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Genetic Engineering Biotechnology - Challenges and Opportunities

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Academy of Sciences, Kuala Lumpur, May 28, 1999

Thank you very much for inviting me to speak here. I am indeed very honoured.

Earlier this month, I attended a Seminar on Biodiversity Law organised by high court judges and legal consultants in Brasilia. They expected 50 to 100. In the event 1200 turned up. The seminar happens to coincide with a series of battles over field trials and commercial approval of Monsanto's transgenic soya by the heavily pro-biotech National Technical Committee on Biosafety against the advice of the Brazilian Academy of Science. This has pitched state governments against the federal government, and different departments of the federal government find themselves in opposition. The federal Environment Protection Agency has formed a 'legal consortium' with Greenpeace and another ngo, the Consumer Defence Institute, and are locked in combat against the partnership of Monsanto and the National Biosafety Committee. The federal court has approved Monsanto's transgenic soya for commercial release, but requires Monsanto to segregate and label the produce. However, Monsanto is trying to overturn this requirement with the help of the National Biosafety Committee. Feelings are running very high over this issue.

The State of Rio Grande do Sul led the revolt by banning the transgenic soya. Just before the seminar, all 27 states of the Republic voted unanimously for a moratorium until environmental impact studies have been done. Paulo Affonso, President of the Brazilian Society of Environmental Law challenged the federal government to prove that its action is not harmful to the environment, stating in the strongest terms that the government must abide by the decision of the states.

Biopiracy is another burning issue. Gurdial Nijar, legal adviser of the Third World Network, pointed out that "indigenous knowledge has fed, clothed and healed the world for millenia". The concept of patenting and owning life is antithetical to all cultures in the Third World. Furthermore, it denies the "cumulative innovative genius" of farmers over the generations. Indian leader, Clovis Wapixana, confirmed that it is the deep knowledge of indigenous plants and animals possessed by the Amazonian Indians which alone can sustain natural biodiversity. One big problem is the expropriation of land by the corporations. Predatory fishing, logging and poisoning of rivers by prospectors happen on a daily basis. Now to top the insult and injury, bioprospectors are expropriating their knowledge.

A notorious case involves ethnobotanist Conrad Gorinsky of Oxford University, who has taken and patented the extracts of two plants from the North of Brazil, *bibiru*, used as contraceptive, and *cunani*, used as anaesthetic and as fish poison. Even more scandalous is the fact that a US company, Coryll Cell Repositories, is listing Amazonian Indian blood cells in a DNA kit for sale, priced at \$500, and openly advertised on the internet. But biopiracy is not new. Adalberto Antonia, Judge of the State of Amazonas, pointed out that 70 000 seeds were taken by Harry Wickham on behalf of the Kew Gardens in Britain. Wickham was knighted for his efforts, but the state of Amazonas was plunged into poverty for 50 years.

I met Dr. Mauro Carneiro, eminent molecular biologist and chief coordinator of all the biotechnology research in the government research institutes of South American countries. He is firmly opposed to the patents on life and the commercialisation of science. The current patenting of genes and cell lines is also denying the cumulative innovative genius of generations of scientists who have contributed selflessly to the intellectual commons for the public good.

Brazil is not alone in opposing gene technology and patents on life. I was in India in March, where angry farmers are calling for an outright ban on transgenic crops. Monsanto bought up an Indian seed company and began to carry out field trials without telling the state Governments. Farmers burnt the field trials in a "cremate Monsanto" campaign, followed by the "Monsanto quit India" campaign.

In 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 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 already declared they will not accept transgenic crops. Tewolde Egziabher of Ethiopia, leading spokesperson of the African Region, rejects the technology as "neither safe, environmentally friendly, nor economically beneficial."

Corporate giants already control more than three-quarters of the world trade in cereals. Now they are patenting genetically engineered seeds, the patents being protected under the Trade Related Intellectual Property Rights agreements of the WTO. Farmers have to pay royalties for the seeds, which they are forbidden by law to save and resow. Currently 80% of crops in the developing country are from saved seeds. The corporations are moving swiftly into developing countries. In Brazil, Monsanto has spent more than \$1billion in buying 60% of all the seed companies in just two years and plans a \$550m factory to produce pesticide for its transgenic soya. In India, not only has it bought major holdings in its largest seed company, but has invested more than \$20m in the country's leading science institution. It has also paid more than \$1bn for the international seed operations of Cargill, the world's largest grain company.

All this is coming at a time when 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 socially and environmentally destructive trends of the so-called high yielding monocultures of the Green revolution which have brought financial ruin and suicides to many in India alone.

It is obvious that transgenic crops are not necessary for feeding the world and cannot feed the world, quite the opposite is the case. 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. 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 food production and distribution, and now on seeds. They buy where and when it is cheapest and selling dear, or undercut farmers by subsidized dumping of surpluses. In fact, the corporations are profiteering from hunger.

To protect their patents on seeds, Monsanto and Zeneca are both planning different versions of the terminator technologies that either genetic engineers harvested seeds not to germinate, or else they will germinate, or express the transgenic trait only when a specific chemical sold by the company is applied.

And that is not all, Monsanto is planning to launch a new water business starting with India and Mexico. It sees new business opportunity in the emerging water crisis estimated to hit 2.5 billion people in India, Mexico, China and the US by year 2010. Monsanto's strategy paper states,

The business logic of sustainable development is that population growth and economic development will apply increasing pressure on natural resource markets. These pressures and the world's desire to prevent the consequences of these pressures, if unabated, will create vast economic opportunity -- when we look at the world through the lens of sustainability, we are in a position to see current and foresee impending-resource market trends and imbalances that create market needs.

We have further focussed this lens on the resource market of water and land.

These are the markets that are most relevant to us as a life sciences company committed to delivering food, health and hope to the world . . .

It estimates that providing safe water is a several billion dollar market, and intends to tap public financing by World Bank with the help of ngos and local governments. The most frightening aspect of the strategy paper is the unapologetic way it presents profiteering from scarce resources which are life necessities, like food and water. It can see nothing wrong with what most of us would regard as deeply unethical.

Why Genetically Engineered Food Does Not Feed the World

- Intensifies corporate feudalism
 - corporate control of seeds through patents
 - corporate control of agriculture through microcredit schemes (small loans made to the poorest to get them to grow transgenic crops)
 - corporate control of world food prices(through buying cheap and selling dear, or undercutting farmers by subsidized dumping of surpluses)
 - farmers become increasingly indebted and poor
- Undermines food security
 - obstructs implementation of sustainable agriculture
 - increase loss of agricultural biodiversity on which food security depends
- Reinforces social structures that create poverty
 - concentrates on cash crops for export
 - corporate control of world markets through WTO-TRIPs and other free-trade and investment agreements
- Reinforces unsustainable practices that decrease yield and destroy land
 - dams for irrigation
 - concentrates on cash crops for export
 - heavy input of agrochemicals
 - over-mechanisation agreements

A new Report released by Christian Aid concluded that the introduction of GM crops to the world's poorest countries could lead to famine, and they are not at all overstating the case. What we are up against is corporate feudalism. The corporate empire is now taking possession of life and our entire life-support system, to use as stakes in a final gamble with a Frankenstein science and technology that may destroy all life on earth. I am using

Frankenstein in the sense that Mary Shelley used it: a reductionist science that thinks it can improve on nature and does not realize it has created monsters.

Warnings are now coming from across the scientific community. The UK Government's Chief Scientific Advisor Bob May has added his voice to the moratorium proposed by English Nature and the Royal Society for the Protection of Birds. Last week's Nature reports high mortality in larvae of the Monarch butterfly fed milk-weed leaves dusted with pollen from transgenic maize engineered with the bt-toxin from a soil bacterium. The same kind of transgenic maize has earlier been found to be toxic to lacewings fed on corn-borers that have eaten the transgenic maize. The impacts on biodiversity are potentially devastating from the current transgenic crops planted. The Government's Chief Medical Officer Liam Donaldson and the British Medical Association are both warning of hazards to human health: the spread of antibiotic resistance, new food allergies and the effects of transgenic DNA.

Current State of World Transgenic Agriculture*	
Total acreage planted 65 million	
USA	74%
Argentina	15%
Canada	10%
Nature of transgenic crops	
a. Trait(s)	
Herbicide tolerance	71%
Insect resistance	28%
Both	1%
b. Species made transgenic	
Soya bean	52%
Corn	30%
Canola	9%
Cotton	9%
Source: Clive James, ISAAA Report, 1998	
*Excluding China	

Resistance to transgenic agriculture is coming from all over the world. Seven countries in Europe including the UK are operating bans or a moratorium on commercial release of transgenic crops. Greece has called for a Europe-wide moratorium. In the UK, resistance has been growing exponentially within the past year and a half, and it came straight from the grassroots. Local groups mushroomed overnight from the most remote villages to the metropolises cutting across the social spectrum and bridging all age gaps. They organised numerous debates, discussions, demonstrations and other actions. And no one should underestimate the power of the barrage of letters sent to Members of Parliament and local supermarkets. Never before has civil society been so united. It is the biggest, most inclusive civil rights movement of the century, if not the millenium. And it is a civil rights movement against corporate feudalism that is forcing GM foods on the world.

Impacts of Genetically Engineered Crops on Biodiversity

- Broad spectrum herbicides used with herbicide tolerant transgenic crops
 - devastates wild plants, which are themselves habitats and food for many animal species
- Increased use of herbicides and insecticides due to accelerated evolution of
 - resistances will add to biodevastation
- Transgenic plants harm non-target species directly and indirectly down the food chain
 - bt-cotton harms bees which are major pollinators
 - bt-maize harms lacewings fed on pests that have eaten bt-maize
 - bt-maize pollen harms larvae of Monarch butterflies
 - transgenic potatoes with snowdrop lectin harms ladybirds fed on aphids that have eaten transgenic potato
 - transgenic potatoes with snowdrop lectin are toxic to rats

A resounding chorus of "No to GMO!" has come from consumers, retailers, wholesalers, food and wine writers and restaurateurs. The two biggest food giants in the world, Nestle and Unilever, have joined in. A record number of farmers are converting to organic as the demand for organic produce is outstripping supply. According to the Soil Association, which sets organic standards in the UK, the acreage dedicated to organic farming increased 5 fold between Feb. 1998 and Feb. 1999. The international market for GMO has collapsed. All agricultural produce in US has been hit because Monsanto has convinced the Government not to require segregation. Major suppliers in the US are sourcing non-GMO produce.

There are very brave people in the resistance movement who are facing harassment and

arrest for taking civil disobedience actions. I want to mention in particular eighty-four year old author and organic farmer, John Seymour, who was charged for destroying Monsanto's transgenic sugar beet test site in Ireland. (This was similar to actions that have been taking place all over the UK.) He compares the invasion of Ireland by "Monsanto's genetically mutilated crops" to the Norman invasion, and sees it his duty to defend his country. He is prepared to go to prison for it, and when he comes out, he says, "I will do it all over again."

Dr. Arpad Pusztai, scientist in the publically funded Rowett Institute, was awarded 1.6 million pound to carry out proper safety testing of transgenic food, which, up to then, has not been done. He found alarming results, and being an honest, caring scientist, decided to inform the public in a TV documentary released last August. A few days later, he was removed from his job, and forbidden to speak until an international group of scientists spoke up for him. He has been vilified by the scientists on the Government's advisory committees on transgenic crops and foods, many of whom are linked to the industry. But why has the Royal Society joined in the condemnation? According to a reliable source, the Royal Society is also dominated by the industry. And the UK Government is hoping to make use of the condemnation of Pusztai's results to reassure the public. Pusztai himself has no regrets, he says the same as John Seymour, "I will do it again!"

The Royal Society has lost a lot of credibility. The issue is not, as they imply, whether sound science has to pass muster by being peer-reviewed and published. After all, very little of the scientific data coming from the industry have been peer-reviewed or published, and they haven't complained about that. The issue is not even whether Pusztai's work is flawed, I personally do not believe so. Scientific disagreement is normal. Many papers that were peer-review and published in top Journals have subsequently been shown to be wrong, or fraudulent. And many papers that went on to win Nobel prizes have been rejected from Journals. Nature rejected Hans Krebs' paper on the metabolic cycle that bears his name. The real issue is the threat to sound and trustworthy science from the commercialisation of science, and with that, a fundamental misunderstanding of what science is.

Science is a system of concepts and methods for obtaining reliable knowledge of nature in order that we may live sustainably with her. This quality is shared by knowledge systems all over the world. It is imbued with moral values at the start, and cannot be disentangled from it. The idea that science is objective, neutral and value-free has misled generations of scientists, and has allowed the most terrible crimes to be committed against humanity. The atom bomb and the eugenicist genocide of indigenous peoples and the Jews come to mind. But there is a more pernicious, insidious way in which social reality is shaped by the dominant scientific paradigm. I am speaking of the reductionist mindset that sees the world as isolated atoms all jostling and competing against one another, that has no concept the organic whole. It sees selfish genes instead of organisms, and selfish individuals instead of societies, ecosystems and communities of nations. Neo-Darwinian evolution theory and neo-liberal laissez-faire economics are mutually reinforcing, both stemming from the same roots in Victorian English high society. Together, they glorify competition and exploitation, and are ultimately responsible for the current dysfunctional global society with enormous and still rapidly widening disparity between rich and poor. Monsanto's strategy, as we have seen, is driven by this mindset. Nature, however, does not conform to our illusion that things are separate. She is organically interconnected and finite, and decades of wanton destruction and exploitation spurred on by corporate capitalism has now brought the planet to the brink

of extinction. Reductionist science has already failed the reality test.

Genetic engineering biotechnology is the latest offering from bad science and big business, which is supposed to solve all the problems that have been created. Unfortunately, the genetic determinist science that is driving the technology and selling it to the public has not only failed the reality test in the real world, but has been thoroughly discredited by scientific findings at least 15 years ago. Genetic determinism is the idea that genes determine the characteristics of organisms in simplistic ways, so by manipulating and transferring genes you can create new organisms to solve any problem. It is of course, also supposed that you can create and clone super-humans and other such eugenic fantasies. Paradoxically, genetic engineering is possible precisely because genetic determinism is invalid, so most of the promises can never be fulfilled. It is all the more urgent that we should preserve and promote alternative approaches and in particular, indigenous knowledge systems that have been shown to work sustainably for millenia and tens of millenia.

Genetic engineering is a new departure from conventional techniques and introduces new hazards. Particularly so, because those keen on exploiting the technology have not really caught up with the implications of the scientific findings.

Genetic Determinism Drives the Technology

The genetic determinist mindset driving the technology offers a misleadingly simplistic view of how genes function in organisms, which is evident in the descriptions below, both taken from literature supposed to promote public understanding of 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"

Food for Our Future, Food and Biotechnology,
Food and Drink Federation, London, 1995, p.5

"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."

The new biotechnologies, opportunities and challenges,
a starting point for discussion, Biotechnology and
Biological Science Research Council 1996, p.1

The proponents of genetic engineering biotechnology still regard organisms as though they were machines controlled by genes in a simplistic, linear fashion -- one gene giving one trait. It is a lego-pieces view of the organism, which supposes that the pieces can be taken apart and put together arbitrarily. It is also supposed that the genes are not subject to environmental influences, that they remain constant and fixed, so if a gene is transferred, you have a new organism with the desired trait once and for all. At least, the promoters of the technology want the public to believe that is the case. So, by manipulating genes, all the problems of the world can be solved, as simple as that.

This kind of reductionist thinking obviously has a tremendous hold on the public imagination, and runs very deep within the collective psyche of our society. For several years, the media have been full of reports on genes for everything, from homosexuality, criminality, to alcoholism and homelessness. These claims are socially irresponsible, and go 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? I can't go into details. For that you have to read my book, *Genetic Engineering Dream or Nightmare?*

Let me contrast the reality with the mindset here. The mindset is a linear one-way flow of information, from the gene ultimately to the trait of the organism, with each gene acting more or less independently of all others. This is epitomised in the Central Dogma of Molecular Biology due to Francis Crick, co-discoverer of the structure of the genetic material, DNA. Genetic instruction or information is supposed to go strictly in one direction, from DNA to RNA to protein, and by implication, the trait of the organism. And no reverse information flow is allowed.

This reductionist, mechanistic scheme is to be contrasted with the organic reality that indigenous knowledge systems all over the world are all based upon, and which, contemporary western science is actually recovering and reinstating. The new genetics is just the beginning. If you want to know more about that, please read another book, *The Rainbow and The Worm* the 2nd edition of which also came out last year.

The organic reality is radically ecological. The genes form a thoroughly interconnected network, with influences and instructions going in both directions at once from genes to the environment and environment back to genes, and at many levels. The environment can influence not only where and when certain genes function and how they function, but can also instruct the genetic material to undergo small and large changes.

There is nothing fixed and constant about genes and genomes. The genome is the totality of all the genetic material which is organised in very precise ways. But the organisation is dynamic. The genetic material is so dynamic and flexible that geneticists have invented the term, 'the fluid genome' more than 15 years ago. Numerous processes are involved in chopping and changing genes, mutating genes, rearranging them, multiplying or deleting them, correcting them, converting them, or move them around, making them jump in and out of genomes.

The genetic material, furthermore, is not confined within organisms. Genes can escape into the environment and directly infect other organisms. This is called horizontal gene transfer,

as opposed to vertical gene transfer, which happens in normal reproduction, from parent to offspring. Horizontal gene transfer is the process exploited by genetic engineers to transfer genes in the laboratory between organisms that would never interbreed in nature.

The new way to think about genes, therefore, is that they have a very complicated ecology, which consists of all other genes in the genome, the particular kind of cell in which the genes find themselves, whether it is a liver cell, a brain cell or a kidney cell, the physiology of the whole organism and the entire ecological environment. Genes are nothing if not sensitive and responsive, ultimately to the whole ecology. The idea that you can patent genes or pieces of genetic material for what it can do is absurd. Because what it does depends on the cellular, physiological and ecological contexts. Furthermore, it is infinitely mutable.

Most importantly, those 'fluid genome' processes are in reality a sophisticated regulatory system that carries out the very precise 'natural genetic engineering' which is necessary for life; for it maintains the integrity and autonomy of the organism and of the species within its ecological environment. These processes keep the genetic material dynamically stable under balanced ecological conditions, but at the same time, enables it to change promptly in response to environmental challenges.

Ecosystems, which include the human beings, are not made up of individuals in constant competition of one against all and all against nature. Instead, ecosystems consisting of organisms of diverse species are sustained as a whole by mutualistic, symbiotic relationships, by reciprocal checks and balances. Species in an ecosystem also keep their genes to themselves, only occasionally exchanging genes horizontally between unrelated species. The fluid genome processes in each species maintain the integrity of species and establish species barriers which limit genetic exchange between species.

Genetic engineering done by human genetic engineers is targeting just this exquisite regulatory system. But, it is anything but precise. It makes crude, unnatural combinations of genes to break down the integrity of the organism and to cross all species barriers. The dangers are inherent to the hit or miss technology. New genes and gene combinations are made that have never existed in nature. These are introduced directly into plant cells by physical methods such as a gun that shoots gold particles coated with the genetic material or the constructs are spliced into artificial gene carriers or vectors, made up of bits of different viruses and other genetic parasites that carry disease and antibiotic resistance genes. While natural viruses and genetic parasites are limited by species barriers, the artificial vectors and the gene-constructs are designed to cross all species barriers and to overcome mechanisms that breakdown, inactivate or inhibit foreign DNA.

The insertion of foreign genes into the genome is neither controlled by the organism nor by the genetic engineer. It ends up being completely 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, raising serious concerns about animal welfare. For the same reasons, transgenic crops are often unstable, do not breed true and do not perform consistently. Small and large failures have occurred even in crops that have been approved for commercial planting. One major cause of failure is gene-silencing -- mechanisms that inactivate or inhibit the expression of foreign genes. A country's agricultural base could be completely ruined if transgenic crops are widely introduced.

Transgenic Crops are Unsustainable

- Transgenic varieties are unstable, do not breed true, and do not perform consistently
- Herbicide tolerant transgenic crops are incompatible with sustainable agriculture dependent on mixed cropping and crop rotation
- Broad-spectrum herbicides harm earthworms and microorganisms that maintain natural soil fertility in organic farming
- Transgenic plants with bt-toxin undermines pest control for organic farming and are toxic to major pollinators and other beneficial insects
- Transgenic lines are even more genetically uniform than conventional mono-culture crops and may hence be more susceptible to diseases and environmental exigencies
- Viral resistant transgenic plants can generate new, often superinfectious viruses
- Terminator technologies destroy seed fertility

Random gene insertion also means that the properties of the resulting transgenic line will be totally unpredictable, and unintended changes including toxins and allergens are likely, all the more so because of interactions between introduced genes and host genes and because of the unnatural gene combinations or gene constructs introduced. Typically, the foreign gene is accompanied by a genetic signal called a promoter, which is taken from a virus. The most common one is from the cauliflower mosaic virus. This promoter makes the gene over-express continuously, at perhaps 10 to 1000 times the rate that any gene in the organism would normally be expressed, effectively placing the foreign gene outside the control of the host organism. The host organism is therefore under permanent metabolic stress.

What Pusztai and his colleagues found is very relevant. His research group was collaborating with two other laboratories, one in the Univ of Durham which created two transgenic potato lines engineered with the snowdrop lectin -- a protein that binds to cell surface carbohydrates, and the other, a pathology lab in the University of Aberdeen, which carries out the histological studies on internal organs. The transgenic lines were made exactly the same way with the same materials, but they were found to be significantly different from each other and from the unmodified potato line in the amount of protein as well as concentrations of various antinutritionals, ie, substances considered not good for nutrition. Yet, the transgenic potato lines were pronounced "substantially equivalent" to the nontransgenic potato by an audit committee set up to discredit Pusztai. According to all

current regulatory systems which follow a 1996 joint FAO/WHO food safety report on biotechnology, "substantially equivalent" means it is safe to eat. Pusztai found that the transgenic potatoes were toxic to rats, affecting all major organs including the brain. Furthermore, most of the toxic effects were associated with the transgenic process. That is why people don't trust the GM products that are on the market. They have been approved in the same cavalier way and may be seriously toxic. Moreover, because there is no segregation and labelling, it is impossible to trace those who have been exposed. The public are being used as guinea pigs, without informed consent, in a bad experiment from which no useful data can be collected. This is surely against basic human rights. There are indeed fatal flaws in the currently accepted biosafety regulatory systems, which most of the countries in the world would want to address with their own national legislations in addition to the International Biosafety Protocol.

When all these crops are released into the environment, the dangerous genes and gene constructs will spread and poison other plants and animals. Remember that they can spread not only by cross-pollination, but by infection, or horizontal gene transfer. Horizontal gene transfer can occur to all the species that the transgenic plants interact with: microbes, nematodes, insects, earthworms and mammals, including human beings eating the transgenic food. These are not theoretical possibilities. They are backed up by experimental evidence. Yet, current regulation does not recognize the reality of horizontal gene transfer.

- Secondary horizontal transfer of genes incorporated into transgenic plants, including antibiotic resistance marker genes, to soil fungi and bacteria have been demonstrated in the laboratory.
- The genetic material, DNA, released from dead and live cells, is not readily broken down in the environment and can persist indefinitely. All kinds of unnatural DNA are being produced by the biotech industry. They are potentially the most dangerous new class of xenobiotics -- meaning substances foreign to organisms -- to pollute our environment. They are much more hazardous than toxic chemicals because they are infectious, and can get into all cells, to multiply, mutate and recombine. The Norwegian Government has commissioned independent virologist Terje Traavik to write a report on the dangers of horizontal gene transfer from DNA released into the environment in 1995. It has recently been updated and translated into English under the title, *Too Early may be Too Late*; stressing the importance of the precautionary approach.
- DNA is not readily broken down in the gut. Viral and plasmid DNA fed to mice not only got into the bacteria in the gut but also into the gut cells, the blood cells, spleen and liver cells where they are incorporated into the cell's genome. When fed to pregnant mice, the DNA end up in the cells of the foetus and newborn.
- Practically all the gene constructs in transgenic plants contain the cauliflower mosaic viral promoter, including the widely grown transgenic soya. CaMV is closely related to the human hepatitis B virus and is also similar to retroviruses that are associated with AIDS and cancer. Its promoter can drive the synthesis of the other viruses. Dormant viruses which are in all genomes may be reactivated by the CaMV promoter or it can recombine with endogenous viruses to generate new viruses. The CaMV promoter is

known to contain a recombination hot-spot, which means it very frequently recombines. This has now been confirmed for transgenic rice lines, the mechanisms for recombination being provided by the host plant. Among the results reported by Pusztai's group are "signs of viral infection" in the gut of rats fed transgenic potato for only 10 days. There is no definitive proof yet that the CaMV promoter has got into the intestinal cells of these mice, but this possibility is being considered.

I should mention that the potential of genetic engineering to generate new viruses and bacteria that cause diseases was foreseen by the pioneers of genetic engineering in the 1970s. That was why a moratorium was declared in Asilomar. However, it was shortlived. Commercial pressures led to guidelines that were based largely on assumptions, everyone of which has been invalidated by scientific findings since. Chief among these assumptions was that DNA is rapidly broken down in all environments.

Genetically Engineered Food Poses Unacceptable Health Risks

- The hazards are inherent to the hit or miss technology
- Random gene insertions give random genetic abnormalities and unexpected effects
- New genes, gene constructs and products from viruses, bacteria and non-food species are introduced into our food for which no safety tests exist
- Interaction between introduced gene and host genes increases unexpected effects including toxins and allergens
- The technology enhances horizontal gene transfer and has the potential to generate new viruses and bacteria that cause diseases and spread drug and antibiotic resistance
 - horizontal gene transfer and recombination spread antibiotic resistance genes and have created new pathogens in recent years
 - strains of four dangerous bacteria, including the one causing tuberculosis, are resistant to all antibiotics and hence untreatable
 - at least 40 new viruses that cause disease in human beings have emerged between 1988 and 1996
 - transgenic plants were found to transfer transgenes and antibiotic resistant marker genes to soil microorganisms and fungi
 - DNA released from dead or live cells persists in all environments and remain infectious
 - viral DNA is often more infectious than the intact virus
 - viral and plasmid DNA resist digestion in the gut of mice, enter the blood stream and into white blood cells, spleen and liver cells and incorporate into the mouse cell genome
 - naked DNA is so efficient in gaining access to mammalian cells that it is now used in somatic gene therapy, administered orally, through the skin or injected into the blood stream.

Since then, the world has seen an accelerated resurgence of drug and antibiotic resistant infectious diseases. There is overwhelming evidence that horizontal gene transfer has been responsible for spreading drug and antibiotic resistance genes and for creating new viruses and bacteria that cause diseases. Moreover, many of the horizontal gene transfers have occurred very recently, as indicated by identical or nearly identical genes being found in unrelated species. Genetic engineering is designed to break down species barriers and to enhance horizontal gene transfer. Has commercial genetic engineering contributed to creating the drug and antibiotic resistant pathogens? A number of scientists including myself have produced a report on the possible links and demanding a public enquiry.

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 the implementation of sustainable agriculture and erodes agricultural biodiversity, which are now widely recognized to be just what we need to guarantee long term food security and counteract malnutrition as many studies are demonstrating.

Seventy scientists from all over the world are now calling for a global moratorium on transgenic agriculture, a ban on patents of living organisms, cells lines and genes, and an independent enquiry into the future of agriculture and food security for all. Civil society must recapture the agenda for the next millenium, to regenerate the earth with the natural resilience and fruitfulness of life. Marina Silva, Senator of Brazil and champion of indigenous peoples' rights have made a plea to western scientists to work together with indigenous scientists, and I would like to endorse that wholeheartedly. It is time we recover the Promethean ideal of sustainable, responsible science for the good of all.

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