide to control pests by organic farmers. But the new generation of transgenic crops has already generated an ecological crisis in creating Bt resistances among major insect pests in the US, where these transgenic crops were released over the past two years.[21] The US EPA is being taken to court by
Greenpeace and 30 other public interest organizations for approving the release of Bt-transgenic plants.

Finally, genetic engineering animals and plants is inherently hazardous. It involves transferring genes horizontally between species that do not interbreed. Horizontal gene transfer is naturally done by viruses and virus-like genetic elements such as plasmids and transposons that are passed from cell to cell, from organism to organism, many causing diseases including cancer and spreading drug and antibiotic resistance genes.
(Transparency 5)

The natural elements are limited by species barriers and all cells have mechanisms that break down or inactivate foreign genes. However, genetic engineers make artifical vectors for transferring genes by joining together parts of the most agressive elements to overcome all species barriers. Most of the genes causing diseases are removed, but the antibiotic resistance genes are left in so that cells carrying the vector can be selected with antibiotics.
(Transparency 6)

Artificial vectors and the genes they carry have the potential to spread horizontally to a wide range of species, to recombine with their genes to generate new viral and bacterial pathogens. This very danger had made the first molecular geneticists impose a moratorium on genetic engineering in the Asilomar Declaration of the 1975.[22] But commercial pressures soon intervened and activities resumed after regulatory guidelines were put in place, and commercial scale production began. Were those guidelines adequate? No, not in the light of recent scientific evidence as eight scientists including myself argue in a new report. (Transparency 7)

There has been a serious resurgence in drug and antibiotic resistant infectious diseases within the past 20 years, which has precipitated a public health crisis worldwide. Microbial geneticists and virologists are just now discovering how horizontal gene transfer and recombination are responsible for generating the new viral and bacterial pathogens and spreading drug and antibiotic resistance genes among the pathogens.[1,3] Are we unleashing wide-spread, cross-species pandemics that will be impossible to control? The signs are that the worst case scenario, predicted by the Asilomar Declaration may already be with us, as the result of 20 years of commercial scale genetic engineering biotechnology.

Can transgenic plants and animals contribute to such processes? Yes. They can. Transgenic plants have been found to transfer their transgenes and antibiotic resistance marker genes to soil fungi[23] and bacteria.[3,24] Transgenic plants with a virus transgene, supposed to resist virus attack, actually have increased propensity to generate new superinfectious viruses by recombination.[25-28]

Even more serious dangers may come from contained users. The regulatory guidelines set up post-Asilomar were based largely on assumptions, practically everyone of which has been overturned by recent scientific findings.[1,3]

- Biologically "crippled" laboratory strains of bacteria can often survive in the environment, or go dormant but continue to exchange genes with
other organisms.[29]
- Routine chemical inactivation methods may leave up to 10% of viruses and other pathogens in an infective state.[30]
- Legal limits of "tolerated releases" from contained use vastly exceed the minimum infective dose of some pathogens: 10 000 colony forming units/ml in air or water[31] versus a minimum infective dose of 50 bacteria
for E. coli 0157:H7[32]
- DNA released from dead and living cells persist in the environment and transfer to other organisms.[33,34]
- Naked viral and vector DNA may be more infectious, and have a wider host range than the virus.[35]

- Antibiotic increase the frequency of horizontal gene transfer 10 to 10000 fold.[36,37]
- Viral DNA resists digestion in the gut of mice, enter the blood stream to infect white blood cells, spleen and liver cells, and integrate into the mouse cell genome.[38,39]

Thus, large amounts of hazardous transgenic microorganisms and recombinant DNA have been and continue to be released into the environment. We may only be seeing the tip of the iceberg as far as the contribution of genetic engineering biotechnology to the etiology of infectious diseases is concerned.

There are no grounds for relaxing existing Directives. On the contrary, we need a firm commitment from the EU to strengthen the Directives in the light of new scientific evidence. At the same time, the EU should support astrong International Biosafety Protocol under the UN Convention of Biological Diversity which can truly safeguard biodiversity and human and animal health, and which takes into full account socioeconomic and ethical impacts.

The wealth of existing scientific evidence and the precautionary principle demand a Europe-wide moratorium on all releases - both deliberate and tolerated - until the new, strengthened directives are in place. Meanwhile, support should be provided to independent scientists to carry out basic research for proper risk assessment.

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Stop This Science and Think Again

(Booklaunch in London, 17 March 1998)

Thank you all for joining us. I am delighted and honoured to be talking to you, particularly in the Linnaean Society, where Darwin first announced his theory of natural selection to the world. Although his followers have concentrated exclusively on natural selection right up to the present day, Darwin's own thesis is much deeper and grander in scope, and it developed considerably during his lifetime. I have reasons to believe that Darwin himself would probably approve of what I am going to say. Ask me about it afterwards.

Genetic engineering biotechnology promises everything: food for the starving billions in the Third World, miracle cures for cancer and other diseases, genetic diagnosis, gene therapy, genetic enhancements and even cloning of human beings. It raises a string of moral dilemmas, and will

profoundly change our lives, not the least of which, our value system as human beings. Are we ready for it? Do we want it? Do we need it? Why is there so little debate?

Beneath the endless summer of hype and promises that have yet to bear fruit are signs of failure, of threats more dangerous and insidious than the nuclear and toxic wastes that are already poisoning us and our planet's life support system. The biotech corporations are holding our Governments to ransom. Instead of legislating to protect us from the dangers, public money is spent on subsidizing the industry in research funds, in public perception task forces to overcome our resistance to genetically engineered products, which is seen to be the major problem for the industry. Meanwhile, corporate scientists are pronouncing everything safe, and giving their blessing to industry to push for further deregulation. The situation, in short, is desperate.

I am going to show that gene technology is fundamentally flawed. It is driven by a mindset that recognizes no moral values, is contrary to scientific evidence, doesn't work the way it claims, and is oblivious of the grave dangers posed by the technology. That is bad science. This bad science, working hand in hand with big business corporations under the banner of free trade and free choice, will effectively take control of every aspect of our lives from food production to reproduction. In the process, it may ruin our food supply, destroy biodiversity and unleash pandemics of drug and antibiotic resistant infectious diseases [1]. That is why I am calling for a moratorium on releases of genetically engineered organisms for at least five years, to create space for basic research, to debate the issues, and most of all to rethink where we ought to be heading as a civil society.

Let's see what the public is told:

"Research scientists can now precisely identify the individual gene that governs a desired trait, extract it, copy it and insert the copy into another organism. That organism (and its offspring) will then have the desired trait.." [2]. This description is typical of literature supposedly "promoting public understanding", and neatly encapsulates the bad science of genetic determinism.

It gives the highly misleading impression of a precise technology, implying that,

1. Genes determine characters in linear causal chains, one gene giving rise to one character;
2. Genes are not subject to influence from the environment;
3. Genes remain stable and constant;
4. Genes remain in organisms and stay where they are put.

So, by manipulating genes, all the problems of the world can be solved, as simple as that!

This picture is reinforced by the media, which have been full of reports on the discovery of genes for any and every human condition, not only diseases like cystic fibrosis, but genes for homosexuality, for shyness, genes for criminality, intelligence, alcoholism. Just a couple of examples here.

The fault lies, not in the popularization, nor in the applications, but in the science itself. It only makes sense to concentrate on gene hunting, to develop genetic screening and to practice eugenics if one believes one's destiny lies in our genes. It is also perfectly logical for genetic determinists like Richard Dawkins, E.O. Wilson and Francis Crick, for example, to be in favour of cloning not just animals but human beings [3].

This same science legitimizes patents on living organisms including human genes and cells lines; and justifies piracy of intellectual and genetic resources from Third World countries. While there is no explicit recognition of morality in western science, genetic determinism specifically denies it exists. So why not legislate for stealing and cheating in the World Trade Organization Trade Related Intellectual Property Rights agreement or the new EU Patents Directive, and what's wrong with patenting and exploiting human genes and cell lines? Genetic determinism is effectively excluding and denigrating all other knowledge systems, which are deemed to have no validity in the intellectual property rights regime. More pernicious still, it is turning science into a fundamentalist religion.

E.O. Wilson is founder of the discipline sociobiology, which attempts to explain all social behaviour in terms of natural selection. He writes,

"True selfishness... is the key to a more nearly perfect social contract....Human behaviour...is the circuitous technique by which human genetic material has been and will be kept intact. Morality has no other demonstrable ultimate function." [4]

Here's a Sunday Times lead article: "Headless frog opens way for human organ factory" [5]. "Scientists have created an embryo of a frog without a head, raising the prospect of engineering headless human clones which could be used to grow organs and tissues for transplant surgery."

I am horrified by the suggestion, as I am sure others are. Are we merely guilty of an irrational, emotional expression of the "yuk factor"? Is it a sin to impede scientific progress by saying no?

I am profoundly disturbed by the present trend towards scientific fundamentalism - the idea that science is about the laws of nature and can never be wrong or bad, that science must go on at all cost. By contrast, moral values are socially negotiated, and the role of ethics - moral codes of conduct - is to serve science, or as Steve Jones has put it, to "lubricate science".

I shall show that science can indeed be both bad and wrong, as in the case of genetic determinism. It is incumbent on us to choose. Good science, in my view, gives reliable knowledge that allows us to improve our lives, to live sustainably with nature. Good science is, therefore, science with moral responsibility.

Genetic determinism obviously has a tremendous hold on the public imagination and runs very deep within the collective psyche of our society. Except that it goes counter to all the scientific evidence accumulated especially within the past 20 years, which gives us the new genetics. What is the new genetics of the present day really like?

- No gene ever works in isolation, but in an extremely complicated genetic network, the function of each gene is dependent on the context of all the other genes in the genome. So, the same gene will have very different effects in different individuals, because the other genes are different. There is so much genetic diversity within the human population that each individual is genetically unique. And if the gene is transferred to a different genome, it is most likely to have new and unpredictable effects.
- The genetic network, in turn, is subject to layers of feedback regulation from the physiology of the organism and its relationship to the external environment.
- These layers of feedback regulation not only change the function of genes but can rearrange them, multiply copies of them, mutate them to order, or make them move around.
- And, genes can even travel outside the original organism to infect another - this is called horizontal gene transfer. I shall come back to that later.

The new picture of the gene is diametrically opposite to the old static, reductionist view. The gene has a very complicated ecology consisting of the interconnected levels of the genome, the physiology of the organism and its external environment [1,6]. Putting a new gene into an organism will create disturbance that can propagate out to the external environment. Conversely, changes in the environment will be transmitted inwards and may alter the genes themselves.

Genetic engineering profoundly disturbs the ecology of genes at all levels, and that is where the problems and dangers arise.

First of all, **I must dispel the myth that genetic engineering organisms is a precise operation. It is not**. The insertion of foreign genes into the host cell genome is a random process, not under the control of the genetic engineer [7,8]. This gives rise to correspondingly random genetic effects, including cancer. Furthermore, and this is important, the foreign genes are equipped with very strong signals, most often from viruses, called promoters or enhancers, that force the organism to express the foreign genes at rates 10 to 100 times greater than its own genes. In other words, the genetic engineering process, both by design and otherwise, completely upsets the first two levels in the ecology of genes - the genome and the physiology - with dire consequences.

It is disastrous for animal welfare, creates unwholesome foods, and endangers our very food supply. For every product that reaches the market, there are perhaps 20 or more that fail.

- The superpig engineered with human growth hormone gene turned out arthritic, ulcerous, blind and impotent [9].
- The supersalmon engineered, again, to grow as fast as possible ended up with big monstrous heads and died from not being able to breathe or feed properly [10, 11].
- The latest clones of the sheep Polly are abnormal and 8 times as likely to die at birth compared with ordinary lambs [12].

And, incidentally, watch out for carcasses of failed transgenic experiments and xenotransplant pigs turning up as meat on our dinner table. They will all pass as "substantially equivalent", and therefore safe, according to standards set by the WHO food safety report, which our Government white paper on food safety has failed to challenge. A colleague and I have written a detailed critique of that Report [8].

Even products that reach the market are failing.

- The Flavr Savr tomato was a commercial disaster and has disappeared [13].
- Monsanto's Bt-cotton failed to perform in the field in both US and Australia, and suffered excessive damages from bt-resistant pests [14].
- Monsanto's Roundup Ready cotton balls drop off and farmers in seven states in the US are seeking compensation for losses [15].

- The transgenic "Innovator" herbicide tolerant canola failed to perform consistently in Canada [16].
- There is widespread instability of transgenic lines, they generally do not breed true [1,8].

The failures are not just teething problems. They are systematically caused by a reductionist science and a hit or miss technology. Moreover, the transgenic foods created are unwholesome, because they involve stressing the developmental and metabolic system of organisms out of balance. There are bound to be unintended effects including toxins and allergens, which current risk assessments are designed to conceal rather than reveal [8].

The same stress factors may account for the widespread instability of transgenic lines, which is a big problem for the industry, and will surely also ruin our agriculture and food supply.

Agricultural gene technology destroys biodiversity, not surprisingly, because ecological relationships are ignored.

-Broad-spectrum herbicides used with herbicide-resistant transgenic crops, such as glufosinate [17] (Novartis' Basta) and glyphosate [18](Monsanto's Roundup) destroy plants indiscriminately, many of which are habitats for wild-life. They are toxic to animals and human beings. Glufosinate also causes birth defects and glyphosate is mutagenic [19].

- Resistant transgenic plants can become weeds themselves or cross-pollinate with wild-relatives, creating resistant weeds [20].
- Food plants are now being engineered to produce industrial chemicals and pharmaceuticals. These will surely cross-pollinate and contaminate our food supply for years to come [8].
- Transgenic plants with insecticidal genes not only harm beneficial species directly, but also indirectly down the food chain [21,22].
- Transgenic crops favour the evolution of resistances [1].

Pesticide resistance, a major and persistent problem in intensive agriculture, has become a textbook example of the supposed power of natural selection to increase rare random mutations. That is a myth. In reality, pesticide resistance turns out to be a classic case of feedback regulation in the ecology of genes of the new genetics. It is due to genetic changes that can occur in most, if not all individuals in pest populations in response to sublethal levels of pesticide. They do not have to wait for rare random mutations. This has been known for more than 10 years. The genetic changes are part and parcel of the physiological mechanisms common to *all* cells challenged with toxic substances, including anti-cancer drugs in mammalian cells or antibiotics in bacteria [6,23]. Similarly, resistance to herbicides readily arises in plant exposed to the herbicide [24]. So, using herbicides with resistant transgenic plants will also hasten the wide-spread evolution of herbicide tolerance among weeds, even in the absence of cross-pollination.

Why is the neo-Darwinian myth that evolution occurs by the natural selection of random mutations still so widely perpetrated? The thesis of randomness, or blind chance, was thrown out by none other than Darwin himself:

"The birth both of the species and of the individual are equally parts of that grand sequence of events that our minds refuse to accept as the result of blind chance.

"The understanding revolts at such a conclusion" [25]

Most of all, genetic engineering organisms is inherently hazardous; again, something the orthodox mainstream is unable to recognize. Genetic engineering involves transferring genes horizontally between species that do not interbreed. Horizontal gene transfer is naturally done by infectious agents such as viruses and virus-like elements that are passed from cell to cell, from organism to organism, many causing diseases including cancer and spreading drug and antibiotic resistance genes.

The natural agents are limited by species barriers, and all cells have mechanisms that break down or inactivate foreign genes. However, genetic engineers make artificial vectors for transferring genes by joining together parts of the most agressive agents to overcome all species barriers. Most of the genes causing diseases are removed, but the antibiotic resistance genes are left in so that cells carrying the vector can be selected with antibiotics.

Artificial vectors and the genes they carry have the potential to spread horizontally to a wide range of species, to recombine with their genes to generate new viral and bacterial pathogens. It is this very danger that persuaded molecular geneticists to impose a moratorium on genetic engineering in the Asilomar Declaration of 1975 [26]. But commercial pressures soon intervened. Regulatory guidelines were put in place, and commercial production began. Were those guidelines adequate? No, not in the light of recent scientific evidence as eight scientists including myself argue in a new report [6].

There has been a resurgence of infectious diseases within the past 20 years, diseases which are resistant to treatment by drugs and antibiotics. A public health crisis is looming worldwide. Geneticists are just now discovering how horizontal gene transfer and recombination

are responsible for generating the new viral and bacterial pathogens and spreading drug and antibiotic resistance genes [1,6]. Are we unleashing wide-spread, cross-species epidemics that will be impossible to control? The signs are that the worst case scenario, predicted by the Asilomar Declaration may already be with us, as the result of 20 years of commercial gene technology.

Can transgenic plants and animals contribute to such processes? Yes. They can. Transgenic plants have been found to transfer their transgenes and antibiotic resistance marker genes to soil fungi [27] and bacteria [6,28]. Plants engineered with a viral gene, supposed to resist virus attack, actually have increased propensity to generate new, superinfectious viruses by recombination [29-32].

Even more serious dangers may come from commercial contained use. The regulatory guidelines set up after Asilomar were based largely on assumptions, practically everyone of which has been overturned by recent scientific findings [1,6].

- Biologically "crippled" laboratory strains of bacteria can often survive in the environment, or go dormant but continue to exchange genes with other organisms [33].
- Routine chemical inactivation methods may leave up to 10% of viruses andother pathogens in an infective state [34].
- Legal limits of "tolerated releases" from contained use vastly exceed the minimum infective dose of some pathogens: 10 000 colony forming units/ml in air or water [35] versus a minimum infective dose of 50 bacteria for *E. coli* 0157:H7 [36]
- Antibiotics increase the frequency of horizontal gene transfer 10 to 10000 fold [37, 38].
- DNA released from dead and living cells persist in the environment and transfer to other organisms [39, 40].
- Naked viral and vector DNA may be more infectious, and have a wider host range than the virus [41].
- Viral DNA resists digestion in the gut of mice, enter the blood stream to infect white blood cells, spleen and liver cells, and integrate into the mouse cell genome [42, 43].

Thus, large amounts of hazardous transgenic microorganisms and manipulated DNA have been and continue to be released into the environment. We may only be seeing the tip of the iceberg as far as the contribution of gene technology to infectious diseases is concerned.

In the face of the wealth of existing scientific evidence and the precautionary principle, the least our Governments could do is to impose a 5 year moratorium and to support independent scientists to go back to basic research. At the same time, there should be a major public enquiry, in which the scientific, social, economic and moral issues are considered together and openly debated.

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Dangerous Liaison - Deadly Diversion

Fabian Society, Tunbridge Wells, 15 Jan. 1999

1 I am speaking as a scientist extremely concerned with the extent to which science has evolved more and more away from its Promethean ideal of knowledge for the good of humanity to being the partner of corporate capitalism which have been responsible for some of the most socially and environmentally destructive policies in the world.

2 Genetic engineering biotechnology is just the latest offering from the alliance between reductionist science and big business which has already brought our planet to the edge of extinction in climate change, ozone depletion, massive loss of species and intolerable levels of toxic and radioactive pollution in our life-support system. After having extracted and ruined all of the planet's resources, reductionist science and big business are targetting life itself, which is our last remaining hope of regenerating and saving the planet.

3 Mary Shelley has predicted the present scenario of human cloning and genetic manipulations in her classic novel, *Frankenstein* , which is about the scientist obsessed with science as a means to control and improve on nature. He created a monster, thinking he could create the perfect human being. Can we afford to let this Frankenstein science take over the world for the sake of profit? What's at stake is life, our life-support and our value system as human beings, which are all under attack, which are all being placed under unaccountable corporate monopoly.

4 The alliance is bolstered by mainstream academic theories stemming from the same roots in Victorian English high society. We have neo-liberal economic theory supporting and validating *laissez-faire* corporate capitalism, while neo-Darwinian genetic determinism drives the technology and sells it to the public.

5 What makes the alliance so powerful is that they are united by a shared vision of the world as so many isolated bits and pieces that can be manipulated with impunity one at a time.
They see selfish genes and selfish individuals jostling and competing against one another, in the struggle of survival of the fittest and the biggest.
They set no limit to exploitation and short-term profit in the war of one against all and all against nature.
But nature does not conform to our illusion that things are separate, and on how the world should be run. She is organically interconnected and finite, and the effects of decades of wanton destruction and exploitation not only spread far and wide, but are rebounding back on us.

6 That's why the global ecology and global economy are collapsing together. This should come as no surprise, as a sound economy is absolutely dependent on a sound ecological base. Enlightened economists such as Hazel Henderson, Herman Daly and James Cobb and ecologists such as Edward Goldsmith and Jerry Mander have been drawing attention to that since the 1970s. The academic theories have failed the reality test in the real world. Genetic determinism has also failed by the criteria of science. It has been thoroughly discredited by scientific findings over the past 20 years. That is why it is a dangerous diversion that not only obstructs the implementation of real solutions to our problems, but also poses unprecedented risks to health and biodiversity.

7 But our Governments have been taken in.
They have handed over ownership of life to the corporations by voting for patents on organisms and genes including human genes.

They will allow corporations unrestricted exploitation their citizens and natural resources in the treaties of the WTO and the MAI. Environmental standards, food safety standards and even basic human rights will be sacrificed to corporate financial imperatives.

Meanwhile, corporate scientists sit on committees at all levels, pronouncing everything safe, in total disregard of scientific evidence.

8 For a quick summary of genetic determinism, I have taken the following description from a booklet produced by the Food and Drink Association and endorsed by Government scientists:

"Research scientists can now precisely identify the individual gene that governs a desired trait, extract it, copy it and insert the copy into another organism. That organism (and its offspring) will then have the desired trait..".

This description, typical of literature supposedly "promoting public understanding", neatly encapsulates the bad science of genetic determinism. It gives the highly misleading impression of a precise technology, implying that,

Genes determine characters in linear causal chains, one gene giving rise to one character;

Gene are not subject to influence from the environment;

Genes remain stable and constant;

Genes remain in organisms and stay where they are put.

So, by manipulating genes, all the problems of the world can be solved, as simple as that!

9 What is the new genetics of the present day really like? No gene ever works in isolation, but in an extremely complicated genetic network, the function of each gene depends ultimately on all the other genes in the genome. So, the same gene will not have the same effects in different individuals, because the other genes are different. There is so much genetic diversity within the human population that each individual is genetically unique (except for identical genes at the beginning of their development). And if the gene is transferred to the genome of a different species by genetic engineering, it is most likely to have new and unpredictable effects.

The genetic network, in turn, is subject to layers of feedback regulation from the physiology of the organism and its relationship to the external environment. So, if the environment changes, a gene may cease to work.

These layers of feedback regulation not only change the function of genes but can rearrange them, multiply copies of them, mutate them to order, or make them move around. Some of the mutations that occur in response to certain environments are so repeatable that they are referred to as "directed mutations".

And, genes can even travel outside the original organism to infect another. This is called horizontal gene transfer, the very process exploited for genetic engineering. I shall come back to that later.

10 Those findings have completely invalidated genetic determinism. *Yet the orthodox mainstream remains firmly wedded to the discredited paradigm.* The new genetics is diametrically opposite to the old static, reductionist view. Genes and genomes can change so much that molecular geneticists themselves have invented the descriptive term, 'the fluid genome', more than ten years ago. It is more accurate, however, to see the gene as having a very complicated ecology consisting of the interconnected levels of the genome, the physiology of the organism and its external environment. Putting a new gene into an organism will create disturbance that may propagate out to the external environment. Conversely, changes in the environment will be transmitted inwards and may well alter the genes themselves. The most important lesson is that the stability of genes and genomes, as much as all the other characteristics of the organisms, depends on a balanced ecology. Genetic engineering profoundly disturbs the ecology of genes at all levels, and that is where the problems and dangers arise.

11 We are told genetic engineering is just like conventional breeding, only faster, cleaner and more precise. Not true. It is a new departure, and introduces new dangers. Genetic engineering bypasses reproduction altogether. It uses artificial virus-like vectors to transfer genes horizontally. So genes can be transferred between species that would never interbreed in nature. Let's deal first with food and agriculture.

12 New genes are engineered into our food, many from bacteria and viruses and non-food species whose long term impacts on health and biodiversity are completely unknown.

13 The foreign genes are bound to interact with host genes to give unintended effects including toxins and allergens.

14 The technology is hit or miss and not at all clean and precise. The vector carrying foreign genes insert at random into the genome of the organism, giving rise to random genetic effects, including cancer in mammalian cells.

For the same reasons, transgenic lines are often unstable, and do not perform consistently.

15 Most of all, the artificial vectors used to transfer genes are made by recombining the most infectious viruses and other genetic parasites and may contribute to creating new viruses and bacteria that cause diseases.
That was why the pioneers of genetic engineering called for a moratorium in the 1970s; though commercial pressures cut it short.
Since then, drug and antibiotic resistant infectious diseases have come back with a vengeance. Strains of at least 4 dangerous bacteria including the one causing tuberculosis are already resistant to all antibiotics and hence untreatable.

16 There is now overwhelming evidence that horizontal gene transfer is responsible for spreading antibiotic resistance and creating new viral and bacterial pathogens.

17 Other scientific findings suggest that
Transgenes and antibiotic resistance genes may spread horizontally from transgenic plants to soil bacteria and fungi, and to gut bacteria.
Transgenic DNA may be 30 times more likely to escape than the plant's own DNA.
Viral genes in transgenic plants may recombine with other viruses to generate new, superinfectious viruses.
Viral DNA, which is in practically all transgenic organisms, resist digestion in the gut of mice, pass into the bloodstream and then into a variety of cells to integrate into the cells' genome. When viral DNA was fed to pregnant mice, the DNA was found in the cells of the foetus.

18 Genetic engineering agriculture is an extremely dangerous diversion.
Far from feeding the world, it intensifies corporate control on food which created poverty and hunger in the first place.
It obstructs implementation of sustainable agriculture and erodes agricultural biodiversity, which are precisely what we need to guarantee long term food security.

19 Farming communities in the Third World have been actively regenerating and revitalizing degraded agricultural land with many forms of sustainable, organic agriculture, and recovering agricultural biodiversity. Since the early 1990s, a number of non-government organizations have joined forces to form the Latin American Corsortium on Agroecology and Development to promote agroecological techniques which are sensitive to the complexities of local farming methods. Yields have tripled or quadrupled within a year. Largescale implementation of bio-dynamic farming and sustainable agriculture is succeeding in the Philippines. Successive studies have highlighted the productivity and sustainability of traditional peasant farming in the third World as well as in the North. In 20 Third World countries, more than 2 million families are farming sustainably on 4-5 million hectares, with tripled or doubled yields, fully matching if not surpassing intensive agrochemical agriculture. And this has happened only within the past 5-10 years. Contracting in to corporate food-production schemes now will set them back once again down the road to escalating debt and poverty, not to mention the devastation of agricultural land and the environment.

20 The recent experience of Cuba is instructive. US economic blockade since the 1960s caused a shortage of agrochemicals, making it necessary for Cuba to go organic on a grand scale. They maintained one-third of the 11 million hectares of agricultural land on agrochemicals, turned another third fully organic, and kept the rest 'transitional' as half agrochemical and half organic. The yields per hectare of the fully organic are equal to the fully agrochemical, while the yields of transitional fields are only half as much. This is the clearest evidence that organic agriculture can work on a large scale, with energetically efficient low inputs and minimal impacts on the environment.

21 And now, let's deal with health. The life industry grossly undermines and distorts healthcare. Far from improving the health of nations, they serve to divert attention from the overwhelming causes of ill-health, which are environmental, and blaming it on the victims. The same chemical and drug industries that have been major polluters of the environment, that have been causing increasing damages to all the organ systems of our body including our genes, are now set to reap enormous profits from those made ill. Instead of punishing the industrial polluters, the European Union and the US Government are legislating to allow radioactive and toxic wastes to be recycled as building material and consumer goods, and to be spread over our crops. If the present trend continues our healthcare system will surely collapse as more and more become ill. It will be replaced by a health-market, serving the rich, if at all, at the expense of the poor.

22 Xenotransplantation - using genetic engineered pigs to supply organs for transplanting into human beings, and even human embryo cloning to supply spare organs and cells are both promoted on grounds of health benefits. They are nothing of the sort. These are commercial enterprises motivated by the billions of dollars of international trade in body parts that have already led to poor people selling organs, criminals murdering people for organs and other abuses.

23 Genuine genetic diseases that can be traced to single genes are less than two percent of all diseases, and even these have proved to be much more complicated than previously thought; while at least one percent of such genetic diseases are *new* mutations, most likely caused by environmental mutagens. In some conditions like muscular dystrophy, fully one-third are new mutations (Graham Bulfield, Melvin Bragg's program, BBC Radio 4, Thursday, 14 Jan.).

24 Meanwhile, the main focus of so-called "preventative" medicine is to identify "predisposing" genes for diseases such as cancers that are strongly linked to occuptional and environmental carcinogens. Already, preimplantation diagnosis are being done for gene "predisposing" embryos to cancers they might suffer as adults, so they can be eliminated. We have indeed gone down the slippery slope of genetic discimination and eugenics.

25 Despite all the promises of gene therapy, there has not been a single documented success in more than 20 years. Yet, it is still being aggressively pursued with dangerous vector techniques that can cause cancer and create new viruses.

26 Another promise - that of personalized medicine based on our genetic makeup - is a pipe-dream. We have between 10 000 to 100 000 genes with hundreds of possible variants in each gene. As I said, each person is genetically unique, except for identical twins at the beginning of their life. The function of each gene depends on the background of all the other genes which which it interacts. That's why even single gene diseases are turning out to be far more complicated. It is impossible to give an accurate prognosis based on knowledge of single genes. Furthermore, up to 95 percent of our genome is called "junk DNA" because no one yet knows what its functions are.

27 Since the 1980s, healthcare systems all over the world have been seriously undermined by "free-market" imperatives. So-called "structural adjustment programmes", supported by the World Bank, have forced Third World Governments to impose charges on healthcare for the poor, to cut public spending by reducing services and to promote private health businesses. As a result, undernutrition and infant mortality rates have been increasing in many Third World countries, reversing a long term trend; and infectious diseases have re-emerged with a vengeance in immunologically compromised populations. It is extremely dubious whether genetic engineering biotechnology can improve the health of anyone, least of all, the poor. It may, instead, be contributing to the resurgence of infectious diseases.

28 While reproductive technologies are promoted to treat infertility among white Europeans in the North, women in racial minorities and in the South are being sterilized against their will, with drugs causing crippling side-effects. This will continue with genetically engineered contraceptives. The Third World poor are routinely used as guinea-pigs for vaccines and drugs. A recent case is a cholera vaccine, tested on 85 000 Bangladeshi women and children by a Swedish company beginning in 1985. The vaccine is found to offer only fleeting protection, if at all, and in any case, is so expensive that no Bangladeshi would be able to afford it. Have large vaccine trials like this one contributed to the re-emergence of new variants of the diseases now raging in the Third World? Third World governments should be on their guard against the new vaccines, especially those involving recombinant DNA, as these may have an increased propensity to generate new viruses or to cause other harmful effects.

29 Scientific findings accumulated over the past twenty years have invalidated every assumption of genetic determinism. The new genetics is compelling us to an ecological, holistic perspective, especially where genes are concerned. Our destiny does not lie in the genes. The genes are not constant and unchanging as previously supposed. Instead, genes are found to respond to the physiology of the organism *and require a stable, balanced ecology to maintain stability*. Organic agriculture is predicated on such a balanced ecology, which depends on a diverse community of healthy organisms free from agrochemicals.

30 In the same way, the key to genetic health is precisely the same as physiological health: unpolluted environment, wholesome organic foods free from agrochemicals, and sanitary, aesthetically and socially satisfying living conditions.

31 Genetic engineering biotechnology, far from addressing the issues of food security and health, actually undermines and endangers both. Our priorities are in curbing toxic and radioactive discharges as well as releases of genetically engineered organisms. Agrochemicals should be

phased out and organic agriculture widely introduced. These are the real choices for civil society.

32 We must turn the tide on bad science and big business, and opt for a life sustaining Promethean science that works for the good of humanity and our planet.

Say No Now

(Public talk in Cork, Ireland, 16 Jan, 1999)

1 Genetic engineering biotechnology is the latest offering from the alliance between reductionist science and big business which has already brought our planet to the edge of extinction in climate change, ozone depletion, massive loss of species and intolerable levels of toxic and radioactive pollution in our life-support system. After having extracted and ruined all of the planet's resources, reductionist science and big business are targetting life itself, which is our last remaining hope of regenerating and saving the planet.

2 The science of genetic determinism which is driving the technology and selling it to the public as the answer to all our ills, regards organisms, including human beings as nothing more than collections of genes determining what they are, so by manipulating and changing genes, any desired organism can be created, and all the problems facing humanity can be solved.

3 Mary Shelley has predicted the present scenario of human cloning and genetic manipulations in her classic novel, *Frankenstein* , which is about the scientist obsessed with science as a means to control and improve on nature. He created a monster thinking he could create the perfect human being. Can we afford to let this Frankenstein science take over the world for the sake of profit? What's at stake is life, our life-support and our value system as human beings, which are all under attack, which are all being placed under unaccountable corporate monopoly.

4 The worst of it is that this Frankenstein science of genetic determinism has already been thoroughly discredited by scientific findings at least ten years ago. It has failed the reality test within science itself. That is why genetic engineering biotechnology is a dangerous diversion that not only prevents us from implementing real solutions to our problems, but also poses unprecedented risks to health and biodiversity.

5 But our Governments have been taken in.
They have handed over ownership of life to the corporations by voting for patents on organisms and genes including human genes.
They will allow corporations unrestricted exploitation their citizens and natural resources in the financial treaties of the WTO and the MAI. Environmental standards, food safety standards and even basic human rights will be sacrificed to corporate financial imperatives.
Meanwhile, corporate scientists sit on committees at all levels, pronouncing everything safe, in total disregard of scientific evidence.

6 We are told genetic engineering is just like conventional breeding, only faster, cleaner and more precise. Not true. It is a new departure, and introduces new dangers. Genetic engineering bypasses reproduction altogether. It uses artificial virus-like vectors to transfer genes horizontally. So genes can be transferred between species that would never interbreed in nature.

7 New genes are engineered into our food, many from bacteria and viruses and non-food species whose long term impacts on health and biodiversity are completely unknown.

8 The foreign genes are bound to interact with host genes to give unintended effects including toxins and allergens.

9 The technology is hit or miss and not at all clean and precise. The vector carrying foreign genes insert at random into the genome of the organism, giving rise to random genetic effects, including cancer in mammalian cells.
For the same reasons, transgenic lines are often unstable, and do not perform consistently.

10 Most of all, the artificial vectors used to transfer genes are made by recombining the most infectious viruses and other genetic parasites and may contribute to creating new viruses and bacteria that cause diseases.
That was why the pioneers of genetic engineering called for a moratorium in the 1970s; though commercial pressures cut it short.
Since then, drug and antibiotic resistant infectious diseases have come back with a vengeance. Strains of at least 4 dangerous bacteria including the one causing tuberculosis are already resistant to all antibiotics and hence untreatable.

11 There is now overwhelming evidence that horizontal gene transfer is responsible for spreading antibiotic resistance and creating new viral and bacterial pathogens.

12 Other scientific findings suggest that
Transgenes and antibiotic resistance genes may spread horizontally from transgenic plants to soil bacteria and fungi, and to gut bacteria.
Transgenic DNA may be 30 times more likely to escape than the plant's own DNA.
Viral genes in transgenic plants may recombine with other viruses to generate new, superinfectious viruses.
Viral DNA, which is in practically all transgenic organisms, resist digestion in the gut of mice, pass into the bloodstream and then into a variety of cells to integrate into the cells' genome. When viral DNA was fed to pregnant mice, the DNA was found in the cells of the foetus.

13 Scientific findings accumulated over the past twenty years have invalidated every assumption of genetic determinism. The new genetics is compelling us to an ecological, holistic perspective, especially where genes are concerned. Our destiny does not lie in the genes. The genes are not constant and unchanging as previously supposed. Instead, genes are found to respond to the physiology of the organism *and require a stable, balanced ecology to maintain stability*. Organic agriculture is predicated on such a balanced ecology, which depends on a diverse community of healthy organisms free from agrochemicals.

14 In the same way, the key to genetic health is precisely the same as physiological health: unpolluted environment, wholesome organic foods free from agrochemicals, and sanitary, aesthetically and socially satisfying living conditions.

15 Genetic engineering biotechnology, far from addressing the issues of food security and health, actually undermines and endangers both. Our priorities are in curbing toxic and radioactive discharges as well as releases of genetically engineered organisms. Agrochemicals should be phased out and organic agriculture widely introduced. These are the real choices for civil society.

16 We must turn the tide on bad science and big business, and opt for a life sustaining Promethean science that works for the good of humanity and our planet.

Gene Biotechnology Undermines Food Security and Healthcare and is Inherently Hazardous

Triodos Bank Conference, Westminster Hall, 27 March, 1999.

I was in India on a conference and lecture tour two weeks ago where I met angry Indian farmers from all over the country calling for a ban on transgenic crops. Monsanto bought up an Indian seed company and proceeded to carry out field trials at 40 locations in 9 Indian states, with the agreement of the Department of Biotechnology, while all state Governments were kept in the dark[1] Farmers burnt the field trials in a "cremate Monsanto" campaign, followed by the "Monsanto quit India" campaign.

The South Asian Network for Food, Ecology and Culture (SANFEC) have launched a two-prong attack: a resistance movement, the South Asia Against Monsanto campaign, directed at all genetic engineering transnational giants like Monsanto, led by a coalition of thousands of farmers, more than 200 ecological activists and ngos working with millions of farmers; and a movement to preserve and save traditional seeds, which alone can truly feed the hungry people in the region.

Similar movements are taking place elsewhere. A coalition of Latin American ngos have declared they will not accept transgenic crops. Brazil has banned Monsanto's transgenic soya from being planted. Tewolde Egziabher of Ethiopia, leading spokesperson of the African Region rejects the technology as "neither safe, environmentaly friendly, nor economically beneficial to us."

What incensed farmers most is the threat of seed monopoly. The seed is the germ of life, its inexhaustible generative capacity and fecundity. It is nature's bounty freely available to birds in the field and to human beings since time immemorial. But corporations have now usurped and patented the seed. Farmers are being lured into growing patented genetically engineered varieties for which they will have to pay royalities, and which they will not be allowed to save and resow. This comes at a time, when, within the past 5 to 10 years, many farmers have gone back to cultivating and conserving traditional varieties in all forms of organic, sustainable agriculture, doubling and tripling their yields and improving their livelihood, health and nutrition. They have been reversing the environmentally and socially destructive trends of the so-called high yielding varieties of the green revolution, which have brought financial ruin and suicides to thousands in India alone [2].

All of which gives the lie to the claims that gene biotechnology will feed the world (or create greener, sustainable agriculture). According to the UN food programme, there is enough

food to feed everyone one and a half times over. World cereal yields have consistently outstripped world population growth since 1980 (2.2% a year compared with 1.7%). But one billion are hungry [3]. It is on account of transnational corporations like Monsanto operating under the globalized economy that the poor are getting poorer and hungrier. They operate through monopoly on seeds, on food production and distribution, through exploitative measures of buying where and when it is cheapest and selling dear, or undercutting farmers by subsidized dumping of surpluses.

Corporate giants already control more than three-quarters of the world trade in cereals [4]. Small farmers are suffering everywhere. In the US, they are receiving below the average cost of production for their produce [5]. The international trade of cereals was US$20 billion in 1995, which was subsidized at $15.7 billion for US and EU. The average subsidy to a farmer in the North is 25 times average per capita income for 42 low income countries. The systematic subsidized dumping has turned previously grans exporting countries into importers. The USDA created Export Enhancement Programmes to counter what it regards to be 'unfair competition' from EU for the Phillipine. The Phillipines purchased 1.2 million tons of wheat at $96/ton. Direct subsidy to the exporting companies was $77 per ton in direct payment and $40 in EEP.

To see it in perspective, genetic engineering biotechnology is merely the latest offering from the alliance between reductionist science and big corporate business which has brought our planet to the edge of extinction in climate change, ozone depletion, massive loss of species and intolerable levels of toxic and radioactive pollution, as you have no doubt heard from previous speakers. After having extracted and ruined all of the planet's resources, the alliance is targetting life itself. The reason so many people feel so passionately against genetic engineering is that we know, intuitively and otherwise, that living organisms are our last resort, our last remaining hope for regenerating and saving the planet. Seeing how organic farmers in India regenerate land laid waste by agrochemicals and industrial chemicals in two to three years [6], convinces me more than ever that we can reverse the destruction with the natural resilience and fecundity of life, and that we have to stop the terminator corporations with their ultimate terminator technologies which genetic engineer harvested seeds not to germinate, thus breaking the very cycle of regeneration.

The alliance between bad science and big business has become most intimate in genetic engineering biotechnology. Practically all established molecular geneticists are linked to industry and are keen to exploit the technology. There are very few independent scientists doing research on the hazards.

What makes the alliance so powerful is that it is bolstered by mainstream academic theories stemming from the same roots in imperial, colonialist England: neo-liberal economic theory supporting *laissez-faire* corporate capitalism, and neo-Darwinian genetic determinism driving the technology and selling it to the public. They are united by a shared vision of the world as so many isolated bits and pieces that can be manipulated with impunity one at a time. They see selfish genes instead of organisms and selfish individuals instead of communities, societies and ecosystems, all jostling and competing against one another, in the struggle of survival of the fittest and the biggest. They set no limit to exploitation and short-term profit in the war of one against all and all against nature. Because there is a two-way connection between mindset and social reality, we end up with a dysfunctional global society with enormous, still rapidly widening disparity between rich and poor.

Fortunately, or unfortunately, nature does not conform to our illusion that things are separate, and of how the world should be run. She is organically interconnected and finite, and the effects of decades of wanton destruction and exploitation not only spread far and wide, but are rebounding back on us.

Both theories have failed the reality test, which is why the global ecology and global economy are collapsing together. This should come as no surprise, as a sound economy is absolutely dependent on a sound ecological base. Conversely, an extractive, exploitative economy destroys the ecology, which is our life support system. Enlightened economists such as Hazel Henderson, Herman Daly and James Cobb and ecologists such as Edward Goldsmith and Jerry Mander have been drawing attention to that since the 1970s. But no one listened to them. This same message has been put most eloquently and forcefully in recent years by Stuart McBurney [7] and David Korten [8]. Now, even the most committed capitalists are worried. "The main enemy of the open society..is no longer the communist but the capitalist threat." This statement is remarkable if only because its author is George Soros [9] a well-known capitalist who has himself benefited a great deal from the system. But, in most of our universities, both theories are still taught as though no alternatives exist. Our universities have become instruments of the corporations.

What is not generally known is that genetic determinism has also failed by the criteria of science. It has been thoroughly discredited by scientific findings over the past 20 years. The

discredited theory of genetic determinism is misguiding gene technology and selling it to the public as the answer to all our ills. It is promoting eugenics and genetic discrimination. It is undermining healthcare by diverting attention and resources away from the overwhelming environmental causes of ill-health and blaming the victim's genes. It is legitimising patents on living organisms cell lines and genes which turn life into commodities. These patents include human genes stolen from indigenous peoples, as well as intellectual and genetic resources pirated from indigenous communities. With the Trade Related Intellectual Property Rights agreements and the treaties of the World Trade Organization and the Multilateral Agreement on Investment, corporations will be granted monopoly on life and on unrestricted exploitation of people and natural resources. Environmental protection, food safety standards, labour standards, and even basic human rights will be sacrificed to trade and financial imperatives.

I was also recently in Cartegena, Columbia, where a legally binding International Biosafety Protocol to regulate genetic engineering biotechnology and ensure its safe use was due to be finalized after seven years of hard negotiations. It was blocked by the USA and five other countries, representing the biotech interests and acting against the overwhelming majority of the world's nations. It is clear that the corporations will stop at nothing to force genetically engineered crops, food and other products on the world. They are actively supported by the US Government. The 1993 USDA report identifies the problem of growing production and shrinking domestic market, and hence the need to aggressively capture a larger share of the world market, particularly in SE Asia. It estimates the 2/3 of the world demand for farm exports will be in SE Asia, giving a total rise of $14 billion by year 2000 [10].

The corporations are also being helped by many corporate scientists who are sitting on advisory committees at international and national levels, pronouncing everything safe, in total disregard of scientific evidence. When honest scientists come up with scientific evidence unfavourable to the industry, the findings are suppressed and the scientists victimized. This happened to a group of Government scientists in Health Canada who recommended rejection of Monsanto's rBGH on grounds that it endangers public health. The scientists had to seek Government protection before they disclosed the results to the Canadian Senate. The Canadian Senate subpoenaed the scientists' report and a court hearing eventually led to Canada banning the rBGH.

I am sure you have heard how within the UK, Dr. Arpad Pusztai, a senior Government scientist commissioned by the Scottish Office to test the safety of transgenic foods, was removed from his post under a cloud after appearing in a TV documentary reporting the damaging effects of transgenic potatoes on laboratory rats. Twenty other scientists have since supported his claims. Potatoes engineered with a lectin (a special protein) from the snowdrop plant caused damaged many essential organs: intestine, liver, spleen, thymus, pancreas and brain. In addition, it also impaired the immune system, and gave signs suggestive of viral infection [11].

Pusztai's work suggests that everything that could go wrong with transgenic foods has gone wrong in those transgenic potatoes, and that the major toxic effects are due to the genetic engineering process. Regardless of the final verdict, his findings are not the first evidence of hazards associated with transgenic foods. Evidence of hazards inherent to the technology is already in the published scientific literature. And scientists like myself and others have been drawing our regulators' attention to it, in vain, for the past 4 years. **The greatest threat to good science is its commercialization. It is time mainstream scientists recognize what is really happening. A discredited science, working in partnership with unaccountable corporate monopolies, is misguiding a hit or miss technology that has the potential to destroy all life on earth** [12].

The bad science of genetic determinism

Gene biotechnology was launched simultaneously with massive, publicly-funded programmes supposed to promote "public understanding of science", resulting in a glut of glossy pamphlets, booklets and reports, which are in reality little more than disguised propaganda for the biotech industry. They are biased and partisan, openly favouring the industry, exaggerating the benefits and dismissing the risks. The report, *Ethics, Morality and Crop Biotechnology* [13], published by the bbsrc - the research council supporting most of publicly-funded work on gene biotechnology - is an oxymoron. It goes to great lengths to dismiss all moral and ethical concerns as irrational and unjustified, finally ending up with a series of falsehoods such as "the possible harmful effects of crop biotechnology are entirely speculative" and outrageous equivocations, such as "excessive caution does not necessarily remove the risk of future catastrophes." for "we may run the greater

risk of failing to produce an innovation which will be desperately needed in some future, unforseen crisis." How about addressing some of the global crises now?

Most of all, the whole genre of literature promotes a simplistic picture of organisms and on how genetic engineering is done.

"Research scientists can now precisely identify the individual gene that governs a desired trait, extract it, copy it and insert the copy into another organism. That organism (and its offspring) will then have the desired trait.." [14].

"The key to these new biotechnologies is the ability to identify, isolate and manipulate the individual genes that govern specific characteristics or traits in plants, animals and microorganisms. We can alter genes and so adjust the characteristics they code for, and we can move specific genes from one organism to another in a very precise manner. As a result, specific characteristics can be transferred from one individual to another with a level of control not imaginable a few decades ago." [15]

These descriptions neatly encapsulates the bad science of genetic determinism. It gives the highly misleading impression of a precise technology, implying that,

- Genes determine characters in linear causal chains, one gene giving rise to one character;
- Gene are not subject to influence from the environment;
- Genes remain stable and constant;
- Genes remain in organisms and stay where they are put.

So, by manipulating genes, all the problems of the world can be solved, as simple as that!

Genetic determinism obviously has a tremendous hold on the public imagination and runs very deep within the collective psyche of our society. For several years, the popular and not so popular media have been full of reports on genes for everything, from homosexuality, criminality, to alcoholism and homelessness. These claims based on genetic determinism are socially irresponsible and plain wrong. Genetic determinism ***goes counter to all the scientific evidence accumulated within the past 20 years*****,** which gives us the new genetics. What is the new genetics of the present day really like?

- No gene ever works in isolation, but in an extremely complicated genetic network, the function of each gene depends ultimately on all the other genes in the genome. So, the same gene will not have the same effects in different individuals, because the genetic background consisting of all other genes are different. Hundreds of variants exist for every gene. There is so much genetic diversity within the human population that each individual is genetically unique (except for identical twins at the beginning of their development). And if the gene is transferred to the genome of a different species by genetic engineering, it is most likely to have new and unpredictable effects.
- The genetic network, in turn, is subject to layers of feedback regulation from the physiology of the organism and its relationship to the external environment. So, if the environment changes, a gene may cease to work, or it may be particularly active.
- These layers of feedback regulation not only change the function of genes but can rearrange them, multiply copies of them, delete them, mutate them to order, or make them move around. Some of the mutations that occur in response to certain environments are so repeatable that they are referred to as "directed mutations".
- And, genes can even travel outside the original organism to infect another. This is *horizontal gene transfer*, the very process exploited for genetic engineering. I shall come back to that later.

Those findings have completely invalidated genetic determinism. The new genetics is diametrically opposite to the old static, reductionist view. It is radically holistic. Genes and genomes can change so much that molecular geneticists themselves have invented the descriptive term, 'the fluid genome', nearly 20 years ago. It is more accurate, however, to see the gene as having a very complicated ecology consisting of the interconnected levels of the genome, the physiology of the organism and its external environment. Putting a new gene into an organism will create disturbance that may propagate out to the external environment, with unpredictable effects on biodiversity. Conversely, changes in the environment will be transmitted inwards and may well alter the genes themselves. The most important lesson from the new genetics is that the stability of genes and genomes, as much as all the other characteristics of the organisms, depends on a balanced ecology. Genetic engineering profoundly disturbs the ecology of genes at all levels, and that is where the problems and dangers arise.

Genetic engineering is an untried, hit or miss technology that brings new dangers

Genetic engineering is not at all like conventional breeding. It bypasses reproduction altogether, making use of artificial virus-like vectors (or carriers of genes) to multiply and manipulate genes, and to transfer genes *horizontally* by infection. So genes can be transferred between species that would never interbreed in nature. For example, human genes are transferred into pigs, sheep, cows, mice and the bacterium, *E. coli.*; and toad genes are transferred into potatoes. **However, the insertion of foreign genes into the genome of the host organism is not under the control of the genetic engineer**. It occurs at random, giving rise to correspondingly random genetic effects, including cancer in mammalian cells. Large failure rates are typical in transgenic animals and many abnormalities are found even among the successes. For the same reasons, transgenic crops are often unstable, do not breed true, and do not perform consistently, even in those that have been approved for commercialization [16]. The agronomic performance of these crops is yet unproven. Not only may the financial bubble burst, we stand to lose our agricultural base.

Genetic engineering agriculture, not only does not feed the world, it is not sustainable, nor does it offer greener agriculture . On the contrary, it poses unacceptable risks to health and biodiversity. The details are in your information pack.

I want to concentrate on the most serious threat to health that is inherent to the vector technology used to multiply and transfer genes, which has the potential for spreading genes out of control and creating new viruses and bacteria that cause diseases. The artificial vectors used in genetic engineering are made by recombining, or joining together parts of the most infectious viruses and other genetic parasites that spread antibiotic and drug resistance genes. Whereas natural viruses and genetic parasites generally respect species-barriers, so that, say, a pig virus will not infect human beings, and a tomato virus will not attack cauliflower, the artificial vectors are designed to break down all species barriers. The same mechanisms that allow the artificial vectors to jump into the genome may enable them to jump out again and spread. In so doing, they may jump into the cells of animals, causing genetic damage including cancer. Most of all, they may recombine with genes from many other species and their pathogens to create new viruses and bacteria that cause diseases. That was why the pioneers of genetic engineering called for a moratorium in the 1970s. Unfortunately, commercial pressures cut the moratorium short. They set up guidelines based largely on untested assumptions, every one of which has been invalidated by recent scientific findings.

Since then, drug and antibiotic resistant infectious diseases have come back with a vengeance. Strains of at least four dangerous bacteria including the one causing tuberculosis are already resistant to all antibiotics and hence untreatable. Has genetic engineering biotechnology contributed to the recent resurgence of infectious diseases? **We have produced a report on the possible links, and demanding a detailed enquiry** [17]. There is now overwhelming evidence that horizontal gene transfer is responsible for spreading antibiotic resistance and creating new viral and bacterial pathogens, and many of the horizontal gene transfer events have occurred very recently.

Pandemics of infectious diseases are increasingly common also in wild-life and farm animals. Just now, Malaysia has been struck by a very serious viral disease, Japanese Encephalities that affect pigs as well as human beings. Sixty one people have died, and the police and army are carrying out mass slaughter of pigs.

Other scientific findings suggest that

- Secondary horizontal tranfer of transgenes and antibiotic resistant marker genes from genetically engineered crop plants into soil bacteria and fungi have been documented in the laboratory [18]. Successful transfers of marker genes to the soil bacterium *Acinetobacter* were obtained using homogenized plant leaf from a range of transgenic plants: *Solanum tuberosum* (potato), *Nicotiana tabacum* (tobacco), *Beta vulgaris* (sugar beet), *Brassica napus* (oilseed rape) and *Lycopersicon esculentum* (tomato) [19]. Transfer of the antibiotic resistance marker gene was very efficient, despite the fact that there was a million-fold excess of plant DNA present. Horizontal gene transfer may well occur under field conditions, as it is now found that DNA released from both live and dead cells can persist for long periods in the environment, and retain the ability to infect other organisms. Transgenic DNA may also be spread by insects. A recent report in the Journal *Nature* suggests that transgenic DNA may be up to 30 times more likely to escape than the plant's own DNA, perhaps carried by syrphid flies that visit the plants for nectar and pollen [20]. A genetic parasite belonging to yeast is found to have jumped horizontally into many unrelated species of higher plants very recently [21]. The researchers themselves have expressed concern over the release of transgenic crops, given that horizontal gene transfer is so widespread.

- Transgenic DNA (including antibiotic resistance marker genes) may spread to gut bacteria, as DNA is not broken down rapidly in the gut, and gene transfers have already been demonstrated between bacteria in the gut.
- The risks from horizontal spread of transgenic DNA are compounded by the extensive use of antibiotics in intensive farming. It is now known that antibiotics can increase the frequency of horizontal gene transfer up to 10 000-fold.
- Plants engineered with genes from viruses to resist viral attack actually showed increased propensity to generate new, often super-infectious viruses [22].
- Viral DNA is now known to be more infectious than the intact virus, which has a protein coat wrapped around the DNA. So, while an intact human virus will not infect rabbits, the naked DNA gave a full-blown infection when injected into the rabbits.
- Transgenic DNA may get into our cells. DNA from a virus fed to mice has been found to resist digestion in the gut. Large fragments passed into the bloodstream and into white blood cells, spleen and liver cells. Viral DNA may have integrated into the mouse cell genome. When the viral DNA is fed to pregnant mice, it ends up in cells of the foetus and the newborn [23].

Genetic engineering agriculture is surely an extremely dangerous diversion. Far from feeding the world, it intensifies corporate control on food which created poverty and hunger in the first place. It obstructs implementation of sustainable agriculture and erodes agricultural biodiversity, which are widely recognized to be precisely what we need to guarantee long term food security and counteract malnutrition. I have told you about the revival of organic agriculture and recovery of indigenous agricultural biodiversity in India. The same is occurring throughout the Third World and in Latin America.

The recent experience of Cuba is instructive. US economic blockade since the 1960s caused a shortage of agrochemicals, making it necessary for Cuba to go organic on a grand scale. They maintained one-third of the 11 million hectares of agricultural land on agrochemicals, turned another third fully organic, and kept the rest 'transitional' as half agrochemical and half organic. The yields per hectare of the fully organic are equal to the fully agrochemical, while the yields of transitional fields are only half as much. This is the clearest evidence that organic agriculture can work on a large scale, with energetically efficient low inputs and minimal impacts on the environment.

I don't have time to say much on health, again you have a summary sheet in your information pack. And of course, you should read my book. **Essentially, the same kind of reductionist biology in partnership with big corporate business has failed in healthcare as in agriculture**. The partnership grossly undermines and distorts healthcare, and genetic engineering biotechnology and the patenting of cell lines and genes are making things worse. Healthcare will be replaced by a health-market, serving the rich, if at all, at the expense of the poor. In addition, many of the most serious health risks are the same: of cancer, of creating new viruses from the vector technologies used in gene therapy, in the new DNA vaccines, and from xenotransplantation and transgenic farm animals.

More and more people are coming around to the view that there is no reductionist solution to health and food security. Both are matters of global human ecology. The same message is coming from science itself.

Scientific findings accumulated over the past twenty years have invalidated every assumption of reductionist genetic determinism. The new genetics is compelling us to an ecological, holistic perspective. Our destiny does not lie in the genes. The genes are not constant and unchanging as previously supposed. Instead, they respond to the physiology of the organism and the ecological environment, *and require a stable, balanced ecology to maintain stability*. Organic agriculture is predicated on such a balanced ecology, which depends on a diverse community of healthy organisms free from agrochemicals. Similarly, the key to genetic health is precisely the same as physiological health: unpolluted environment, wholesome organic foods free from agrochemicals, and clean, aesthetically and socially satisfying living conditions.

Our priorities are in curbing toxic and radioactive discharges as well as releases of genetically engineered organisms. Agrochemicals should be phased out and organic agriculture widely introduced. These are the real choices for civil society. Civil society must seize this opportunity to reset the agenda for the next millenium, and not let it be hijacked by the terminator corporations. We must turn the tide on bad science and big business, and opt for a life-sustaining science and industry working for the good of humanity and our planet.

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20. Bergelson *et al*, 1998. The authors of the report did not suggest this possibility. I put this possibility to the first author. She replied that they did not find evidence for horizontal gene transfer, although the possibility could not be ruled out.
21. Cho *et al*, 1998.
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Trafalgar

(Talk given at rally at Trafalgar Square, London, April 10, 1999)

Friends and colleagues! It is great to be here with all of you, in the midst of the biggest, most inclusive civil rights movement of the century, if not the millenium. It is against the evil empire of corporate feudalism, that has ruthlessly exploited and ruined all of the earth's resources, to make the rich ever richer, and the poor ever poorer and hungrier. And now, to top it all, the corporate empire is taking possession of life and our life-support system, to use as stakes in a final gamble with a Frankenstein science and technology that may destroy all life on earth.

There are very brave people in the movement, who are accepting arrest and harassment to put our case to our Governments. Some of them are here today. Ten days ago, I was an expert witness helping to defend seven people who took civil disobedience action against Monsanto's genetic test sites in Wexford, Ireland. Among the seven was John Seymour, 84-year old author and organic farmer, who compares the invasion of Ireland by Monsanto's "genetically mutilated" crops

to the invasion by the Norman army, and sees it as his duty to defend his country. "And if I have to go to prison because of it then I will go with a good will, and make the best of it, and when I get out I will try to stop them again!"

And we are not alone. The whole world is with us. Last month, I was in India where I met angry farmers calling for a ban on transgenic crops. Monsanto bought up an Indian seed company and began to carry out field trials at 40 locations in 9 states without telling the state Governments. Farmers burnt the field trials in a "cremate Monsanto" campaign, followed by the "Monsanto quit India" campaign.

In the region of South Asia, a large coalition of ngos representing millions of farmers, have launched a two-prong attack: a resistance campaign directed against all genetic engineering transnational giants like Monsanto and a seed-saving campaign to save and preserve traditional seeds, which alone can truly feed the hungry people in the world. Similar resistance and seed-saving campaigns are happening elsewhere. A coalition of Latin American ngos have declared they will not accept transgenic crops. Brazil has banned transgenic soya from being planted. Tewolde Egziabher of Ethiopia, leading spokesperson of the African Region, rejects the technology as "neither safe, environmentally friendly, nor economically beneficial." And Greece has now called for a Europe wide moratorium.

What incense farmers most of all is the threat of seed monopoly. The seed is the germ of life. The seed is nature's bounty freely available to birds in the field as much as to human beings since time immemorial. Farmers have always depended on saving seeds and replanting them. It is a symbiotic linkage of the human life-cycle to that of crop-plants that perpetuates and propagates both. Peruvian farmers adopt plants into their gardens as members of their family. Every year, a potato-ceremony is held, in which the old potato hands over the job of breeding the human beings to the new seed-potato.

Corporations have now usurped the seed, genetically multilated (to use John Seymour's very apt term) and patented it. Farmers have to pay royalties for the seeds, which they are forbidden by law to save and resow. This comes at a time when, within the past 10 years, many farmers have gone back to cultivating and conserving traditional varieties in all forms of organic, sustainable agriculture, doubling and tripling their yields and improving their livelihood, health and nutrition. They have been reversing the environmentally and socially destructive trends of the so-called high yielding monocultures of the green revolution, which have brought financial ruin and suicides to thousands in India alone.

Corporate feudalism, with the help and encouragement of reductionist western science, has brought our planet to the edge of extinction. The reason so many people all over the world feel so passionately against genetic engineering biotechnology is because we know, intuitively and intellectually, that living organisms are our last resort, our last remaining hope for regenerating and saving the planet. I saw how organic farmers in India can regenerate land completely laid waste by agrochemicals and industrial chemicals and given up for good. And they did it in just two to three years. That convinces me more than ever that we can reverse the destruction, and that we have to stop the terminator corporations targetting the very natural resilence and fecundity of life that make it possible to reverse the destruction. In order to protect their seed monopoly, the corporations are even planning to release the ultimate terminator - harvested seeds that do not germinate - thus breaking the very cycle of life.

The power for regeneration is not only in the seed. It is in the will of each and everyone of us who cares, who, for the love of life and nature, works for a better, more equitable and compassionate world. The power for regeneration is especially in the organic farmer who understands how to work with holistic, organic nature. Organic farmers everywhere are poets. I met one Charles McGuire in Ireland who tells me, "When I walk into my fields, I can feel the earth singing to me." Another, Sultan Ismail, in India says, "The soil is a living organism. We have placental connections with the soil." and "Trees are poems that the earth writes in the sky, But we cut them down to fill our emptiness." What I find most encouraging as a scientist is that after centuries of reductionist, mechanistic thought, contemporary western science is finally re-discovery and re-instating this same view of holistic, organic nature that many indigenous cultures in the world have never lost touch with.

Unfortunately, mainstream biology is left far behind. It has no real appreciation of interconnected nature. It has no concept of an organism as a whole. It thinks it can improve on nature by arbitrarily manipulating and transferring genes, and does not realize it has created monsters. It is a Frankenstein science in exactly the way Mary Shelley's genius portrayed it. Except that the original Dr. Frankenstein did not do it for money, while the Frankenstein science we have now is driven and blinded by profit; it is both master and handmaiden to corporate feudalism.

Genetic engineering agriculture is a new departure from conventional techniques and introduces new hazards. Eminent biochemist Dr. Arpad Pusztai was victimised for drawing attention to the findings of his group, which suggest that the major toxic effects of transgenic potatoes are in the transgenic process itself. He was also vilified by the scientific establishment for not subjecting his results to peer review and publication. But Pusztai's findings are not the first experimental results indicating that the hazards may be *inherent* to the technology. A large literature already exists, which has been ignored, or downplayed by our Government's scientific advisors.

I have heard our Government's scientific advisors say, "No one has died yet from eating genetically engineered food." How would they know? There is no segregation, no effective labelling or monitoring. When faced with the evidence that genes can spread horizontally from transgenic plants to soil microorganisms, another one say, "Just because it happens in the laboratory does not mean it will happen in nature." Can he guarantee it will not happen in nature? Of course not. These statements are irresponsible and not in accord with good sound science. They are based on what I can only describe as the inverse precautionary principle, according to which, everything must be approved unless proven absolutely unsafe. It is equivalent to saying that 8000 babies have had to be born with truncated limbs before they would admit there is scientific evidence that thalidomide is harmful.

It is symbolic that we have gathered in Trafalgar Square. We are working for a much more important victory than Lord Nelson's. When we win, and I am confident we will. It will be the triumph of democracy over feudalism, of reason over stupidity, of love and compassion over exploitation, of life over death. It will be the end of the brave new world of bad science and big business. It will be triumph of sustainable, responsible science and industry working together for the good of all.

No to GMO
Civil Society vs Corporate Empire

(Talk presented in Progressive Farm Leader Summitt on Geneti Manipulation and Agriculture, Coalition of Family Farmers, USA, Mannasas, Virginia, September 11, 1999)

Friends and colleagues! It is great to be here with you. As has been made clear by speakers in the previous panel, the issue is not just whether we should accept GM crops. We are involved in the biggest, most inclusive, world-wide civil rights movement of the century, if not the millenium, and it is against the corporate empire that has ruthlessly exploited and ruined all of the earth's resources, to make the rich ever richer, and the poor ever poorer and hungrier. And now, to top it all, the corporate empire is taking possession of life and our life-support system, to use as stakes in a final gamble with a Frankenstein science and technology that has the potential to destroy all life on earth. As some of you will know, the movement has been going on for well over twenty years. I am a late-comer, an ex-ivory tower academic who has been moved and inspired to join in the struggle since 1994.

There are very brave people in the movement, who are accepting arrest and harassment to put our case to our Governments. The destruction of GM field trials in the UK by Genetix Snowball and others has been grabbing the international headlines, but that kind of action started several years ago in Germany. It is now also happening in Ireland, France, India, Brazil, and I am told, in your country as well. The perpetrators are not the usual eco-warriors, but ordinary citizens like you and me, from all age groups and right across the social spectrum, literally from prince to pauper. I was an expert witness helping to defend seven people who took civil disobedience action against Monsanto's GM test sites in Ireland. Among the seven was a journalist, a lawyer and 84-year old author and organic farmer, John Seymour, who compares the invasion of Ireland by Monsanto's "genetically mutilated" crops to the invasion by the Norman army, and sees it his duty to defend his country. "And if I have to go to prison because of it then I will go with a good will, and make the best of it, and when I get out I will try to stop them again!" The resistance to GM crops is world-wide.

In India, I met angry farmers calling for a ban on GM crops. They burnt the field trials in a "cremate Monsanto" campaign, followed by the "Monsanto quit India" campaign. In the region of South Asia, a large coalition of ngos representing millions of farmers launched a two-prong attack: a resistance campaign directed against all genetic engineering corporations and a seed-saving campaign to save and preserve traditional seeds, which alone can truly feed the hungry people in the world. Similar resistance and seed-saving campaigns are happening elsewhere. A coalition of Latin American ngos have declared they will not accept GM crops. In Brazil, the agricultural minister of the State of Rio Grande do Sul was the first to declare his State GM-free, and a remarkable group of eminent judges and lawyers played a major role in getting Monsanto's GM

soya banned from the whole country. Monsanto has appealed three times and failed to get the federal court decision overturned. At the same time, Brazil is drafting biodiversity/biosafety laws in order to protect their genetic resources and indigenous knowledge from biopiracy.

In Japan, three of the largest consumer associations, with membership running into millions and hundreds of thousands, succeeded in getting mandatory labelling of GM products. Tewolde Egziabher of Ethiopia, leading spokesperson of the African Region, has rejected the technology as "neither safe, environmentally friendly, nor economically beneficial." The African Region has taken the lead in drafting the most comprehensive International Biosafety Protocol under the UN Convention on Biological Diversity in order to regulate the use and transport of genetic engineered products. The negotiations broke down in Cartegena, Columbia, this February, blocked by the US and its 5 allies of the Miami Group against the overwhelming majority of the 170 countries who have signed onto the Convention on Biological Diversity. Since then, African countries have been drafting Biosafety Law for the entire region, in order to protect themselves against the dumping of GM crops and products. The European Union has a *de facto* moratorium at least until 2002, but consumer resistance has already led to all major food chains and suppliers to declare themselves GM-free.

Although consumers reject GM products primarily on grounds of safety, farmers do so because of the threat of seed monopoly. Farmers have always depended on saving seeds and replanting them, and 85% of the farmer in the Third World still do so. It is the symbiotic linkage of the human life-cycle to that of crop-plants that perpetuates and propagates both.

Corporate patents are now preventing farmers from saving and replanting under penalty of heavy fines. This comes at a time when, within the past 10 years, many farmers in the Third World have gone back to cultivating and conserving indigenous varieties in all forms of organic, sustainable agriculture, doubling and tripling their yields and improving their livelihood, health and nutrition. They have been reversing the environmentally and socially destructive trends of the so-called high yielding monocultures of the green revolution, which have brought financial ruin and suicides to thousands in India alone, and for the same reasons it is now happening in US and Europe. The liberalisation of trade and investment under the globalised economy of the World Trade Organisation has effectively allowed corporations to buy when and where it is cheapest and sell at inflated prices, and in addition, undercut farmers by getting the state to subsidise dumping of surpluses. Farmers are reduced to serfs in a feudal system run by corporations.

As a scientist, I have to say that reductionist western science has a lot to answer for. It has been working hand in glove with corporations to bring our planet to the edge of extinction in climate change and a string of ecological disasters. The reason people feel so passionately against genetic engineering biotechnology is because we know, intuitively and intellectually, that living organisms are our last resort, our last remaining hope for regenerating and saving the planet. I saw how organic farmers in India can regenerate land completely laid waste by agrochemicals and industrial chemicals and given up for good. And they did it in just two to three years. In Japan, Takeo Furuno introduced the 'one-bird revolution' ten years ago by releasing ducklings into paddy fields which are complex ecosystems of rice plants, nitrogen-fixing duckweed, roach, daphnia, plankton, and innumerable species of so-called weeds and pests including insects and the golden snail on which the ducklings thrive. I am hopeful that we can reverse the destruction, and convinced that nature's harvest is bountiful to all who, instead of engaging in perpetual warfare against nature, learn how to work in partnership with her.

The corporations stop at nothing to protect their patents and to profiteer. They have even threatened to release the ultimate terminator - harvested seeds that do not germinate - thus breaking the very cycle of life. The terminator corporations and their scientists are playing dangerous games with the natural resilience and fecundity of life which are also needed to reverse the destruction and to regenerate the earth.

The power for regeneration is in the seed. It is also in the will of each and everyone of us who cares, who, for the love of life and nature, works for a better, more equitable and compassionate world. The power for regeneration is especially in the farmer who understands how to work with holistic, organic nature. Organic farmers everywhere are poets. Charles McGuire in Ireland tells me, "When I walk into my fields, I can feel the earth singing to me." Sultan Ismail in India says, "The soil is a living organism. We have placental connections with the soil." and "Trees are poems that the earth writes in the sky, But we cut them down to fill our emptiness."

What I find most encouraging as a scientist is that after centuries of reductionist, mechanistic thought, contemporary western science is finally re-discovering and re-instating the same view of holistic, organic nature that many indigenous cultures in the world have never lost touch with.

Unfortunately, mainstream biology is left far behind. It has no appreciation of interconnected nature. It has no concept of an organism as a whole. It thinks it can improve on nature by arbitrarily manipulating and transferring genes, and does not realize it has created monsters. It is a Frankenstein science in exactly the way Mary Shelley's genius portrayed it. A cloned human embryo has even been created by transferring the human genetic material into a cow's egg. Thankfully, they've destroyed it at day 14, the current legal limit. The original Dr. Frankenstein, at least, did not do it for money, while the Frankenstein science we have now is driven and blinded by profit.

Genetic engineering is a new departure from conventional techniques and introduces new hazards. Eminent UK scientist Arpad Pusztai was recently victimised for calling attention to the research findings of his group, which suggest that the GM potatoes they were testing are toxic and that the toxicities are in the genetic engineering process. Pusztai's findings are not the first to indicate that the hazards may be *inherent* to the technology. A large literature already exists, much of it described in my book, *Genetic Engineering Dream or Nightmare*.[1] But the evidence has been ignored, or dismissed by the protagonists.

Many ecological and health impacts are well-known. GM crops have created herbicide-tolerant weeds and insecticide-resistant pests. The broad-spectrum herbicides used with the herbicide-tolerant GM crops not only decimate wild species indiscriminately, but are toxic to animals. Glufosinate causes birth defects in mammals, while glyphosate is now linked to non-Hodgkin's lymphoma. GM crops with bt-toxins kill beneficial insects such as bees and lacewings, and scientists in Cornell University have recently shown that pollen from bt-maize is lethal to monarch butterflies. You may not be aware, however, of the hazards inherent to the technology.

Genetic engineering introduces new genes and combinations of genes into crops whose ecological and health impacts have never been tested. Many of these genes are from viruses and bacteria that cause diseases, including antibiotic resistance genes that can compromise treatment for infectious diseases. Furthermore, the methods used to introduce foreign genes are uncontrollable. They give rise to random, unpredictable effects including new toxins and allergens.

Most dangerous of all, the foreign genes introduced can spread, not just by cross-pollinating related species, but to unrelated species by infection. This is called horizontal gene transfer, in which the genetic material itself is taken up. It has the potential to create new viruses and bacteria that cause diseases and spread antibiotic and drug resistance genes. The pioneers of genetic engineering called for a moratorium in the 1970s precisely because they were worried about this possibility. Unfortunately, commercial pressures cut the moratorium short. Since then, drug and antibiotic resistant infectious diseases have come back with a vengeance. New viruses appear at alarming frequencies, while dangerous bacteria are becoming resistant to all antibiotics and hence untreatable. What we now know that they didn't in the 1970s is that DNA itself is infectious, and can remain indefinitely long after the organisms have died. Genetically modified DNA can spread to organisms in all environments, including bacteria in the mouth, the gut and the respiratory tract of mammals. It can spread in pollen and dust.

Why is genetically modified DNA any more likely to spread than non-modified DNA? There are several reasons, the chief of which is that because genetically modified DNA has been designed to invade and jump into genomes, it may be more likely to jump again into other genomes. This involves an increased tendency of genetically modified DNA to break and join up with other DNA.

Indeed, foreign DNA jumping into the genomes of cells can itself give rise to many harmful effects including cancer. In its interim report published in May this year, the British Medical Association called for an indefinite moratorium on the release of GM crops pending further studies on new allergies, on the spread of antibiotic resistances and on the effects of genetically modified DNA. These concerns are shared by more than 100 scientists from 23 countries, including 37 from the US, who have signed a World Scientists' Statement calling for a 5 year global moratorium and a ban on patents of life-forms. It was launched this February in Cartegena, Columbia, during the United Nations Conference on the international Biosafety Protocol.[2]

The biotech industry is being driven by the erroneous, outmoded belief that genes are the most important, constant determinants of organisms, so that by manipulating and transferring genes, new life-forms could be created to satisfy all our needs, and that by eliminating or replacing

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[1]Ho, M.W. (1998, 1999). *Genetic Engineering Dream or Nightmare? Turning the Tide on the Brave New World of Bad Science and Big Business*, Gateway Books, Bath and Dublin.

[2]See Institute of Science in Society website <www.i-sis.dircon.co.uk>

bad genes, we can get rid of all diseases. Instead, scientific findings for the past twenty years are demonstrating that the genetic material is fluid and dynamic, and can itself change in response to the ecological environment. Indeed, genes and genomes need a stable, balanced ecosystem to remain stable. Sustainable, organic agriculture is predicated on such balanced ecosystems. The conditions for genetic health, similarly, are no different from those for physiological health: unpolluted environment; wholesome organic foods free from agrochemicals; clean and socially satisfying living conditions. Those are the *real* choices for civil society.

It is symbolic that we have gathered in Washington. We are once again fighting for independence, this time from the transnational feudal lords. When we win, and I am confident we will. It will be the triumph of democracy over feudalism, of reason over stupidity, of love and compassion over exploitation, of life over death. It will be the end of the brave new world of bad science and big business. It will be the triumph of sustainable, responsible science and industry working together for the good of all.

IFG Forum Seattle

(This talk was given at an International Forum for Globalisation Conference, Seattle, 27 November, 1999)

I joined the biotechnology debate in 1994 because my friends from the Third World Network inspired me with their selfless dedication to equity, justice, democracy, compassion, in short, all the human ideals that are severely under threat, especially from the biotech industry. These same ideals have brought us out here in droves today. The biotechnology debate has united the world, and all of society in resisting GM crops. It is not just the Europeans who are refusing to accept them, it is also India, Japan, Brazil, the whole of South Asia, the entire African Region, South Korea, Thailand, Australia, New Zealand. In fact, the more real knowledge people have, the greater their resistance. The debate has captured the imagination of the global civil society, and becoming part of the biggest, most inclusive civil rights movement against the corporate empire and the WTO. We've won the first round: Monsanto is to be split up and sold off, its ag biotech division declared worthless.

I am here on behalf of more than 140 scientists from 27 countries to deliver an open letter to all government delegates at the WTO, calling for the immediate suspension of all environmental releases of GM crops and products on grounds of threats to health and biodiversity and for patents on life-forms and living processes to be revoked and banned because they are deeply immoral.

Patents on life-forms and living processes are thefts from nature. They also expropriate the inventive genius and knowledge accumulated by indigenous communities and by previous generations of western scientists who have worked entirely for the public good. These patents threaten food security, violate basic human rights and dignity, compromise healthcare, impede medical and scientific research, and are against animal welfare.

There is a lot of misinformation and dis-information put out by the biotech industry and our governments. Contrary to what they would like the public to believe, GM crops are neither needed nor beneficial. They are a dangerous diversion from the real task of providing food and health around the world. To put it bluntly: the existing technologies are crude, unreliable, uncontrollable and unpredictable, they don't qualify as technologies, let alone patentable inventions. And they are inherently hazardous. Moreover, these technologies are misguided by a scientific paradigm which is fundamentally flawed, out of date and in conflict with scientific findings. They call that sound science. But it is the ultimate phoney science.

The promises to genetic engineer crops to fix nitrogen, resist drought, improve yield and to 'feed the world' have been around for at least 30 years. Such promises have built up a multibillion-dollar industry now controlled by a mere handful of corporate giants.

But the miracle crops have not materialised. So far, two simple characteristics account for all the GM crops in the world. More than 70% are tolerant to broad-spectrum herbicides, with companies engineering plants to be tolerant to their own brand of herbicide, while the rest are engineered with bt-toxins from a soil bacterium to kill insect pests. A total of 65 million acres were planted in 1998 within the US, Argentina and Canada. The latest surveys on GM crops in the US, the largest grower by far, showed no significant benefit. On the contrary, the most widely grown GM crops - herbicide-tolerant soya beans - yielded on average 6.7% *less* and required two to five times *more* herbicides than non-GM varieties.

The same GM crops have already given rise to herbicide-tolerant weeds and bt-resistant insect pests. Worse still, the broad-spectrum herbicides not only decimate wild species indiscriminately, but are toxic to animals. One of them, glufosinate, causes birth defects in mammals, while another, glyphosate, is now linked to non-Hodgkin's lymphoma. GM crops with bt-

toxins kill beneficial insects such as bees and lacewings, and pollen from bt-maize is lethal to monarch butterflies.

According to the UN food programme, there is enough food to feed the world one and a half times over. World cereal yields have consistently outstripped population growth since 1980, but one billion are hungry. It is on account of corporate monopolies operating under the globalised economy that the poor are getting poorer and hungrier. Corporations already control 75% of the world trade in cereals. The new patents on seeds will intensify corporate monopoly by preventing farmers from saving and replanting seeds, which is what 80% of the farmers still do in the Third World. Christian Aid, a major charity working with the Third World, concludes that GM crops will cause unemployment, exacerbate Third World debt, threaten sustainable farming systems and damage the environment. It predicts famine for the poorest countries.

It is clear that GM crops offer no benefits and cannot feed the world. There are also enormous risks. You know the children's joke of what do you get when you cross impossible things like a spider with a goat? Part of the joke is knowing you can't because there are biological barriers between species which only allow one to cross closely related species such as horse and donkey, for example. Genetic engineering bypasses all these barriers, so that is not a joke anymore. Genes are being transferred in the laboratory between any and every species. Indeed, spider genes have been transferred into goats in an attempt to make the poor female goats produce silk in their milk, and human genes have been transferred into cows, sheep, mice, fish and bacteria.

The most immediate dangers are random and unpredictable, basically because the genetic engineer cannot control where and how the foreign genes are integrated into the genetic material of the host. Genetic engineering animals are acts of cruelty, there are high failure rates and even the so-called successes are often monstrously deformed. Genetic engineered plants may end up having new toxins and allergens. Dr. Arpad Pusztai, an eminent scientist in the Rowett Institute of Scotland, lost his job when he released findings showing that two GM potato lines were unexpectedly toxic to rats.

A more insidious danger is horizontal gene transfer - the transfer of genetic material directly to unrelated species. In genetic engineering, many viral and bacterial genes are being combined in new combinations that have never existed before, and introduced into organisms by invasive methods that make the foreign genes (or transgenic DNA) more likely to transfer again to unrelated species. Such horizontal gene transfer can give rise to new viruses and bacteria that cause diseases and spread antibiotic and drug resistances among the pathogens.

It was because of these concerns that the pioneers of genetic engineering called for a moratorium in the '70s. Unfortunately, commercial pressures cut the moratorium short. Since then, drug and antibiotic resistant infectious diseases have returned with a vengeance. New viruses are appearing at alarming frequencies, while life-threatening bacteria are rapidly becoming resistant to all antibiotics and are hence untreatable.

Another hazard is that the transgenic DNA can jump into the genomes of cells, resulting in harmful effects including cancer. In its interim report (May 1999), the British Medical Association called for an indefinite moratorium on the release of GM crops pending further studies on new allergies, on the spread of antibiotic resistances and on the effects of transgenic DNA.

These hazards are acknowledged by sources within our Governments. UK scientists advising the Ministry of Agriculture Fisheries and Food are warning of horizontal transfer of genetically modified DNA.

These same scientists are pointing out that genetically modified DNA can spread from GM plants, not only to soil bacteria, but by dust and pollen to bacteria in our mouth, our gut and respiratory tracts. They point out that transgenic DNA may even spread to our cells. They advised against using GM crops as animal feed because DNA is not readily broken down during processing, nor in the silage.

Unless it changes direction, the whole biotechnology enterprise has little chance of success, not the least among the reasons being that the scientific paradigm promoting and misguiding the technology has been thoroughly discredited at least 15 years before. Genetic has changed out of all recognition, and yet the old paradigm is still dominating the scene. The old paradigm offers a simplistic view that the characteristics or traits of organisms are each tied to specific genes, which are unaffected by one another or by the environment. And that, except for very rare random mutations, the genes are passed on unchanged to the next generation.

Instead, scientific findings within the past 20 years reveal an immense amount of cross-talk between genes. Genes are nothing if not sensitive, dynamic and responsive, to other genes, to the cell or organism in which they find themselves and to the external environment. The layer upon layer of feedback between genes and environment, not only determine whether genes are active or

not, but what function and structure they have. Genes can mutate, multiply, rearrange and jump around in response to the environment. They may even jump out of the genome of one organism to infect another one. Geneticists have coined the phrase "the fluid genome" to describe the situation. It is more accurate to see the genes as having a very complicated ecology, and that for genes and genomes to remain constant, you need a balanced ecology. So the new genetics is radically ecological and holistic.

I referred to genetic engineering biotechnology as a hoax back in 1994. This hoax is perpetrated by an unholy alliance between corporate capitalism and the discredited scientific paradigm. Together, they mean to control every aspect of our lives, from the food we eat, to the healthcare we can receive or not, to the babies we can conceive and give birth to, and humans beings we can clone. Yes, the first so-called human clone has already been created by transferring the genetic material of a human being to a cow's egg. Mercifully, they destroyed it at day 14, the current legal limit, before the real Frankenstein monster takes shape. And all done in the name of scientific progress and free enterprise.

Fortunately, the game is up, the bubble has burst. The tidal wave of protest is sweeping across the world and has hit the United States. Your national coalition of family farming groups have taken the lead in demanding a moratorium on GM crops and a ban on patents of life-forms and processes. Support your family farmers. When the farmer dies, so dies America.

While the 'benefits' from GM crops remain illusory and hypothetical, the successes of sustainable, organic farming are well-documented, in the Third World, in Latin America, in Europe and North America. There is also an enormous 'health bonus' in phasing out agrochemicals which are linked to many forms of cancer, to reproductive abnormalities and degenerative diseases. An organic revolution in farming is underway all over the world.

What excites me most as a scientist is that there is also an organic revolution going on in western science, which restores and reaffirms the holistic, ecological perspectives that many traditional indigenous cultures have never lost touch with. This organic revolution in western science will put an end to the dominant culture that treats organisms as machines and life and life-necessities as commodities, that glorifies competition and sanctions exploition in the name of the struggle for survival of the fittest. Instead, we begin to appreciate the universal entanglement of all nature, which will transform the very meaning and texture of our lives. The future looks great. Let's go for it.

Reclaiming the Good Food Agenda
Seattle

Consumer Choice Council Conference on Genetic Engineering, 1 December, 1999

Thank you very much for inviting me here and thank you all for being here. I am very honored, especially to be in a session moderated by Senator Dennis Kucinich who has introduced such an important bill for labeling genetic engineered foods to the US Congress. I am a senior academic in the Open University in UK, a geneticist and a biophysicist, also advisor to the TWN and other public interest organizations on biotechnology and biosafety since 1994. I have debated biotech issues in more than 20 countries and written a book*, Genetic Engineering Dream or Nightmare? The Brave New World of Bad Science and Big Business.*

I am here on behalf of more than 140 scientists from 27 countries to deliver an open letter to all government delegates at the WTO, calling for a moratorium on genetic engineered crops and products because they are dangerous, and for patents on life-forms and living processes to be revoked and banned because they are deeply immoral. As you have already heard, they give unaccountable corporations a monopoly on life and our life-support system.

There is a lot of misinformation and dis-information put out by the biotech industry and their suppporters including our governments. Only yesterday, US Senator Kit Bond gave a press conference in which four scientists, all biotechnologists and friendly to the industry, told reporters how,

- We absolutely need genetic engineered crops to feed the world. (You have just heard that myth soundly exploded by David Bryer of Oxfam.)
- The miracle crops are just around the corner. (We have been promised miracle crops that fix nitrogen, resist drought, tolerate salt, increase yield and so on for at least 30 years. They have not materialized. It has been a series of broken promises.)
- There is no difference between genetic engineering crops and conventional breeding, except it is much more precise. (That is not true, and I shall deal with that in detail.)

- Genetic engineered crops offer no new risks. (Again I shall deal with that in detail.)
- No one has died yet from eating genetic engineered foods. (Well, there has been no segregation, no labelling and no one has been looking!)
- Genetic engineered food is the most tightly regulated and scrutinized for safety than any other food. (I'll deal with that later too.)

Let me add that engineering crops to enhance nutrition ignores the root cause of malnutrition, which is the industrial monoculture crops that have led to a deterioration of the nutritional value of food within the past 50 years, and the destruction of natural and agricultural biodiversity on which a healthy balanced diet depends. We don't need vitamin A enhanced rice when we can eat carrots with our rice.

The latest surveys on genetic engineered crops in the US, the largest grower by far, showed no significant benefit. On the contrary, the most widely grown genetic engineered crops - herbicide-tolerant soya beans - yielded on average 6.7% *less* and required two to five times *more* herbicides than non-genetic engineered varieties.

Genetic engineering agriculture is a dangerous diversion and obstruction to the real tasks of providing food and health around the world. To put it bluntly: the existing technologies are crude, unreliable, uncontrollable and unpredictable, they don't qualify as technologies, let alone patentable inventions. And they are inherently hazardous. More so because are misguided by a scientific paradigm that is fundamentally flawed, out of date and in conflict with scientific findings. They call that sound science. It is really the ultimate phony science.

The was the ruling paradigm before genetic engineering really got underway 20 years ago. It offers a simplistic, reductionist view that ignores interconnections and complexity of real processes. That has no concept of the organism as a whole, nor of societies or ecosystems. Only individuals as isolated atoms each competing against all the rest. The organism is seen as a collection of traits each tied to specific genes which do not, by and large, interact with one another, nor with the environment, and these genes are passed on unchanged to the next generation except for very rare random mutations. If this were true then, genetic engineering would be as precise and effective as is claimed.

Unfortunately, scientific findings within the past 20 years reveal an immense amount of cross-talk between genes which function in complex networks. Genes are nothing if not sensitive, dynamic and responsive, to other genes, to the cell or organism in which they find themselves and to the external environment. They can mutate, multiply, rearrange and jump around in responding. Genes may even jump out of one organism to infect another one. This is called 'horizontal gene transfer', the transfer of genetic material directly to unrelated species, to distinguish it from the vertical gene transfer from parent to offspring which happens in normal reproduction. (Horizontal gene transfer across species barriers is the process exploited by geneticists in genetic engineering.) The genetic material is so flexible and dynamic that geneticists have coined the phrase "the fluid genome" to describe the situation.

Genetics has changed out of all recognition. It is more accurate to see the genes as having a very complicated ecology, and that for genes and genomes to remain constant, you need a balanced ecology. So the new genetics is radically ecological and holistic.

Now, what is genetic engineering? You know the children's joke of what do you get when you cross impossible things like a spider with a goat? Part of the joke is knowing you can't because there are biological barriers between species which only allows one to cross closely related species, such as horse and donkey. There are good reasons for keeping species distinct, they have to do with the balance of the ecosystem. When viruses cross species barriers, for example, we have outbreaks of infectious diseases. Genetic engineering bypasses all species barriers, and it is not a joke anymore. Genes are being transferred in the laboratory between any and every species many of which would never interbreed in nature. Indeed, spider genes have been transferred into goats in an attempt to make the poor female goats produce silk in their milk, and human genes have been transferred into cows, sheep, mice, fish and bacteria.

The most immediate dangers are random and unpredictable, basically because the genetic engineer cannot control where and how the foreign genes are integrated into the genetic material of the organism. Genetic engineering animals are acts of cruelty, there are high failure rates and even the so-called successes are often monstrously deformed. Genetic engineered plants may end up having new toxins and allergens. Dr. Arpad Pusztai, an eminent scientist in the Rowett Institute of Scotland, lost his job when he released findings showing that two GM potato lines were unexpectedly toxic to young rats.

A more insidious danger is horizontal gene transfer. The genetic material, the DNA, can survive indefinitely in all environments after the organisms are dead. It can be taken up by other

organisms and become incorporated into their genetic material. This has the potential to create new viruses and bacteria that cause diseases. Why?

In genetic engineering, new genes, many from viruses and bacteria, including antibiotic resistance genes that make infectious diseases untreatable, are introduced into our crops and livestock. They are combined in new combinations that have never existed, and introduced into organisms by invasive methods that make the foreign genes (or transgenic DNA) more unstable and more prone to transfer horizontally than the organism's own genes which have been adapted to stay together for hundreds of millions of years.

Another danger is that the transgenic DNA can jump into the genetic material of our cells and cause damages including cancer.

In its interim report (May 1999), the British Medical Association called for an indefinite moratorium on the release of GM crops pending further studies on new allergies, on the spread of antibiotic resistances and on the effects of transgenic DNA.

These hazards are acknowledged by sources within our Governments. UK scientists advising the Ministry of Agriculture Fisheries and Food are now calling attention to the same dangers.

Our regulatory system is still based on the old reductionist paradigm.

1. They are in denial on the evidence accumulated over the past ten years that DNA suvives in the environment and can be taken up by all cells. The UK Health and Safety Executive regards DNA as a chemical, and as it is in all organisms, it is not considered a hazardous chemical and therefore not subject to regulation. One of the scientists in Kit Bond's press conference yesterday even referred to genetic engineered crops as the ultimate organic crops, because it involves manipulating "the totally organic substance DNA".

- The reductionist paradigm of regulation means that insufficient attention is paid to unintended, unexpected effects.
- Because they assume there is no difference between genetic engineered crops and those obtained from traditional breeding, regulation is largely based on no need to look, so don't look, and you don't see anything.
- The principle of substantial equivalence on which risk assessment is based is a farce. Anything passed as substantially equivalent is supposed to be safe. But the genetic engineered variety can be compared with any and every variety within the species, it can even be compared to a collection of unrelated species. It is like saying that someone who does theoretic physics like Einstein and plays baseball like Mark Macguire is substantially equivalent to another who plays baseball like Einstein and does theoretic physics like Mark Macguire.

There is a science war on. It is between a reductionist, mechanistic science and an emerging holistic, organic science which is reaffirming and restoring the deep ecological perspectives of indigenous sciences around the world. Contrary to reductionist western science, these indigenous sciences have enabled people to live sustainably with nature for tens of thousands of years, but they are being destroyed and marginalized.

Intensive mechanised agriculture has taken the soul out of farming. It has turned farmers into tractor-drivers. Food is more than just the combination of proteins, carbohydrates and fats, or vitamins and other micronutrients. It is an emotional, aesthetic experience.

To really do us good, we have to know that our food is produced, not just without agrochemicals, but also without exploiting our fellow human beings, without cruelty to animals and without destroying the earth. Most of all, we want to know that it is produced with love and creativity of farmers who are poets and artists at heart, who know how to work with nature to make both human beings and nature prosper. That is the real agenda for civil society.

Gene Biotechnology Undermines Food Security and Healthcare and is Inherently Hazardous

Dolly and the Bean, Lulea, Sweden, 19-21, December 1999.

Reductionist Science

I am speaking as a scientist extremely concerned with the extent to which science has evolved more and more away from its Promethean ideal of knowledge for the good of humanity, to being the partner of corporate capitalism which has been responsible for some of the most socially and environmentally destructive policies in the world.

Genetic engineering biotechnology is the latest offering from the alliance between reductionist science and big corporate business which has brought our planet to the edge of extinction in climate change, ozone depletion, massive loss of species and intolerable levels of

toxic and radioactive pollution. After having extracted and ruined all of the planet's resources, the alliance is targeting life itself, which is our last remaining hope for regenerating and saving the planet.

Mary Shelley has predicted the present scenario of human cloning and genetic manipulations in her classic novel, *Frankenstein*, which is about the scientist obsessed with science as a means to control and improve on nature. He created a monster, thinking he could create the perfect human being. Can we afford to let this Frankenstein science take over the world for the sake of profit? What's at stake is life, our life-support and our value system as human beings, which are all being placed under unaccountable corporate monopoly.

The alliance is bolstered by mainstream academic theories stemming from the same roots in Victorian England: neo-liberal economic theory supporting *laissez-faire* corporate capitalism, and neo-Darwinian genetic determinism driving the technology and selling it to the public. Together, they project a travesty of organic reality in terms of isolated atoms jostling and competing in the struggle for survival of the fittest. But nature does not conform to our illusion that things are separate, and on how the world should be run. She is organically interconnected and finite, and the effects of decades of wanton destruction and exploitation not only spread far and wide, but are rebounding back on us.

Both theories have failed the reality test in the world, which is why the global ecology and economy are collapsing together. Genetic determinism – the idea that genes determine the characteristics of organisms in linear causal chains - has also failed the reality test within science. It has been thoroughly discredited by scientific findings at least 15 years ago. Yet, mainstream biology remains firmly wedded to the discredited paradigm, just as our policy-makers are held to ransom by corporate capitalism.

Environmental protection, food safety and even basic human rights will be sacrificed to corporate trade and financial imperatives in the treaties of the WTO and MAI, while the discredited science continues to misguide a hit or miss technology that has the potential to destroy all life on earth [1].

Genetic Networking

For a quick summary of genetic determinism, I have taken the following description from a booklet produced by the Food and Drink Association and endorsed by Government scientists:

"Research scientists can now precisely identify the individual gene that governs a desired trait, extract it, copy it and insert the copy into another organism. That organism (and its offspring) will then have the desired trait...".

This description, typical of literature supposedly "promoting public understanding", neatly encapsulates the bad science of genetic determinism. It gives the highly misleading impression of a precise technology, implying that,

- Genes determine characters in linear causal chains, one gene giving rise to one character;
- Genes are not subject to influence from the environment;
- Genes remain stable and constant;
- Genes remain in organisms and stay where they are put.

So, by manipulating genes, all the problems of the world can be solved, as simple as that!

What is the new genetics of the present day really like?

No gene ever works in isolation, but in an extremely complicated genetic network, the function of each gene depends ultimately on all other genes in the genome. So, the same gene will not have the same effects in different individuals, because the other genes are different. There is so much genetic diversity within the human population that each individual is genetically unique (except for identical genes at the beginning of their development). And if the gene is transferred to the genome of a different species by genetic engineering, it is most likely to have new and unpredictable effects.

The genetic network, in turn, is subject to layers of feedback regulation from the physiology of the organism and its relationship to the external environment. So, if the environment changes, a gene may cease to work. These layers of feedback regulation not only change the function of genes but can rearrange them, multiply copies of them, mutate them to order, or make them move around. Some of the mutations that occur in response to certain environments are so repeatable that they are referred to as "directed mutations". And genes can travel outside the original organism to infect another. This is called horizontal gene transfer, the very process exploited for genetic engineering.

Those findings have completely invalidated genetic determinism. *Yet the orthodox mainstream remains firmly wedded to the discredited paradigm.* The new genetics is diametrically

opposite to the old static, reductionist view. Genes and genomes can change so much that molecular geneticists themselves have invented the descriptive term “the fluid genome”, more than ten years ago. It is more accurate, however, to see the genes as having a very complicated ecology consisting of the interconnected levels of the genome, the physiology of the organism and its external environment. Putting a new gene into an organism will create disturbance that may propagate out to the external environment. Conversely, changes in the environment will be transmitted inwards and may well alter the genes themselves. The most important lesson is that the stability of genes and genomes, as much as all the other characteristics of the organisms, depends on a balanced ecology. Genetic engineering profoundly disturbs the ecology of genes at all levels, and that is where the problems and dangers arise.

We are told that genetic engineering is just like conventional breeding, only faster, cleaner and more precise. Not true. Genetic engineering biotechnology is a new departure, and introduces new dangers. It bypasses reproduction by using artificial virus-like vectors to transfer genes horizontally, often between species that would never interbreed in nature.

Vectors

New genes and new combinations of genes are engineered into our food, from bacteria, viruses and non-food species, which have already been shown to be harmful to pollinators and other beneficial insects. Interactions of foreign genes with host genes give many unintended effects including toxins and allergens.

The technology is hit or miss and is not at all clean and precise. The random insertion of foreign genes into the genome gives rise to random genetic effects, including cancer in mammalian cells. Large failure rates are typical in transgenic animals and many abnormalities are found even among the successes. For the same reasons, transgenic lines are often unstable, do not breed true, and do not perform consistently [2].

Most dangerous of all, the artificial vectors used to transfer genes are made by recombining the most infectious viruses and other genetic parasites and may contribute to creating new viral and bacterial pathogens. That was why the pioneers of genetic engineering called for a moratorium in the 1970s. But commercial pressures cut it short. They set up guidelines based largely on assumptions, every one of which has been invalidated by scientific findings. Since then, drug and antibiotic resistant infectious diseases have come back with a vengeance, raising serious questions over the safety of genetic engineering biotechnology under current regulatory regimes [3]. Strains of at least four dangerous bacteria including the one causing tuberculosis are already resistant to all antibiotics and hence untreatable. There is now overwhelming evidence that horizontal gene transfer is responsible for spreading antibiotic resistance and creating new viral and bacterial pathogens.

Other scientific findings suggest that

Transgenes and antibiotic resistance genes may spread horizontally from transgenic plants to soil bacteria and fungi, and to gut bacteria.

Transgenic DNA may be 30 times more likely to escape than the plant’s own DNA.

Viral genes in transgenic plants may recombine with other viruses to generate new, superinfectious viruses.

Viral DNA, which is in practically all transgenic organisms, resist digestion in the gut of mice, pass into the bloodstream and then into a variety of cells to integrate into the cells’ genome. When viral DNA was fed to pregnant mice, the DNA was found in the cells of the foetus.

Genetic Engineering Agriculture

Genetic engineering agriculture is an extremely dangerous diversion. Far from feeding the world, it intensifies corporate control on food, which created poverty and hunger in the first place. It obstructs implementation of sustainable agriculture and erodes agricultural biodiversity, which are widely recognised to be precisely what we need to guarantee long term food security.

Farming communities in the Third World have been actively regenerating and revitalising degraded agricultural land with many forms of sustainable, organic agriculture, and recovering agricultural biodiversity. In 20 Third World countries, more than 2 million families are farming sustainably on 4-5 million hectares, with tripled or doubled yields, fully matching if not surpassing intensive agrochemical agriculture. And this has happened only within the past 5-10 years.

Healthcare

Genetic engineering biotechnology also grossly undermines and distorts healthcare. It diverts attention from the overwhelming causes of ill health, which are environmental, and blaming the

victims. The same chemical and drug industries that have been major polluters of the environment, that have been causing increasing damages to all the organ systems of our body including our genes, are now set to reap enormous profits from those made ill. If the present trend continues, our healthcare system will collapse. It will be replaced by a health-market, serving the rich, if at all, at the expense of the poor.

Genuine genetic diseases that can be traced to single genes are less than two percent of all diseases; while at least one percent of those are *new* mutations, most likely caused by environmental mutagens. In some conditions like muscular dystrophy, fully one-third are new mutations. The main focus of so-called "preventative" medicine is to identify “predisposing” genes for diseases such as cancers that are strongly linked to occupational and environmental carcinogens. Pre-implantation diagnosis is being done for gene “predisposing” embryos to cancers they might suffer as adults, so they can be eliminated. We have gone down the slippery slope of genetic discrimination and eugenics.

Despite the lavish promises of gene therapy, there has not been a single success in more than 20 years. Yet, it is still being aggressively pursued with dangerous vector techniques that can cause cancer and create new viruses [4].

Another promise - personalised medicine based on our genetic makeup - is a pipe dream. We have an estimated 100 000 genes with hundreds of possible variants in each gene. Each person is genetically unique, except for identical twins at the beginning of their life. The function of each gene depends on the background of all the other genes with which it interacts. That is why even single gene diseases are turning out to be far more complicated. It is impossible to give an accurate prognosis based on knowledge of single genes. Furthermore, up to 95 per cent of our genome is called “junk DNA” because no one yet knows what its functions are.

Since the 1980s, healthcare systems all over the world have been seriously undermined by “free-market” imperatives. So-called “structural adjustment programmes”, supported by the World Bank, have forced Third World Governments to impose charges on health care for the poor, to cut public spending by reducing services and to promote private health businesses. As a result, undernutrition and infant mortality rates have been increasing in many Third World countries, reversing a long-term trend; and infectious diseases have re-emerged with a vengeance in immunologically compromised populations. It is extremely dubious whether genetic engineering biotechnology can improve the health of anyone, least of all, the poor. It may, instead, be contributing to the resurgence of infectious diseases.

Summary

Scientific findings accumulated over the past twenty years have invalidated every assumption of genetic determinism. The new genetics is compelling us to an ecological, holistic perspective. Our destiny does not lie in the genes. The genes are not constant and unchanging as previously supposed. Instead, they respond to the physiology of the organism by altering their function as well as structure. *Genes and genomes require a stable, balanced ecology to maintain stability*. Organic agriculture is predicated on such a balanced ecology, which depends on a diverse community of healthy organisms free from agrochemicals.

Similarly, the key to genetic health is precisely the same as physiological health: unpolluted environment, wholesome organic foods free from agrochemicals and sanitary, aesthetically and socially satisfying living conditions.

Our priorities are in curbing toxic and radioactive discharges as well as releases of genetically engineered organisms. Agrochemicals should be phased out and organic agriculture widely introduced. These are the real choices for civil society. We must turn the tide on bad science and big business, and opt for a life sustaining science and industry working for the good of humanity and our planet [5].

1. Ho, M.W., Meyer, H. and Cummins, J. (1998). The biotechnology bubble. *The Ecologist* 28(3), 146-153, and references therein; also Ho, M.W. and Steinbrecher, R. (1998). *Fatal Flaws in Food Safety Assessment: Critique of The Joint FAO/WHO Biotechnology and Food Safety Report*, *Environmental and Nutritional Interactions* 2, 51-84.

3. See Ho, M.W., Traavik, T., Olsvik, R., Tappeser, B., Howard, V., von Weizsacker, C. and McGavin, G. (1998). Gene Technology and Gene Ecology of Infectious Diseases. *Microbial Ecology in Health and Disease* 10, 33-59.

4. There is now (April, 2000) a moratorium on gene therapy after a healthy teenage volunteer died in a clinical trial. An enquiry, still going on, has revealed five other deaths and at least 650 other adverse events. See Ho, M.W., Ryan, A., Cummins, J. and Traavik, T. (2000). Unregulated Hazards, ‘Naked’ and ‘Free’ Nucleic Acids, ISIS and TWN Report, London and Penang, circulated

at the Biosafety Protocol Meeting, Montreal, Jan. 2000, available on Institute of Science in Society website <www.i-sis.org.uk>

5. As this paper goes to press, more than 300 scientists from 36 countries around the world have signed an open letter to all governments calling for a moratorium on genetic engineered crops and products, a ban on patents of life-forms and living processes as well as a public enquiry into the future of agriculture and food security for all. See Institute of Science in Society website: <www.i-sis.org.uk>

Reclaiming the Good Life

(This talk was given in Taunton, Wales, August 4, 2000)

It is great to see all of you here in my home country. It's people like you who have inspired the waves of resistance around the world and making my life hell. I have debated in 23 countries in the past three years, and I shall be visiting 10 before this year is over, six of them for the first time. Everywhere, farmers are rejecting GM crops because it tightens the noose of corporate monopoly around their necks in patented seeds that they are not allowed to resow. Consumers don't want them because they are worried about safety. The GM debate has united the world as never before and we are winning.

Gene giant Novartis has just announced they won't be selling GM produce in their own brand anywhere in the world.

We are turning the tide on the brave new world of bad science and big business to reclaim the good life in the full sense of the word.

As a scientist, I am acutely aware that one main obstacle standing in our way is that our universities and the scientific establishment have been bought by the corporations. We can't leave decisions on science and technology to the experts anymore, nor to the Government which is altogether too industry-friendly. This is a very dangerous situation, especially as technologies are becoming increasingly powerful and uncontrollable.

Society as a whole must regain control. In order to do so, everyone has to understand the science and technology. I am here to do my duty, to expose some of the myths perpetrated by corporate scientists who claim to be promoting public understanding of science.

First of all, what is genetic engineering? If you are old enough, you will remember the children's joke of what do you get when you cross impossible things, such as a spider with a goat. Well, you might get a spigot. But it ceases to be a joke anymore, because genetic engineers have done just that. They have put spider silk genes into goats to make the poor female goat produce spider silk in her milk. Animals are being exploited as bio-reactors for drugs and industrial material in their milk, blood, urine and semen. Pigs are being modified to produce spare body parts for sale. And it has even been suggested that human embryos might be created to provide spare organs and tissues.

Genetic engineering is not just about whether we should have GM crops. It is a whole way of life, a brave new world dominated by mechanistic science in the service of corporations that transgresses all limits of decency in the pursuit of profit. The good news is that the mechanistic approach has already been thoroughly discredited in the world at large as well as within science itself. The bad news is that this discredited approach is still dominating the mainstream in politics as well as in science. It is driving and promoting genetic engineering, a hit or miss technology that has the potential to destroy all life on earth.

Genes are the units of heredity. They are arranged in linear sequences in long chemical strings called DNA that are present in every cell of the body, and are passed through the germ cells, to the next generation. The DNA strings are organized and wound up into structures called chromosomes, which often exist in pairs, one of each pair coming from either parent. Thus, human beings have 23 pairs of chromosomes. The totality of all the genetic material in an organism or cell is known as the genome. Genes are in part responsible for the resemblance between parent and offspring.

Genetic engineering is a set of laboratory techniques for cutting, joining, modifying and multiplying the genetic material, for creating new genes and new combinations of genes and most of all for transferring genetic material between species that would never interbreed in nature.

They tell you it is a precise technique, and that only one or a few genes are transferred, therefore it is much safer as well as quicker. All of that is far from the case.

First of all, there is no limit to the new genes and new combinations of genes that can be created, which have never existed in billions of years of evolution. These are transferred into genomes that they have never been in before. You never transfer just one gene into the cells. You

transfer an artificial unit called a gene expression cassette, where the gene is accompanied by a signal for starting and another one for stopping, a promoter and a terminator, and these 3 bits are often from different sources. Several different cassettes are often stacked, or linked in series, and one of them will be a gene coding for antibiotic resistance, which will enable the cells that have taken up the foreign gene constructs to be selected with antibiotics. The stacked constructs are in turn spliced into an artificial gene carrier or vector, which smuggle the genes into the cells and jump into the cell's genome.

Unfortunately, the genetic engineer cannot control where, and in what form the foreign genes end up in the genome. This creates monstrous abnormalities in animals, even among the so-called successes. It will not be surprising therefore, that you end up with unexpected toxins and allergens in case of plants.

In addition, these foreign gene constructs are unstable. They often end up in a scrambled form when they are integrated into the genome, and in later generations, they may be scrambled some more, become silenced and may also be eliminated. The best kept secret in the industry is that there is no evidence documenting the stability of any GM line out there. Monsanto has recently found extra gene fragments in the GM soya that they did not know were there.

Now, having new genes and new combinations of genes in our crops is bad enough. These could spread by pollination with unknown, unpredictable consequences. But genes can also spread to unrelated species by the genetic material itself being taken up. I remind you of the recent report from Germany that GM genes in GM pollen have transferred to the bacteria and yeasts in the gut of baby bees.

This kind of horizontal gene transfer involves the direct uptake of foreign genetic material. It has been found to happen also in the field. After GM sugar beet was harvested, the GM genetic material persisted in the soil for at least two years and was taken up by soil bacteria.

Not only microorganisms, but animal cells, including human cells can readily take up the GM constructs and the foreign genes often end up in the cell's own genome.

Not so long ago, the pro-biotech scientists were insisting horizontal gene transfer couldn't happen. Now, they are saying it happens all the time, so no need to worry.

So the crucial question is whether GM genetic material is like ordinary genetic material. The answer is no. There is a world of difference between GM genetic material and natural genetic material

Natural genetic material in non-GM food is broken down to provide energy and building-blocks for growth and repair. And in the rare event that the foreign genetic material gets into a cell's genome, other mechanisms can still put the foreign genes out of action or eliminate it. These are all part of the biological barrier that keeps species distinct, so gene exchange across species is held in check. And that has been so for billions of years of evolution.

GM-constructs, however, are designed to invade genomes and to overcome natural species barriers. Because of their highly mixed origins, GM constructs tend to be unstable as well as invasive, and may therefore be more likely to spread by horizontal gene transfer.

Also, GM constructs are generally made from genetic material of dangerous bacteria, viruses and other genetic parasites from widely different origins, include antibiotic resistance genes that make bacterial infections very difficult to treat. Typically an aggressive promoter from a virus is used to make the gene over-express continuously – something which never happens in healthy organisms.

One virus promoter in practically all GM crops out there is from the cauliflower mosaic virus, CaMV for short. This CaMV promoter has a recombination hotspot – a site where it is prone to break and join up with other genetic material. It is promiscuous in function. Plant genetic engineers thought it works in all plants and plant-like species, but not in animals. Several weeks ago, we discovered in the scientific literature more than 10 years old that this same CaMV promoter works extremely well also in frog eggs and extracts of human cells. It is already known to be able to substitute for promoters of other viruses to give infectious viruses.

What will happen when these dangerous GM constructs spread? GM constructs are made from genetic material of viruses and bacteria and are designed to cross species barriers and to invade genomes. In the process, there's the obvious potential that they may recombine with viruses and bacteria to create new strains that cause diseases. The antibiotic resistance genes may also spread to bacteria associated with serious diseases such as meningitis and tuberculosis. GM constructs that invade genomes may recombine with, and wake up dormant viruses that have now been found in all genomes.

GM crops are turning out to be useless as well as unsafe. The bacterial bt-toxins, engineered into many crops, are poisonous for beneficial and endangered species such as

lacewings, the Monarch butterfly as well as the black swallowtail. Bt crops encourage new resistant pests to evolve. Stink Bugs in North Carolina and Georgia are eating up the bt-cotton crops and have to sprayed with deadly pesticides. A study in the University of Nebraska shows that GM Roundup Ready soya yielded 6-11% less than non-GM soya, confirming an earlier Univ. of Wisconsin study which also found that the GM soya required 2 to 5 times more herbicides.

The way to fight world hunger is definitely not GM crops. World population figures have been wildly exaggerated. The figure of 10 billion has been bandied about. In fact, figures have had to be revised downwards several times in the late 1990s. By mid-1998, the UN's estimate was that world population will peak at 7.7 billion in 2040, then go into long term decline to 3.6 billion by 2150, less than two-third of today's number.

Population arguments are based on the ecological concept of carrying capacity. But ecologists are increasingly finding that the more biodiverse the ecosystem, the greater the carrying capacity, and hence the more people and wild-life it can support. Biodiverse systems are also more stable and resilient. The same principles have guided traditional indigenous farming systems, and are now being re-applied in holistic approaches that integrate indigenous and western scientific knowledge. Some 12.5 million hectares around the world are already farmed in this way. The yields have doubled and tripled and are still increasing, at the same time reversing some of the worst environmental, social and health impacts of the green revolution.

World market for GM crops has collapsed because people all over the world are rejecting them and opting for organic sustainable agriculture. An organic revolution is rising from the grass-roots and also sweeping across the disciplines within western science. From quantum physics to the ecology of complexity and the new genetics, the message is the same: nature is dynamic, interconnected and interdependent. Proponents of GM technology are stuck in the mechanistic era, it is that above all that makes the technology both futile and dangerous. It is just not innovative enough!

GM crops are not safe, not needed and fundamentally unsound. Far from helping to fight world hunger, they are standing in the way of the necessary global shift to sustainable organic agriculture that can really provide food security and health

Can biotechnology help fight world hunger?

Special Forum organized by Congressman Tony Hall, Capitol Hill, Washington DC, 29 June 2000

1. It's a great honor to be invited to speak here. I'm a scientist who loves science and believes science and technology *can* help build a better world and combat world hunger. But it must be the right kind of science and technology, and it must be decided by people themselves. There is no alternative to the democratic process of seriously informing and empowering people. And I congratulate Congressman Tony Hall for putting on this special forum.
2. I am among the 327 scientists from 38 countries who have signed an Open Letter to all Governments demanding a moratorium on GM crops because we have reasons to believe they are not safe (1). We are also calling for support of sustainable agricultural methods that are already working successfully around the world. There is genuine disagreement within the scientific community. The public are not served by portraying the debate as science versus anti-science.
3. Let me begin with the recent report from Germany that GM genes in GM pollen have transferred to the bacteria and yeasts in the gut of baby bees (2).
4. This kind of horizontal gene transfer involves the direct uptake of foreign genetic material. It has been found to happen also in the field. After GM sugar beet was harvested, the GM genetic material persisted in the soil for at least two years and was taken up by soil bacteria (3).
5. Not only microorganisms, but animal cells, including human cells can readily take up the GM constructs and the foreign genes often end up in the cell's own genetic material, its genome (4).
6. Not so long ago, the pro-biotech scientists were insisting horizontal gene transfer couldn't happen. Now, they are saying it happens all the time, so no need to worry.
7. So the crucial question is whether GM genetic material is like ordinary genetic material. The answer is no. There is a world of difference between GM genetic material and natural genetic material
8. Natural genetic material in non-GM food is broken down to provide energy and building-blocks for growth and repair. And in the rare event that the foreign genetic material gets into a cell's genome, other mechanisms can still put the foreign genes out of action or eliminate it. These are all part of the biological barrier that keeps species distinct, so gene exchange across species is held in check. And that has been so for billions of years of evolution.

9. GM-constructs are designed to invade genomes and to overcome natural species barriers. Because of their highly mixed origins, GM constructs tend to be unstable as well as invasive, and may therefore be more likely to spread by horizontal gene transfer (5).
10. GM constructs consist of genetic material of dangerous bacteria, viruses and other genetic parasites from widely different origins. They are combined in new ways that have never existed, and put into genomes that they have never been part of. They include antibiotic resistance genes that make bacterial infections very difficult to treat. And, you never just put a gene in by itself. It needs a gene switch or a promoter to work. Typically an aggressive promoter from a virus is used to make the gene over-express continuously – something which never happens in healthy organisms.
11. One viral promoter in practically all GM crops out there, including the so-called second generation GM plants such as the 'golden rice' (6) is from the cauliflower mosaic virus, CaMV for short. This CaMV promoter has a recombination hotspot – a site where it is prone to break and join up with other genetic material (7). It is promiscuous in function (8). Plant genetic engineers thought it works in all plants and plant-like species, but not in animals. Just last week, we discovered in the scientific literature more than 10 years old that this same CaMV promoter works extremely well also in frog eggs (9) and extracts of human cells (10). It is already known to be able to substitute for promoters of other viruses to give infectious viruses.
12. What will happen when these dangerous GM constructs spread? Remember, GM constructs are made from genetic material of viruses and bacteria and are designed to cross species barriers and to invade genomes. In the process, there's the obvious potential that they may recombine with viruses and bacteria to create new strains that cause diseases. The antibiotic resistance genes may also spread to bacteria associated with serious diseases such as meningitis and tuberculosis. GM constructs that invade genomes may recombine with, and wake up dormant viruses that have now been found in all genomes (reviewed in 8).
13. GM crops are turning out to be useless as well as unsafe. The bacterial bt-toxins, engineered into many crops, are poisonous for beneficial and endangered species such as lacewings, the Monarch butterfly as well as the black swallowtail (11). Bt crops encourage new resistant pests to evolve. Stink Bugs in North Carolina and Georgia are eating up the bt-cotton crops (12) and have to sprayed with deadly pesticides. A study in the University of Nebraska shows that GM Roundup Ready soya yielded 6-11% less than non-GM soya (13), confirming an earlier Univ. of Wisconsin study which also found that the GM soya required 2 to 5 times more herbicides.
14. The way to fight world hunger is definitely not GM crops. World population figures have been wildly exaggerated. The figure of 10 billion has been bandied about. In fact, figures have had to be revised downwards several times in the late 1990s. By mid-1998, the UN's estimate was that world population will peak at 7.7 billion in 2040, then go into long term decline to 3.6 billion by 2150, less than two-third of today's number (14).
15. Population arguments are based on the ecological concept of carrying capacity. Ecologists are increasingly finding that the more biodiverse the ecosystem, the greater the carrying capacity (15), and hence the more people and wild-life it can support. Biodiverse systems are also more stable and resilient. The same principles have guided traditional indigenous farming systems, and are now being re-applied in holistic approaches that integrate indigenous and western scientific knowledge (16). Some 12.5 million hectares around the world are already farmed in this way. The yields have doubled and tripled and are still increasing, at the same time reversing some of the worst environmental, social and health impacts of the green revolution.
16. World market for GM crops has collapsed because people all over the world are rejecting them and opting for organic sustainable agriculture (17). An organic revolution is rising from the grass-roots and also sweeping across the disciplines within western science. From quantum physics to the ecology of complexity and the new genetics, the message is the same: nature is dynamic, interconnected and interdependent (18). Proponents of GM technology are stuck in the mechanistic era, it is that above all that makes the technology both futile and dangerous. It is just not innovative enough!
17. In conclusion, GM crops are not safe, not needed and fundamentally unsound. Far from helping to fight world hunger, they are standing in the way of the necessary global shift to sustainable organic agriculture that can really provide food security and health around the world.

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Beyond Bad Science Big Business

Lecture for 'Big Money Bad Science' Teach-in on globalisation and genetic engineering, Vogue Theatre, Vancouver, November 10, 2000

The mechanistic mindset of western science is all of a piece with the neo-liberal economic theory promoting globalisation - the removal of all international barriers to trade, investment and finance - that has enabled corporations to ruthlessly exploit human beings and destroy our planet in their

quest for maximum profit. This paradigm has failed us in life as it has within science, but is still perpetrated by the academia and the political mainstream, if only because it serves so well to promote gene biotechnology and to make even unethical uses seem compelling.

GM crops destroy livelihood and self-sufficiency, and are strenuously opposed by family farmers everywhere. There is compelling evidence that genetic modification is inherently unsafe, as are many of the GM products. While the benefits of GM crops remain illusory, the success and benefits of ecological, natural farming systems are well documented. It is time to turn the tide on bad science and big business, to reclaim the good life in every sense for everyone.

Britain might be mistaken for a Third World country, says a newspaper headline: chaos on the rail network and protests over fuel price increase in the midst of the worst storms and floods in decades, and a CJD epidemic that may claim up to tens of thousands of lives.

The public enquiry report, published at the end of October, blames persistent government denials over the link between CJD and BSE beef based on the 'best scientific advice' given by the Southwood Committee in 1989, which concluded "it was most unlikely that BSE will have any implications for human health". The 'best scientific advice' is saying the same about genetic engineering. The scientific establishment has failed, again and again, to acknowledge that science is by its nature incomplete and uncertain and to insist on the precautionary approach. The precautionary approach might also have averted global warming, had it been adopted ten, twenty years earlier. It is high time that the precautionary approach is applied now in gene biotechnology.

If climate change and the CJD fiasco can teach us anything, it is that science is too important to be left to the politicians or to a scientific establishment increasingly in bed with big business. Our academic institutions have given up all pretence of being citadels of higher learning and disinterested enquiry into the nature of things; least of all, of being guardians of the public good. The corporatization of science is the greatest threat to our survival, and it works in subtler ways than generally recognized.

Western science dominates the world through its technologies, many of which become instruments of destruction and oppression in the hands of corporate business. More significant, however, is the mechanistic mindset of the science, through which the world is perceived and shaped. It presents nature as isolated atoms at every level, jostling and competing against one another in the Darwinian struggle for survival of the fittest. Organisms are mistaken for machines, and there is no limit to how they can be manipulated for profit, especially by changing their genes. Genes and genetically modified organisms (GMOs) have become the latest, hottest commodities.

The mechanistic mindset is all of a piece with the neo-liberal economic theory promoting globalization - the removal of all international barriers to trade, investment and finance - that has enabled corporations to ruthlessly exploit human beings and destroy our planet in their quest for maximum profit. That was why 50 000 took to the streets of Seattle to close down the World Trade Organisation last November; and a further 20 000 turned up to demonstrate against the World Bank in Prague this September. And it will go on, until peoples' aspiration for a safe, just, equitable, sustainable and compassionate world is heeded.

The mechanistic paradigm has failed us in life. It has also failed within science. Contemporary western science, across the disciplines, has been rediscovering how nature is organic, dynamic and interconnected. There are no linear causal chains linking genes to the characteristics of organisms, let alone the human condition. Genes function in complex entangled networks, constantly responding to feedback from the internal and external environment. Genetic engineering grew out of laboratory techniques for modifying the genetic material of organisms discovered some 25 years ago. These same techniques enabled geneticists to study the genetic material in ways that were not possible before. The findings have turned genetics upside down.

By the 1980s, geneticists have coined the phrase, "the fluid genome" to describe the dynamic state of the genetic material in all organisms, which is subject to both small and large changes in the course of development and in response to feedback from the environment. The new genetics is radically holistic and ecological, as is life itself. But the discredited paradigm is still perpetrated by our academia and the political mainstream, if only because it serves so well to promote gene biotechnology, and to make even unethical uses seem compelling.

The human genome project to map the genetic material of our species has been hyped a great deal, but the only concrete offers thus far are patented gene tests, some 740 already in the market. In cases where such tests can help to diagnose and treat patients, exorbitant licence fees have prevented their use. On the other hand, healthy people testing positive are denied employment and health insurance. Among the human genes and cell lines patented and sold by corporations are those stolen from indigenous tribes under the pretext of providing medical care, and even coercion is used.

Prenatal and pre-implantation diagnoses are eliminating human foetuses and embryos carrying genes said to pre-dispose them to cancer as adults. Jim Watson, co-winner of the Nobel Prize for the structure of DNA, the genetic material, suggested that parents might want to eliminate the unborn carrying homosexuality genes. There are no such genes, by the way.

The overwhelming causes of ill health are environmental and social. The World Health Organisation has long concluded that at least 80 percent of all cancer is attributable to environmental influences. Hundreds of actual and potential carcinogens have been identified among the 70 000 industrial chemicals that pollute our air, water and soil. Rising epidemics of childhood cancers are linked to mutations caused by radioactive wastes seeping from processing plants, or dumped into the sea and washed up on our beaches. But the cancer research establishment is doing little for cancer prevention except identifying putative genes predisposing people to cancer.

The focus on genes is misplaced. It is diverting attention and resources away from the real causes of ill health, allowing the chemical industry to continue to pollute our life support system with impunity, and to profit from the lucrative health market created by the rising tide of ill health. A headline in the financial pages of *The Guardian* (Wednesday August 2, 2000) says it all: “Gene hunters say patients are a bankable asset”. Worse yet, the ‘genetic mantle’ placed on diseases and other human conditions end up blaming the victims, fueling the re-emergence of genetic discrimination and eugenics that have blighted the history of the last century.

A prominent band of scientists and ‘bioethicists’ are advocating human germline gene therapy, which amounts to making genetically modified human beings. They see the creation of a gene-rich class of human beings to be inevitable due to the free reign of the global marketplace. The rich will pay to genetically enhance their offspring, in the same way that they will pay for expensive private education. Consequently, there will be a genetic underclass - children of the poor - that will eventually become a separate, inferior species. Social inequity is thereby translated into genetic inequity and *vice versa*.

Human embryos are cultured in the laboratory to provide cells and tissues for transplants. International trafficking of human organs is already rife, and eggs and embryos will be added to the list. In the Indian Seed Tribunal in September, three farmers in the same family in told the Tribunal how each had to sell a kidney when their crops failed from the bad seeds they were sold. They were the responsible ones, other farmers committed suicide instead. In future, the women may well be forced into selling their eggs and embryos.

Two years ago, the first ‘human’ clone was created, by transferring the genetic material of a human cell into a cow's egg. In October this year, researchers from an Australian and a US company made another by transferring human genetic material into the egg of a pig. Mercifully, the experiments were destroyed at 14 days, which is the current legal limit; or we would have been faced with Frankenstein. At least the original Dr. Frankenstein did not do it for money. And that is the bottom line. In deciding whether any application is ethical or beneficial, ask whether it would be done if there were no money to be made. And who but the rich can benefit when all the genes, cell lines and reproductive processes are patented for commercial exploitation?

Gene biotechnology is not just about GM food or GM human beings. It is a commitment to an existential nightmare, a descent into a self-made hell on earth. Mary Shelley´s brilliant novel was not only a parable of the arrogant scientist playing God, it is also about mechanistic science out of control, today, in the service of the corporate empire.

In China, where my family originates, ‘rice’ pronounced ‘faan’ means livelihood, it means contentment and self-sufficiency. In Thailand, rice is life, and the Karen hill tribes are so intimately connected to rice that the ‘rice spirit’ is brought back to the people and the land in a rice ceremony every year. Tens of thousands of rice varieties still exist in Thailand, which have been collected, created and propagated by farmers in the course of thousands, if not tens of thousands of years. That, despite the fact that a US scientist, Dr. Love, absconded with 120 000 varieties collected for the Thai gene bank in the 1950s.

Thai rice varieties come in endless shades of gold, red and black, each with a distinctive fragrance, serving different purposes and occasions, to enhance life as much as to provide nutrition. Each variety is valued and loved for its own sake, more than a connoisseur might appreciate varieties of tea, coffee or wine. I was given a bag of red rice to take home to London, and have savoured every mouthful since. Seeds are freely given and exchanged as gifts among farmers in Thailand, as they are all over Asia, Latin America and Africa.

To people whose lives are so inextricably interwoven with their indigenous plant varieties, what else can GM crops be but an abomination? And why should the rest of us not recover to some extent this aesthetic and spiritual connection to our food?

There is little doubt that GM crops will further destroy livelihood and self-sufficiency through corporate patents on seeds that farmers cannot resow or exchange, and through GM 'terminator' seeds that are rendered sterile, breaking the very cycle of renewal and regeneration that is the essence of life. There are 152 patents on rice, some 70 of them associated with the GM 'golden rice' that Astra Zeneca is supposed to be offering free to the Third World as a cure for Vitamin A deficiency.

Farmers all over South East Asia are incensed about the introduction of GMOs and the accompanying corporate propaganda and intimidation. In September, thousands of Thai citizens plus representatives from Cambodia, India, Malaysia and the Philippines took part in a long protest march. They issued a joint declaration rejecting all GMOs and patenting of seeds and plant varieties, and demanding government support for sustainable, natural farming systems.

GM is furthermore an untried, inadequately researched technology. There is no evidence that GM crops are safe, of the kind that could stand up in a court of law or to scientific scrutiny, despite what our regulators and their chosen scientists are saying.

The UK Government tried to place Aventis' Chardon LL GM corn on the National List, but overwhelming objection from the public forced a public hearing which is still going on. Aventis is also behind the recent massive recall of taco shells and other maize products contaminated with the 'Starlink' GM variety that has not been approved for human consumption because it showed all the signs of being allergenic. As for Chardon LL, Aventis' unpublished report submitted to the hearing showed that there were twice as many deaths in chickens fed the GM corn compared to those fed non GM corn. And on the basis of that, our Government had approved it for use as animal feed.

There is less than a handful of published papers on GM food safety from industry, and these are no better. The two papers from Monsanto on Roundup Ready GM soya showed that it increased milk fat in cows and decreased weight gains in male rats, and has an unexpected 26.7% increase in □-antitrypsin, a major allergen and growth inhibitor. Monsanto failed to make available even more damning data indicating that the GM soya had 100% increase in soya lectin, another allergen, which was also unexpected.

The evidence of hazards, much of it in the scientific literature, is stronger than ever before. That is why some 370 scientists from more than 40 countries are calling for a moratorium, as well as a ban on patents of organisms and living processes and support for sustainable, organic agriculture (see www.i-sis.org.uk).

The hazards are inherent to the uncontrollable, unpredictable nature of the genetic modification process (see Boxes 1 and 2).

Box 1

GM is inherently hazardous

- GM involves making artificial genes and combinations of genes that are transferred into cells and embryos to create GMOs, none of which may ever have existed in billions of years of evolution.
- GM genetic material are typically from dangerous bacteria, viruses and other genetic parasites that cause diseases and include antibiotic resistance genes that make infectious diseases untreatable. The gene products encoded by the genes may be harmful, as they have never been part of our food chain, and are also new to the ecosystem.
- GM constructs are designed to cross species barriers and to invade genomes. But the genetic engineer cannot control where and in what form the GM constructs end up in the genome. Unexpected toxins and allergens may result.
- GM constructs are unstable, as are GM lines. GM constructs are often scrambled when inserted in the genome. In later generations of the GMO created, the GM constructs may get scrambled further, become inactive or lost altogether. This seriously compromises agronomic performance as well as safety, because the GM line will change further in unexpected ways, and the lost genes may jump into unrelated species.
- Dangerous GM genes and constructs can spread, not just by cross pollination to related species, but by horizontal transfer to unrelated species, spreading antibiotic resistance genes, creating new viruses and bacterial pathogens, and triggering cancer in animals.

The biotech industry and their supporters claim we need GM crops to feed a growing world population. But UN studies show that world population growth has been slowing down since the 1960s. The prediction in 1998 was that total world population will peak at 7.7 billion in 2040, then go into long term decline to 3.6 billion by 2150, less than two-third of today's number. The FAO

report on Agriculture released earlier this year, similarly concludes that existing technologies, not counting GM, will produce enough and more than enough food to meet population growth for the foreseeable future. The real problem is distribution, as generally acknowledged. People are starving in the midst of plenty.

Finally, there is plenty of evidence that low input, ecological farming methods using crops and knowledge adapted to local conditions have been increasing yields two, three-fold or more in Latin America, Africa and Asia since the 1980s, providing social, environmental and health benefits besides. There are compelling reasons for farmers to grow and sell locally crops adapted to local conditions, rather than national or international varieties for export. Export industrial agriculture is responsible for a great proportion of the fossil fuel consumption that contributes to climate change. There is also incalculable health bonus to be gained by all in phasing out agro-chemicals already linked to cancers and many other illnesses.

In short, now is the time for all of us to join forces to turn the tide on bad science and big business, to reclaim the good life in every sense for everyone.

Box 2

Evidence that GM and GMOs are unsafe

1. Bt-toxins, isolated from a soil bacterium, *Bacillus thuringiensis*, and incorporated into a wide range of GM crops, are harmful to beneficial and endangered species, such as lacewings and the monarch butterfly.
2. Several Bt toxins are allergens or suspected allergens, including the Cry9C in Aventis' Starlink GM corn, which is responsible for the recent massive recall of contaminated taco shells and other corn products in the United States and elsewhere.
3. Random insertion of GM constructs result in monstrous abnormalities in animals such as pigs and fish. No one has checked for toxins and allergens.
4. In plants, unexpected toxins and allergens have arisen, as in Monsanto's GM soya: 26.7% increase in allergen and growth inhibitor, □-antitrypsin, and 100% increase in soya lectin, another allergen.
5. In 1989, a genetically modified batch of tryptophan killed 37 and made 1500 seriously ill, many to this day.
6. The instability of GM constructs lead to inconsistent performance in the field, yield drag, and other failures which have frequently turned up in GM crops.
7. Herbicide tolerant GM crops created weeds and superweeds. A canola resistant to three different herbicides made by different companies, was found in Alberta, Canada.
8. GM genes in GM pollen have transferred to bacteria and yeasts in the gut of baby bees.
9. UK government scientists provided indirect evidence that antibiotic resistance genes from GM pollen and dust can transfer to bacteria inhabiting the human mouth and respiratory tract.
10. GM genes from GM plants have been found to transfer to soil bacteria in laboratory experiments and in field monitoring.
11. GM corn DNA has been found transferred to chicken.
12. 'Gene therapy' experiments show that animal cells, including human cells, can readily take up GM constructs, and incorporate them into the genome. These GM constructs are similar to those used to make GM plants and animals and pose the same risks.
13. New viruses have arisen in GM plants engineered with viral genes.
14. GM constructs may recombine with, and wake up dormant viruses that have now been found in all genomes. Reactivation of dormant viruses by GM constructs in cultured cells is a major problem in packaging gene therapy vectors.
15. Random insertion of GM constructs into animal genomes may lead to cancer. This also occurs when GM constructs are put into cultured cells.

GMOs are Dead

Global Development Debate, St. James, Piccadilly, March 13, 2001

"Food biotech is dead" (trans 1). This pronouncement has come at a time when rejection of GM crops has gone global for good reasons. Consumers everywhere are concerned about safety, while farmers, already driven to destitution and suicide by the corporate take over of agriculture, are fighting against GM for their right to save and exchange seeds, the last thing that can safeguard their self-sufficiency livelihood. GM crops are definitely not needed to feed the world. The world needs to get rid of GM crops and corporate monopoly so people can feed themselves.

Eleven countries in Europe are declaring GM-free zones, bans or moratoriums on GM crops. And ten other countries including the US are operating or declaring GM-free zones, bans on imports or crop trials (trans.2)

Resistance is rapidly rising in the United States, which is responsible for 68.5% of world's GM produce. Several cities have declared moratoriums or ban on GM crops and some are even urging the federal government to ban GM food. Some 20 states are now discussing GMO-related legislation, including moratorium bills in New York, Massachusetts and elsewhere.

The corporations Syngenta, Aventis and Monsanto have announced they are giving up on GMOs, to concentrate on genomics, using genetic engineering as a research tool to find out what genes do, and to help speed up conventional breeding. Though at the same time, they are actively foisting unwanted GMOs on poor countries in food aid packages. This is scandalous, as the malnourished and immune-compromised populations will be especially susceptible to infections and other diseases.

Also, Syngenta's announcement of the rice genome sequence in January does not bode well for the Third World. There are already 229 patents on rice, 72 of these covering the fraudulent golden rice that's supposed to prevent children from going blind from vit. A deficiency. Rice is grown in 100 countries but nine-tenths of the world's crop is produced in Asia, and provides four-fifths of South East Asia's calories. Syngenta and its partner company said they would not patent the rice genome but would patent the genes identified.

If the human genome is anything to go by, it would take no time at all to cover the rice genome dozens of times over with patents. The result is to stifle independent research and innovation, and seriously undermining the farmers' right to create new varieties or even to preserve or use existing ones.

I am among nearly 400 scientists from 51 countries around the world who have signed an Open Letter to all Governments demanding a moratorium on environmental releases of GMOs because they are unsafe, and a ban on patenting life-forms and living processes because they are unethical. We also want support for non-corporate, sustainable, organic agricultural methods that can truly bring food security and health for all.

Evidence of hazards of GMOs has emerged all too clearly since we launched the Open Letter two years ago. I must stress that genetic engineering uses the same tools and makes similar constructs, whether in agriculture or in medicine; and therefore carries the same risks. I highlight some of these here (trans. 3).

The terms of the GM debate have shifted. It is no longer a moratorium that is needed. GM crops are unsafe and unsustainable as well as immoral. We must abandon GM crops right now, along with intensive corporate agriculture that has brought BSE and the food and mouth epidemic now threatening to get out of control. People all over the world are sending strong messages to their governments. They are overwhelmingly rejecting GM and opting for organic produce. The organic market has been growing exponentially in the UK by up to 40% per year since 1993. Next year, UK sales should reach £500m. Some 3.5million acres have now been converted, and as much again is in the pipeline. Europe-wide, there has been more than 20-fold increase in organic acreage since 1985.

The successes of organic, sustainable agricultural practices and technologies have been documented in study after study, despite the appalling lack of research funding compared to the hundreds millions that has gone into biotech. At least 3% of the arable land, some 28.9m hectares in Africa, Asia and Latin America are already farmed sustainably, with impressive gains in crop yield as well as social, economic and health benefits. Organic farming is also working well in the United States and Europe, with yields matching and even surpassing agrochemical agriculture. The Soil Association found clear evidence that organic farms are good for wild-life, supporting many more species of plants, songbirds butterflies spiders, earthworms. We need organic farming for the world to feed itself and for the planet to thrive.

Organic sustainable agriculture is also important for alleviating, if not reversing global warming. Not only does it significantly reduce the consumption of fossil fuel, it increases organic matter in the soil, in the form of both carbon and nitrogen. The choice is clear and we must make it now.

Scientists, above all, must free themselves from the corporate agenda, to work for the people, for the paradigm change that can really recover the good life in every sense for everyone.