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Turning the Tide on the Brave New World

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Abstract

This paper explains the science and technology of genetic engineering to expose the misinformation and disinformation put out by the industry and their supporters, including many of the scientists researching and exploiting the technology. The existing genetic engineering technologies are crude, unreliable, uncontrollable and unpredictable; and they are inherently hazardous. More so because they are misguided by a scientific paradigm that is fundamentally flawed, out of date and in conflict with scientific findings. That is what they are calling ‘sound science’.

A campaign of mis-information and dis-information

During the summer of 1998, the biotech giant Monsanto tried to sell GM food to Europe with the slogan, ‘Food, Health and Hope’, in a series of advertisements filling full pages of our top newsprints. GM crops are needed to feed the world, and they benefit consumers and the environment, so the advertisements claim; furthermore, Monsanto has conducted "rigorous tests" throughout its 20 year biotech history to ensure their food crops are "as safe and nutritious as the standard alternatives". Many complaints were filed by campaigning groups with the UK Advertising Standards Authority, which subsequently condemned those advertisements for making claims that were "confusing, misleading, unproven and wrong". [1]

In the same summer, eminent scientist Dr. Arpad Pusztai, of the Government-funded Rowett Institute in Scotland, revealed findings in a brief TV interview which suggested that GM potatoes were toxic to young rats. A few days later, he was removed from his job, denied access to his own data, and forbidden to speak on the subject. But 20 scientists spoke up for him in February, 1999. [2]

By that time, public acceptance of GM foods has plummeted. Eventually, all major wholesalers and supermarkets announced they would not deal in GM products. This sent shock waves of resistance around the world, from Europe to India, Brazil, Japan, Southeast Asia, and a year later, to the heartland of GM crops, the United States [3]. World market for GM produce has collapsed. Monsanto’s stock-market rating dropped so low that the corporation is to ‘spin off’ its agricultural biotech business, which was valued at zero, to merge with the pharmaceutical company Pharmacia & Upjohn. [4]

‘Sound science’ to the rescue

The misinformation and dis-information that led to Monsanto’s downfall are being perpetrated under the banner of ‘sound science’, starting with no less than the UK Royal Society, the core of the scientific establishment. Nineteen Fellows of the Society wrote to the papers accusing Pusztai of endangering ‘sound science’ in making public findings which have not been peer-reviewed and published in a scientific journal. The Royal Society then set up its own official review of Pusztai’s unpublished work, declared it flawed, and warned that no conclusions should be drawn. The Society’s Report [5] found no evidence of adverse

effects from GM potatoes (but fell short of saying the GM potatoes were safe). And even if Pusztai's experiments had been properly done, it stated that the results were only relevant to rats and potatoes, and it would be unjustifiable to draw conclusions on whether genetically modified foods in general are harmful to human beings. If animal testing is deemed to have no relevance for human beings, that would invalidate much of standard toxicological testing!

Pusztai's findings were not the first to suggest GM foods might not be safe. Many scientists have been warning of different hazards inherent to the genetic engineering technology [6]. Even the British Medical Association issued its own Interim Report in May, 1999, calling for an indefinite moratorium on GM crops and products, and for research to be done on the hazards of GM foods including new allergies, spread of antibiotic resistance genes and effects of the genetically modifed DNA in the GM crops (see later). The UK Government's Chief Scientific Advisor agreed with a demand for a moratorium on commercial release until at least 2003 [7]. To top all that, research at Cornell University in the United States found that milk-weed leaves dusted with GM-maize pollen engineered with a bt-toxin from the soil bacterium, *Bacillus thuringiensis*, killed 44% of the larvae of the Monarch butterfly after 4 days, whereas no mortality occurred in larvae fed non-GM pollen [8]. The public have good reasons to reject GM foods.

The industry is looking to our Governments and friendly scientists to bail them out, and the latter have obliged. During the recent World Trade Organization (WTO) Conference in Seattle (Nov. 29 to December 3, 1999), US Senator Kit Bond gave a press conference launching an open letter addressed to him from more than 300 scientists. These scientists stated their support for agricultural biotechnology in food production and "strongly advocate the use of sound science as the basis for regulatory and political decisions pertaining to biotechnology" [9]. Kit Bond is Senator for Missouri, home of Monsanto. One third of the scientists signing the letter are from Monsanto, Novartis or other biotech companies; and most of the rest are from universities and research institutions receiving substantial industrial support. In the press conference, four scientists spoke in turn, telling reporters that,

- We absolutely need genetic engineered crops to feed the world.
- The miracle crops are just around the corner; the latest being gentic engineered rice with enhanced vitamin A.
- There is no difference between genetic engineering crops and conventional breeding, except the former is much more precise.
- Genetic engineered crops pose no new hazards.
- Genetic engineered food is the most tightly regulated and scrutinized for safety of all foods.
- No one has yet died from eating genetic engineered foods, which has been available in the United States for several years.

It is remarkable how the same messages are repeated by scientists within the UK and elsewhere who are defending the industry [10].

The last point betrays this supposedly 'sound' science. There has been no segregation of the GM from non-GM products nor labeling; and no one has been monitoring for post-market health impacts. No proper scientist would, or should make such an obviously unscientific claim.

Actually, there *was* a batch of genetic engineered tryptophan that killed 37 and made 1500 people ill back in 1989, which was attributed to a trace contaminant [11]. Another recognized hazard is the availability of large amounts of genetically engineered hormones which are being abused and misused. Genetic engineered bovine growth hormone, for example, is sold to farmers to be injected into cows to increase milk yield. This not only causes excessive suffering and illnesses for the cows but increases IGF-1 in their milk, which is linked to breast and prostate cancers in humans [12]. Moreover, soya food allergy among the British public has unexpectedly risen 50% between 1998 and 1999, jumping from 14th to 9th place on the list of the top allergenic foods [13]. This finding coincides with the large increase in imported foods from the US containing GM soya.

A coalition of US public interest organisations have mounted a lawsuit against the Food and Drug Administration (FDA), which stands accused of not carrying out proper safety tests before approving GM food, and not requiring labeling. Internal memoranda from the FDA revealed it had ignored warnings from its own scientists that GM food could pose unforeseen health threats, and that there is a profound difference between the types of risks from GM crops compared with those obtained from conventional breeding [14].

Broken promises and corporate monopoly

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. Instead, two simple characteristics account for all the GM crops in the world [15]. 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 to kill insect pests. A total of 65 million acres were planted in 1998 within the US, Argentina and Canada [16]. 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 [17].

And what about genetic engineering crops to enhance nutrition? That simply does not address the root cause of malnutrition worldwide, which is the substitution of industrial monocultures for the varied diet provided by traditional farming/ foraging systems. Moreover, intensive agricultural practices accompanying industrial monocultures deplete and leach nutrients from the soil, thereby changing the nutritional values of all food crops for the worse within the past 50 years [18]. No amount of genetic engineering can reverse this trend, which can be achieved only by re-introducing sustainable farming methods and recovering agricultural biodiversity.

Corporate agriculture, GM seed patents and hunger

According to the United Nations 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 [19]. It is on account of corporate monopoly operating under the globalised economy that the poor are getting poorer and hungrier. Family farmers all over the world have been driven to destitution and suicide, *and for the same reasons*. Between 1993 and 1997 the number of mid-sized farms in the US dropped by 74,440 [20], and farmers are now receiving below the average cost of production for their produce [21]. Four corporations currently control 85% of the world trade in cereals [22].

The new patents which are awarded on GM seeds (as well as other life-forms and living processes) will intensify corporate monopoly by preventing farmers from saving and replanting seeds, which is what most 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 [23].

Hazards of GM crops now acknowledged

The hazards of GM crops are now becoming apparent, and some of them even acknowledged by sources within the UK and US Governments. For example, the UK Ministry of Agriculture, Fisheries and Food (MAFF) has admitted that the transfer of GM crops and pollen beyond the planted fields is unavoidable [24], and this has already resulted in herbicide-tolerant weeds [25]. Bt-resistant insect pests have evolved in response to the continuous presence of the toxins in GM plants throughout the growing season, and the US Environment Protection Agency is recommending farmers to plant up to 40% non-GM crops in order to create refugia for non-resistant insect pests [26]. The broad-spectrum herbicides used with herbicide-tolerant GM crops not only decimate wild species indiscriminately, but are toxic to animals. One of them, glufosinate, causes birth defects in mammals [27], A Swedish study now links the top-selling herbicide, glyphosate, to non-Hodgkin lymphoma [28]. GM crops with bt-toxins kill beneficial insects such as bees [29] and lacewings [30], and, as mentioned earlier, pollen from bt-maize is lethal to monarch butterflies. GM potatoes with snowdrop lectin, previously found to harm ladybirds [31], are now confirmed to be unsafe for young rats: Pusztai and his collaborator, Stanley Ewen, have published part of their results amid a fresh storm of attack (see later) [32]. Genetic engineering agriculture is a dangerous diversion and obstruction to the real tasks of providing food and health around the world.

The technology is crude and inherently hazardous, the science fundamentally flawed

To put it bluntly: the existing genetic engineering technologies are crude, unreliable, uncontrollable and unpredictable; and they are inherently hazardous. More so because they are misguided by a scientific paradigm that is fundamentally flawed, out of date and in

conflict with scientific findings. That is what they are calling ‘sound science’.

Genome and Genes

A *genome* is the totality of all the genetic material in an organism, which is organised into linear structures called *chromosomes*. Each chromosome is really a very long DNA molecule. Each DNA molecule consists of two chains wound around each other. Each chain is made up of millions of simple units linked end to end. The units are distinguished by the base they contain. There are only four different bases, represented by the alphabets, A,T,C, G. The DNA molecules are distinguished by the sequence in which the bases occur along the chain. Bacteria like *E. coli* which live in the gut of human beings and other mammals have one chromosome. Humans have two sets of 23 chromosomes (or 23 pairs of chromosomes) one set from each of our parents. Each chromosome resembles its partner (or homologue) in the pair and differs in size, shape and structure from all others.

Just as the sequence of alphabets in our language makes words and combination of words make messages, so each linear DNA molecule (chromosome) exists as stretches corresponding to genes, which are also combined into more complicated messages.

But there the analogy ends, because genes function in vastly complicated, parallel networks with lots of cross-talk between the networks as well as feedback from the internal environment of the body and the external environment. Geneticists have discovered within the past 20 years that feedback from the internal and external environments not only changes the function of genes, but also the structure (or base sequence) of the genes and the organisation of the genome.

A *gene* is a stretch of DNA with a defined function in the organism or cell. It usually codes for a protein. There are many genes on each chromosome. For example, the human genome is estimated to contain 100 000 genes. Each gene exists in hundreds of different variants (called *alleles*) each differing slightly in the base sequence. For this reason, each individual is genetically unique, and has a distinctive combination of alleles. Furthermore, each individual has two alleles of every gene, one on each of a pair of homologous chromosomes.

Genes are passed on from parents to offspring through the germ cells (egg and sperm) at reproduction. A special kind of cell division takes place in making germ cells, called *meiosis*. First, the homologous chromosomes pair up and exchange parts by the two DNA molecules breaking and rejoining with each other. This is the process of *recombination*, which results in chromosomes with different combinations of alleles from the originals. Second, the chromosomes duplicate only once while the cell divides twice; consequently, the germ cell ends up with only one set of chromosomes. When egg and sperm unite at fertilization, each contributes one set of chromosomes to restore the 23 pairs in the offspring.

The scientific paradigm I am referring to is genetic determinism, which ruled biology as well as the popular culture at large before genetic engineering really got underway 25 years ago. It offers a simplistic, reductionist view that ignores interconnections and complexity of real ecosystems. It has no concept of the organism as a whole, nor societies or ecosystems. Instead, there are only selfish individuals, each competing against all the rest. The organism is seen as nothing more than a collection of 'traits', each mechanically 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 all that were true, genetic engineering would be as precise and effective as is claimed.

Genetic engineering is being driven and promoted by a discredited genetic determinist science

"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." [33]

" 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."

These claims are based on the genetic determinist science which has been discredited by scientific findings at least 15 years ago. Genetic determinist science assumes,

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

Unfortunately, scientific findings over the past 25 years reveal an immense amount of cross-talk between genes, which function in complex, entangled 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 back in the 1980s.

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, we need a *balanced* ecology. The new genetics is radically ecological, organic and holistic, it is diametrically opposed to the mechanical conception of reality that has dominated the west for hundreds, if not thousands of years [35].

What do you get when you cross a spider with a goat?

What *is* genetic engineering? Remember 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, which have to do with the balance of the ecosystem. Each species has a distinctive role, a different way of life that fits in with the whole of the ecosystem. Furthermore, 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. That is because the genetic engineer cannot control where and how the foreign genes are inserted 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 [36]. Genetic engineered plants may end up having new toxins and allergens, as in the batch of tryptophan mentioned earlier.

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 [37].

The horizontal transfer of transgenic DNA from GM crops to soil fungi and bacteria has been demonstrated in the laboratory [38], *Furthermore, there is overwhelming evidence that horizontal gene transfer and recombination have generated the new drug and antibiotic resistant viruses and bacteria. These viruses and bacteria are associated with the recent resurgence of infectious diseases which has precipitated a public health crisis*

worldwide [39]. Has commercial-scale genetic engineering contributed to creating the new pathogens? This was the urgent question posed by a number of scientists demanding a public enquiry [40]. Another danger is that the transgenic DNA may jump into the genetic material of our cells and cause damages including cancer.

Let us look at the findings of Pusztai and his coworkers in the light of these potential hazards that are inherent to the genetic engineering technology, and then examine how current risk assessment fails to address them.

The genetic material DNA
and how it is replicated and recombined

DNA (deoxyribonucleic acid) is the genetic material of all organisms, including some viruses. In other viruses, the genetic material is RNA (ribonucleic acid), which is chemically similar to DNA, but does not have the latter's double-helical structure (see below).

DNA is a long molecule consisting of two strands wound around each other, like an electric flex, in a double helix. Each strand is a linear sequence of many thousands to millions of units linked together. There are four different units, each identified by an alphabet, A, T, C and G representing the organic base contained in the unit, adenine, thymine, cytosine and guanine. (In RNA, U for uracil replaces T.) An example of a DNA sequence is as follows:

ATTTCCGCTACGCGTTA..

The sequence of one thread determines that of its partner or complement in the double helix, because there is a precise pairing relationship between the units: A pairs with T, and C pairs with G. So, the complement of the above sequence is:

TAAAGGCGATGCGCAAT..

And the complete, double-stranded DNA molecule is hence,

ATTCCGCTACGCGTTA..

TAAGGCGATGCGCAAT..

The length of a DNA molecule is expressed as number of base-pairs, bp for short. DNA molecules can be thousands, hundreds or thousands or millions of base-pairs long.

The precise base-pairing between the strands enables the DNA molecule to be replicated. During DNA replication, the two strands separate, and each acts as the template for making the other, rather in the way that a positive image can be printed from its negative. So, when each cell divides into two daughter cells, its entire

complement of genetic material is also duplicated. Enzymes involved in duplicating the genetic material -- polymerases -- have been isolated, enabling genetic engineers to make many copies of specific DNA molecules in the test-tube.

Duplication is often inexact, mistakes are corrected by proof-reading enzymes in the cell under normal conditions. But under stress, the mistakes are not corrected, and it is one way of creating new *mutations* (changes in the DNA base sequence) rapidly which may enable the organism to overcome the stress. In the test-tube, no such proof-reading is available, hence *copies made by genetic engineers often have mistakes*.

Breaks can also occur in the DNA molecule to allow different DNA molecules to exchange parts. This is referred to as *recombination* , and gives rise to new combinations of genes. Special enzymes are involved in breaking and joining DNA. These enzymes have also been isolated and enable new combination of genes to be created in the laboratory by genetic engineers.

The Pusztai affair and risk assessment based on 'sound science'

A fresh storm of attack greeted the publication of Pusztai's work, and even reported threats to the Editor of the Journal publishing the paper [41]. Why is the work so controversial?

Pusztai and his coworkers created GM potatoes expressing a snowdrop lectin (GNA) to increase resistance to insects and nematodes. GNA was chosen because previous studies showed that the effects of the lectin have been 'minimal', at least when rats were fed on large amounts of the lectin for ten days or less. Pusztai's collaborator, Stanley Ewen, undertook to examine the microscopic structure of the lining of different parts of the rat gut in groups of young animals fed for ten days, respectively, on non-GM potatoes, GM-potatoes and non-GM potatoes spiked with the GNA protein. All the diets had the same protein and energy content.

Variable effects were found in different parts of the gut. In the stomach, a highly significant thickening of the lining was found in both rats fed GM potatoes and those fed non-GM potatoes spiked with lectin. It was reasonable to conclude, therefore, that the effect on the stomach lining was mainly due to the GNA protein. However, significant changes in the lining of the small intestine and parts of the large intestine were found only in the group of rats fed GM potatoes. Ewen and Pusztai conclude that "other parts of the construct or the genetic transformation (or both) could also have contributed to the overall biological effects of the GNA-GM potatoes." In addition, rats fed GM potatoes also had significantly increased lymphocytes (white blood cells) in the gut lining, which indicates damage to the intestine [42].

The explosive claim is that "other parts of the construct or the genetic transformation process" may be toxic. If that is the case, *all* GM crops may not be safe. Elsewhere, Pusztai has questioned the safety of the promoter from the cauliflower mosaic virus (CaMV), a piece of genetic material isolated from the virus, which is stitched next to a gene to enable the gene

to be switched on. The CaMV promoter is in the GM potatoes fed to the rats, as well as in practically all current GM crops. Could the signs of damage to the intestine be due to viral infection? That was a claim made in Pusztai's earlier communications [43], though not in the present publication. If so, might the cauliflower mosaic viral promoter have anything to do with it?

The CaMV promoter is known to have a 'recombination hotspot' -- a site at which it is prone to break and join up with other DNA [44]. We have reviewed all the relevant scientific findings, which suggest that the CaMV promoter will enhance the horizontal spread of transgenic DNA to unrelated species, and that the CaMV promoter may recombine with dormant viruses -- present in all genomes -- to generate infectious, disease-causing viruses [45]. On that basis, and in accordance with the precautionary principle, we recommend that all GM plants containing CaMV promoter and products with incompletely degraded DNA should be immediately withdrawn from use.

Neither Pusztai nor Ewen regards their research as definitive proof that GM potatoes, or GM food in general is *harmful*. Pusztai has repeatedly stressed the need for further research. However, the results do throw into serious doubt the claim of the biotech industry and regulatory authorities that GM food is *safe*. A leading British statistician had said privately that one should be worried if even a single rat had been affected.

The attacks on Pusztai say more about the 'sound science' his critics are defending, that lies behind current risk assessment, whether it be for radioactive discharge, industrial chemicals, toxic wastes or GMO. As is made clear above, it is a reductionist, mechanistic science that ignores the complexity and interdependence of living systems, that has, furthermore, been thoroughly discredited by recent scientific findings. More importantly, it is directly in conflict with the precautionary principle that has been accepted in several international conventions including the Convention of Biological Diversity and the European Union [46].

As applied to GMOs, the principle may be stated as follows: where there is scientific evidence to suspect serious irreversible harm, lack of scientific certainty or consensus should not be used as justification for not taking preventative measures. This is based on that offered by Norwegian virologist Terje Traavik who advises his government, [47] and in line with that adopted by Swedish law for hazardous and chemical products [48].

Risk assessment based on so-called 'sound science' not only ignores the complexity and interdependence of real living systems and reasonable suspicion of harm based on scientific evidence, it also places the onus on regulators and civil society to demonstrate that something is definitely harmful before it can be refused approval, withdrawn or banned. It is such systematic misuse and abuse of scientific evidence that has continued to allow corporations to endanger human health, destroy wild-life and our planet with impunity. No wonder there is a debate on whether risk assessment should be 'science-based' at all.

I believe that risk-assessment should be science-based, *but it should be based on honest, reliable science whose goal is to enable us to live sustainably with nature* [49]. It goes without saying that this science also obliges us to act in accordance with the precautionary principle.

The dangers of horizontal gene transfer are now acknowledged by sources within our governments, but regulation is still entrenched in the reductionist mode

The possibility for 'naked' or 'free' DNA to be taken up by mammalian cells is explicitly mentioned in the US Food and Drug Administration (FDA) draft guidance to industry on antibiotic resistance marker genes [50]. In commenting on the FDA's document, the UK MAFF pointed out that transgenic DNA may be transferred not just by ingestion, but by contact with air-borne pollen and plant dust during farm work and food processing [51]. The general public too, could become exposed to such dangers of horizontal gene transfer.

Thus, plant DNA is not readily degraded during most commercial food processing [52]. Procedures such as grinding and milling left grain DNA largely intact, as did heat-treatment at 90°C. Plants placed in silage showed little degradation of DNA, and a UK MAFF-commissioned report advises against using GM plants or plant waste in animal feed. The letter from UK MAFF to US FDA also mentions new findings that the human mouth contains bacteria capable of taking up and expressing naked DNA containing antibiotic resistance marker genes, and similar transformable bacteria are also present in the respiratory tracts [53].

Despite all that, our regulatory system is still firmly entrenched in the old reductionist paradigm [54].

- The regulations do not take account of the evidence accumulated over the past ten years that DNA survives in all environments and can be taken up by all cells. The UK Health and Safety Executive, in line with the EU Directives, still 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 [55]. One of the scientists in Kit Bond's press conference (see above) even referred to genetic engineered crops as the ultimate organic crops, because they involve manipulating "the totally organic substance DNA".

- The reductionist paradigm of regulation concentrates on the gene(s) and gene product(s) introduced into the GMO and on known toxins and allergens. 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 farcical. Everything 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 regarding someone who does theoretic physics like Einstein and plays football like Pele as substantially equivalent to another who plays football like Einstein and does theoretical physics like Pele.

Turning the tide on the brave new world

Genetic engineering biotechnology is not just about food production. It is about any and every way of exploiting life and our life-support system for profit. It is the ultimate in the dominant way of life that knows the monetary cost of everything and the value of nothing [56].

Apart from the existing herbicide-tolerant and insect-resistant GM crops which are already known to pose serious threats to biodiversity, crops are also being engineered to produce textiles, industrial chemicals, and pharmaceuticals that will contaminate our food supply. More dangerous 'terminator' crops that threaten the natural fertility of living organisms are also in the pipelines [57]. Trees are engineered to be more readily pulped for paper, that may wipe out our forests. Livestock and other animals are engineered to produce pharmaceuticals and drugs in their milk or spare body parts for transplanting into human beings. Even human embryos are being cloned to produce cells, tissues and spare body parts. The science driving the industry is devoid of moral values because it is based on denying and explaining them away in the first place.

A science which claims to be 'objective, neutral and value free' falls easy prey to commercial motives [58]. It then becomes all too easy for scientists to misread, misuse and abuse scientific evidence, and to ignore the grave dangers posed by the technology. This bad science has become both master and handmaiden to unaccountable business corporations driven solely by profit. Together, they will effectively control every aspect of our lives, from the food we eat to the healthcare we can have, the babies we can conceive and give birth to, the human beings we can clone. In the process, they may ruin our food supply, destroy biodiversity and unleash pandemics of drug and antibiotic resistant infectious diseases. They will also undermine every single moral value and ideal that makes us human.

The genetic engineering debate has concentrated the global mind on how the corporate agenda has dominated the world and worked against people and against our planet. At the recent WTO Conference in Seattle, the superpowers tried to promote the corporate agenda behind closed doors, which would sacrifice environmental protection, labour standards, food safety and basic human rights to trade and financial imperatives. The talks collapsed as Third World countries united in saying "No!" inside the conference hall, while 50 000 held peaceful protests in the streets. Seattle showed us that things could be different. We need not be ruled by corporations and global financiers.

What I find most encouraging is the high degree of convergence of all sectors of civil society in envisioning the sort of life they want that would benefit *everyone*. Above all, people want democracy and equity, and they want to protect and regenerate the earth. They are sickened by the rapidly widening gap between rich and poor. The richest 20% in the world make 150 times what the poorest 20% are forced to live on [59]. People are sickened by the accelerating rate of extinction, now estimated at up to 200 species per day [60]. Genetic engineering, in targeting the integrity of life itself, is in danger of destroying the last resort we have to save ourselves and our planet.

The way forward

While the ‘benefits’ of 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 [61]. Jules Pretty presents a powerful case for a more sustainable and community-led approach to rural economic development in both the Third World and in industrialized nations. 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 [62]. The success of organic agriculture is part of a larger paradigm shift that has come from the grassroots all over the world.

It is an organic uprising, a movement towards a way of being that celebrates the interdependence and richness of biodiverse nature. This has spread to western science. Jim Lovelock’s Gaia theory invites us to see the earth as one super-organism [63]. Even more remarkable is the message from quantum theory: we are intimately entangled with one another and with all nature, which we participate in co-creating [64]. This restores and reaffirms the holistic perspectives that many indigenous communities worldwide have never lost touch with.

The mechanistic paradigm that has dominated mainstream politics and misguided government policies for centuries has failed the reality test in the real world as well as within science. It presents a travesty of organic reality in its Hobbesian-Darwinian view of isolated, selfish atoms, all jostling and competing against one another in the struggle for survival of the fittest. It has created and reinforced an oppressive, social reality through a self-fulfilling prophecy, which is also destroying our planet.

When we really pay attention to nature, we find it is the symbiotic, mutualistic relationships that sustain ecosystems and make all life prosper, each in its own way, *including the human beings* who are active, sensitive participants in the ecosystem as a whole. The reciprocal relationship of human beings with fellow species in the ecosystem is so strongly felt among indigenous Peruvian farmers that they adopt plants into their gardens as members of their own family. Every year, they have a potato ceremony in which the old potato hands over to the new seed potatoes the responsibility for breeding the human beings [65]. Conservation policies that exclude human beings are pernicious, and so are proposed solutions which place population control above all else. China has 22 percent of the world’s population on only seven percent of the earth’s arable land. Most of the farms use intensive organic methods so sound that the fields are still fertile after two thousand years [66]. When land is well used and managed, wild and domesticated species can co-exist, and the carrying capacity increased (see below).

Many exceptional individuals are changing their own lives and the world around them. They all do so by learning from nature. For example, industrial processes are being redesigned to resemble balanced ecosystems, towards zero waste-emission and maximum productivity [67]. Nancy and John Todd’s ‘ecological design’ depends on assembling self-contained ecosystems for projects ranging from organic farming to water purification and building eco-cities [68]. Their motto is: "Waste is a resource out of place". Waste and pest for one organism is food for another [69].

There is coherent, regenerative energy in living organisms [70], especially in human beings who know how to work with nature and within nature. I have met organic farmers in India who reclaimed land laid waste by industrial chemicals and given up for good, and they did it in two or three years. Within the United States, cattle ranchers are restoring the prairies destroyed by overgrazing with the help of the cattle themselves. By skillfully herding the cattle on the land, they brought the prairies back, resplendent with indigenous species and wild life which have been lost for decades [71] At the same time, the carrying capacity of the land is increased up to 6-fold; so instead of supporting 50 cattle, it now supports 300, in addition to the wild elk and deer which have returned. The ranchers are even recovering land completely destroyed by mining. They spread straw and grass seeds over the barren land, then herd the cattle in to feed on the straw and fertilize the ground. Next year, grass began to germinate, presaging the return of the 'working wilderness'.

Progressive thinkers across the disciplines are pointing the way forward. Pioneers like Edward Goldsmith [72], Hazel Henderson [73], Jerry Mander [74] and Herman Daly [75] who have been telling us that economics and ecology must go together since the 1970s and 1980s, are spelling out the steps to shift from a money-centred, destructive economy to a people-centred regenerative economy [76]. In the business world, people like Paul Hawken are advocating, and putting into practice, the ecological principle, which says it is not enough to do no harm; business must contribute positively to restoring and healing the planet [77].

National governments have a very important role to play in this paradigm shift. They must legislate at the global level to safeguard democracy, basic human rights and the environment. At the same time, they must protect and encourage local creativity and enterprise, to enable the local to flourish, to celebrate diversity and complexity, and to ensure maximum participation of people in a regenerative, life-enhancing economy.

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