

# **BIOTECHNOLOGY, ENVIRONMENT and REGULATIONS**

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# Introduction

In 1973 Stanley Cohen and Herbert Boyer introduced a recombined piece of gene into a laboratory bacterium and the gene was biologically active inside its new host. (Cohen et al. 1973) –A revolutionary technology–the recombinant DNA technology or genetic engineering–was born.

One of the first responses to this invention among the scientists was a voluntary moratorium on certain experiments with combining genes. This research ban was self-imposed by a group of molecular biologists, including the inventors themselves (Berg 1974). They were concerned that combining genes from two different organisms might accidentally create a novel organism with undesirable and dangerous properties. However, within a few years, these concerns were allayed as scientists gained laboratory experience with this technology and safety guidelines were formulated for such research. By the late 1970s, although some apprehension persisted, the technology was on the fly. (Glick & Pasternak 1998: 3-6).

In 1980, in a landmark decision US Supreme Court decided in favor of issuing patent on a bacteria which was genetically engineered for biodegradation of crude oil (Glick & Pasternak 1998: 614). In the same year, on October 15, the first genetic engineering based biotechnology company, Genentech went public on the New York Stock Exchange. Within 20 minutes of the start of trading the price of shares in the Genentech went from \$35 to \$89. At the time, this was the fastest increase in the value of any stock in the history of this market. Within next two decades, by the end of the millennium, more than 3,000 biotechnology companies would be born worldwide, thousands of biotech products and processes would be created. (Glick & Pasternak 1998: 3, 8).

However, at the same time the alarm and fear which occupied the scientists in the mid seventies dissipated and got hold on the general population. By mid nineties movement against biotechnology gained momentum, especially in Europe and some parts

of the “third world”, particularly under the leadership of European environmental activists. The wave hit Bangladesh too.

On 25 June 1998 Grameen Bank and Monsanto Corporation, a transnational US biotechnology company, announced to launch the "Grameen Monsanto Center for Environment-Friendly Technologies" in Bangladesh with the declared initial aims of supplying hybrid seed technology, making the country self-sufficient in cotton, rice and maize and improving tilling techniques (Tait 1998; Authers 1998; . Mann 1998). Just after one month on 27 July Grameen declared to cancel the partnership with Monsanto, reportedly due to pressure from "environmental NGOs" (Mortished 1998; “Grameen” 1999)

On May 1999 a preliminary research report on toxic effects of pollen from biotechnologically derived corn plants on monarch butterfly was published (Losey et al. 1999.). The butterfly became a symbol against biotechnology in demonstration by the environmental activists at the World Trade Organization conference on November, 1999 in Seattle, USA. (McMahon & Cox 1999)

All these events demonstrate at least two things. Firstly, that biotechnology has deep impact on our food, health, growth, economy and environment. Secondly, that there is either a serious conflict of interest or a gross miscommunication between the opposing groups. Being an active professional in the field of biotechnology it is not possible to be neutral on the debated issues, yet I would try to present the science, technology and the controversy as objectively as possible, along with my opinions.

## **Background**

### ***What is biotechnology?***

As one could guess, it simply means application of technology to get goods and services from biological agents. The most common and one of the first examples of biotechnology is making yogurt by using bacteria or fermenting beer by yeast. Thus,

speaking historically, it is one of the most ancient and original branches of science and technology.

The key factor in a biotechnological process is the biological agent or organism. The demand and search for a better and better organism is the central theme of biotechnology research. In the early 1970s, the available methods for getting a better organism were limited to searching among natural variants, selective breeding, hybridization, and induced mutation chemical and physical agents. Despite some significant successes, this traditional biotechnology was not a well-known scientific discipline.

However, the nature of biotechnology was changed forever when Stanley Cohen and Herbert Boyer invented in 1973 the recombinant DNA technology (also called molecular biotechnology, genetic engineering, gene cloning, gene splicing or gene transplantation). DNA or Deoxyribo Nucleic Acid is at the root of all inherited characteristics of an organism. DNA contains the genes - functional units of heredity - each bearing a message of hereditary characteristic. The above scientists invented methods of recombining genes from different sources, thus producing “Genetically Engineered” (GE) or “Genetically Modified” (GM) organisms with newer characteristics.

The recombinant DNA technology essentially involves:

1. Identifying a gene (unit of inheritance) with desirable characteristic in one organism.
2. Isolate the gene
3. Introduce the gene to and express the characteristic in another organism

Before the advent of the above technology genetic materials of two organisms could be combined almost exclusively through sexual reproduction, which was possible only within a species and between closely related species or genera. Cross or hybridization, that is, sexual union crossing the species boundary, often resulted in sterile offspring. By hybridization technique it was impossible to combine genes, say of, rice and carrot, tomato and cow, etc. The molecular biotechnology or genetic engineering opened up the possibility of transferring characteristics of one organism to another,

irrespective of their relationship, that is, a bacterial characteristic to a plant or even a human characteristic to a bacterium could be transferred by transferring one's gene to the other.

Moreover, cross or hybridization involves recombination of thousands of genes on whole chromosomes, consequently a breeder has to accept many undesirable combination of traits in the new offspring. The undesirable traits are eliminated by time consuming back-crossing. Whereas recombinant DNA technique made it possible to transfer or modify only one or a few well characterized and known gene(s).

Thus it appears that so far as combination of genes or life-characteristics are concerned, for recombinant DNA technologists, only sky is the limit. Ironically, this very power of the technology gave rise to the awe for and fear of it.

### ***Range of reactions to the new technology***

Like any revolutionary technology it immediately strung multiple cords of society including economics, health, environment, ethics and the future of the humankind.

The optimists immediately found a new vista for solving so many kinds of problems. They started dreaming of another agricultural revolution, revolutionary methods for diagnosing and treating diseases, new industrial products and business, etc.

The pessimists found in it the myth of Frankenstein a reality; a real possibility that the nature, earth and human race destroyed by franken-bacteria, -plants or -animals; the fear of impending doomsday. In the 70s, the popular press often used phrases such as "playing God", "manipulation of life", "manmade evolution", "the most threatening scientific research ever undertaken", etc. when describing molecular biotechnology.

There of course were people on the middle ground, who beside being optimistic or pessimistic tried to look at things more objectively, took calculated risks and subjected the new thing under constant study and development.

Historically and culturally Bangladesh has several problems in accepting a revolutionary invention like biotechnology:

1. Scientific institutions and practices are undeveloped, non-science institutions are much developed. Naturally, misunderstanding, techno-phobia, traditionalism has much wider appeal to general populace.

2. History of long exploitation by the multinationals from present industrially developed countries makes their initiatives always a matter of suspicion.

3. The technology is coming from a foreign land.

4. Fear could be transferred more easily than the technology.

It is the duty of the conscious and educated people to get over undue pessimism or optimism, phobia or fascination , and lead the people in proper direction.

### ***The prospects, potentials and successes***

After the initial shock, confidence grew up and many entrepreneurs came forward to harvest the fruit of the new technology.

In 1982 Europe approved the first animal vaccine produced by recombinant DNA technology. By the mid-1990s, more than a dozen new recombinant drugs been certified for use with humans; over 100 are in the process of human trials, and more than 500 other recombinant pharmaceutical products are being developed. In 1996, the annual sales of first recombinant protein, erythropoietin, exceeded 1 billion dollars. (Glick & Pasternak 1998: 6-8)

By the end of 1997 there were over 3,000 biotechnology companies worldwide, over 1,500 in the USA alone. The annual earnings of the molecular biotechnology industry have increased from about \$6 million in 1986 to about \$30 billion in 1996. It is estimated that by 2000, product sales for molecular biotechnology commodities will be more than \$60 billion per year. (Glick & Pasternak 1998:8)

### **Agriculture and Food**

- Plants have been modified to have inheritable characteristics of:

Resistance to a variety of pests

Resistance to herbicide, draught, excessive heat or cold.

Richer nutrient contents

More attractive taste and flavor

- GM bacteria have been used to:
  - Produce variety of food substances
  - Promote plant growth
  - Control other pathogens (?)
- Livestock have been created with the ability of:
  - Producing special substances
  - Faster growing times
  - More efficient feed utilization

## Medical

- Microorganisms have been genetically modified to produce human and animal antibodies, hormones, vaccines, enzymes, interferons and so many other compounds needed for diagnosis and therapeutics.
- Chimerical proteins, say part human part mouse, have been created for novel therapeutic usage.
- Genetic disorders in human beings are being treated by introducing the healthy gene.

## Industrial

- Suitable microorganisms, plants or animals have been engineered to produce commercially valuable proteins and chemical compounds.
- Commercially important characteristics of the microorganisms used so far for industrial production have been improved.

## Environmental

It is very interesting to mention that the first patent on a living organism was given in 1980 on a *Pseudomonas* bacteria that was genetically modified to degrade oil spills, thus for bioremediation of environment. It is doubly interesting that the genetic engineer in this case was Ananda Mohan Chakrabarty, a Bengali, who was working in the USA for General Electric (Glick & Pasternak 1998: 614). In the next two decades successes have been achieved in various other ways to produce a more environment friendly or less polluting processes through biotechnology.

- Microorganism have been created to degrade environmentally obnoxious agents, as engine oil, heavy metals, etc.
- Agricultural plants have been created to be resistant to common pests resulting in reduced use of chemical pesticides.
- GM bacteria might replace chemical fertilizers and thus reduce the environmental pollution.
- Alternative environmentally safer biotechnological methods has been invented for producing many conventional chemicals, e.g. indigo.

An example: Common colon bacterium, *E. coli*, has been engineered to synthesize indigo by Genencor International (GCI, South San Francisco, CA). The biotech indigo is indistinguishable from synthetic material in handling, dye-mix preparation, and most importantly in performance. Whereas, it is environmentally much safer. For comparison of the essential features of the synthetic and biotech indigo are presented in the table below (Bialy 1999):

	SYNTHETIC INDIGO	BIOTECH INDIGO
Operation steps	8 step operation	3 step operation
Raw materials	organic solvents and	acquous solvents and

	hazardous chemicals	innocuous starting materials as corn syrup
Processes	cyanilation, saponification and sodium-ammonia reactions that require special conditions to protect workers and environment	no special hazard
Co products	highly toxic chemicals	biomass and CO <sub>2</sub>
Cost & Performance	equal and comparable	equal and comparable

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So far thousands of strategies and attempts have been taken to alleviate environmental pollution or helping in the conservation of environment by GM organisms. The most interesting that I have read recently was on using GM bacteria as bio-sensors for detecting left over land mines. (Bolin 1999)

### ***The Risks & Concerns***

There were some accidents and unexpected incidences related to if not resulting from this technology. For example, there were about 37 human deaths in the USA in 1989 from a toxin containing food supplement from a GM bacteria (Mayeno & Gleich 1994). Recently, toxicity on Monarch Butterflies under laboratory conditions from eating pollens of GM pesticide producing corn plants (Losey et al. 1999) and a controversial report on toxic effects GM potatoes on mouse intestinal growth have been published (Ewen & Pusztai 1999; Loder 1999). Although these accidents and failures are comparatively much lower compared with those from so many other technological systems, yet these further raised the concerns and fear in significant sections of people.

As the technology advanced on at the closure of the last millenium even the human cloning or GM human being became a technological feasibility, it also raised the

concerns of risks, accidents and various ethical issues. The risks and concerns may be enumerated as follows:

### Economic

- Will agricultural molecular biotechnology undermine traditional farming practices?
- Will the high-tech commercial successes mean that the benefits of molecular biotechnology will be available only to the wealthy, creating more socio-economic disparity?
- Should GM organisms be patentable?

### Social

- What would be the social consequence of genetic engineering of human being?
- Will biotechnological diagnostic procedures undermine individual privacy ?

### Health

- Will it create some super-pathogens, against human, other animals or plants?
- Will we be under constant threat of unanticipated toxins and allergens from GM Organisms (GMOs).

### Environmental

- Will some GM organism be harmful either to other organisms or to the environment?
- Will the development and use of GM organisms reduce natural genetic diversity?

Above is a birds eye view of biotechnology and its relation with various aspects of our life. It is not really possible to draw clear lines between environment and other aspects of the issue as health, economy, industry or society; because environment affects all other things and vice versa. Yet, considering the general goal of this conference I would try to concentrate on the biotechnology that primarily affects environment, specifically the issues of recently aggravated "biotech-environment controversy".

## **The "Biotech-Environment Controversy"**

Despite all promise of biotechnology in solving the world's agricultural problem and to help creating safer environment, it seems that agricultural and environmental activist groups are most opposed to this technology. (Mahler 1999; Dale 1999; Nuffield 1999; )

From the recent picture of the confrontations it appears that the governments and regulatory agencies of the technologically advanced countries such as USA, UK, Canada, etc.; established international organizations as WHO, FAO, OECD, etc.; the industrial establishment, the political right, and almost all of the scientific institutions and organizations including Royal Society, European Federation of Biotechnology, National Research Council USA, etc.; are supporting and championing the technology. They also think that the existing regulatory measures in the technologically advanced countries, although not full proof yet reasonable enough for the security of health, environment and well being of the society. (Mahler 1999; Nuffield 1999; FAO/WHO 1991; OECD 1993; National 1987)

On the other hand the radical environmental conservationists, as Greenpeace, Friends of Earth, etc.; many of the "third-world" NGOs and some governments, most of the churches and some of the political lefts feel alarmed by the technology and want to have a ban or at least a moratorium on it. For example, one of the most renowned environmentalist group "Greenpeace" has following slogans in their web page on genetic engineering (<http://www.greenpeace.org/~geneng>):

No Genetic Manipulation of Nature

Prevent Genetic Pollution

No Patents on Life

Protect Global Bio-Diversity.

Similarly other radical environmentalist organizations and individuals have declared almost an all out war against biotechnology. The well known Grameen-Monsanto joint venture was given up due to pressure from the environmental NGOs (Mortished 1998; “Grameen” 1999)

I would first examine more closely the arguments of the radical environmentalists against biotechnology and the answers from the biotechnology experts, industries and regulatory authorities. Then discuss in a separate section the aborted Grameen-Monsanto joint venture as a case study in the context of Bangladesh.

The environmental criticisms against biotechnology may be discussed under following headings:

### ***Biotech Natural Disaster***

The most popular argument for impending disaster from genetically engineered organism is:

Genes that have been engineered into plants and animals can be transferred to other species, they can mutate in response to environmental influences and thus may disturb the ecological balance. Therefore, “Genetically modified organisms must not be released into the environment as the consequences for the environment and the evolution are unpredictable and irreversible.” (Anderson 1999a)

There is some truth in this argument. However, as a general rule the organisms do not like or tolerate an introduced foreign gene, unless it gives them special survival advantage. In almost all of the cases the traits that we human being want from an organism are not required for the survival of the organism itself. Therefore, the genetically engineered organisms are not particularly fit for competing in the wild without human protection.

Still, there are some risk and the risk has been addressed by the biotechnologists and regulatory agencies. There is detailed procedure worked out by regulatory agencies, say for example by USEPA, to check the ecological impact of an organism under controlled conditions before its release in the field. (“The Safety” 1999; Tiedje et al. 1989; USEPA 1997; National 1987;).

As I mentioned before this was the most original concern immediately after the invention of genetic engineering. By the late 1970s the scientists gained enough knowledge and confidence to start new experiments, however, many sections of the population are still worried. I think this lack of confidence and worry is caused by lack of knowledge and acquaintance with this specific discipline of science.

We must have to understand that the issues here are highly technical and the risks have to be assessed by scientific bodies and managed by authorities appointed by the people. Now, if somebody says that s/he has no faith on the scientists or regulatory authorities then it is really difficult to alleviate such fear.

### ***Hazardous Food***

Probably the hottest issue in the anti-biotech battle field is the issue of GM food. \* Introduction of GM crops and food has become highly controversial in UK, parts of Europe and some other parts of the world. By contrast their introduction has been greeted with near-indifference by farmers and consumers in the USA and Canada. (Ewen & Pusztai 1999; Feldbaum 1999; Fisker 1999; FitzGerald et al 1999; Gaskell et al. 1999; Kilpatrick 1999; Klug 1999; Lachmann 1999; Loder 1999; Miller 1999a; Miller 1999b; Mowat 1999; Munro 1999; Nuffield 1999; Saegusa 1999; Trewavas 1999a)

The possibility of health hazard arise from the GM-food for the fact that an introduced gene not only synthesize its own product but may also affect expression of other genes. That is it may either increase the production of toxic substances which are produced in very low amounts in natural plants and foods or may decrease the production of essential nutrients thus reducing the nutritive and protective value of a food. The chances of affecting is further increased by the present procedure of introducing the transgene randomly in any site of the host genome.

Now, the biotechnologists and regulatory authorities say that they have taken adequate precaution and investigative procedure to check GM foods before approving it for markets. (Burke 1999; Butler & Reichhardt 1999; Kearns & Mayers 1999; Maryanski 1995; Miller 1999a; Trewavas & Leaver 1999b )

The preliminary method for testing GM foods rests on the concept of “Substantial Equivalence”, a term coined by the Organization of Economic Cooperation and Development in 1993. USFDA also has essentially similar principle. Under this principle GM foods are compared with analogous conventional food by chemical analysis of known nutrients, anti-nutrients and food toxins, test for allergens, in addition to the testing of the introduced gene, protein and its possible degradation products. If a safety question remains after these tests further toxicological studies are performed. (Butler & Reichhardt 1999; Maryanski 1995)

But the GM food antagonists are not satisfied with this procedure. They demand that all GM foods must be tested as an unknown chemical, as a new drug is tested. Moreover, the GM foods have to be labeled, segregated or banned altogether. (Anderson 1999b; Millstone 1999; Thompson 1997)

It appears that the protestors assumed that introduction of a foreign gene in an organism has a substantial chance of producing any known or unknown toxin in the world. This is a hyperreaction is imaginary and there is no substantial evidence in support of such reaction. I think, it is arising from lack of adequate knowledge about genetics and physiology of organisms.

While it would have been very good to satisfy their fear and concerns by performing extensive testing on each and every GM food, but that would result in enormous research expenditure which would effectively strangle the progress of biotechnology or put enormous burden on part of the consumers, as ultimately the consumers have to pay all the expenditures of testing.

## **Toxic and Polluted Nature**

A number of objections against biotechnology is based on the GM corn plant which incorporated an insecticide protein, called Bt toxin, from *Bacillus thuringiensis*. For limitation of space I would confine my discussion around this GM corn plant and the toxin.

Since this toxin is produced in every cell including the pollens of the plant and this corn plant is intended to be cultivated widely many environmentalists see it as a massive intoxication of nature. However, it has to be kept in mind that the farmers had been using some other insecticide chemicals over their corn fields. And those chemicals were sprayed all over the field, killing all the sensitive insects, no matter they eat the corn plant or not. Compared to that the Bt corn only kills those insects which feed upon it. Bt toxin is very selective in its action, it is nontoxic not only on animals but also on most of the insects. Moreover, this toxin is degraded as fast as in a day by sunlight. (Glick & Pasternak 1998: 378-390)

Therefore, if somebody is totally against using any insecticide then Bt corn is no solution for him or her. However, in the perspective of using conventional insecticide the biotechnological development of Bt corn is a one step forward towards cleaner environment.

As mentioned before, a recent research report on killing of Monarch butterfly larvae by pollens from Bt corn has drawn much focus from the environmentalist (Losey et al. 1999). The butterfly became the symbol of protest against biotechnology in the WTO conference last November. However, it is really astonishing that such a strong symbol has got such a weak base as the sole research report. Firstly, there was nothing new in the report, because butterfly belong to the genus *Lepidoptera* and it is known long since the discovery of the Bt toxin that it kills butterfly larvae. It is a text book knowledge. Let me quote from a textbook “For example, *B. thuringiensis* susp. *kurstaki* is toxic to lepidopteran larvae, including moth, butterfly, and skipper larvae, cabbage wormss, and spruce budworms.” (Glick & Pasternak 1998: 378). Secondly, the larvae in the experiment were forced fed on pollens from Bt corn. They were not given any other choice of food, which is present in the field condition. In the nature the larvae could have

just avoided the toxic pollen covered leaves. Thirdly, to make it a case against biotechnology one has to show that this biotechnological toxin is more dangerous than conventional toxins, at least on the monarch butterfly larvae. This has not been done by any of the analysis so far.

Raising the monarch butterfly as a symbol against biotechnology, in fact, symbolizes the scientific ignorance and shallow thinking of these environmental activist groups.

### ***Loss of Biodiversity***

Another popular concern among the radical environmentalist against genetic engineering is the fear of loss of biodiversity. A typical argument is as follows:

“The use of genetic engineering in agriculture goes hand in hand with the globalisation of monoculture farming practices which has been a major factor in the erosion of species diversity.” Interestingly, parallel are drawn also between “green revolution” and “gene revolution” citing that cultivation of few high yielding variety of crops resulted in huge losses in genetic diversity during the green revolution era. (Anderson 1999a)

But, they failed to understand that the farmers would always look for high yielding varieties. If that results loss of the low yielding varieties then that can not be prevented by blocking the technology. To me, that seems outrageously unethical and manipulative on the farmer. I think, the preservationists rather create the sanctuary for all the low yielding varieties at their own costs and funds.

A point of optimism – since manipulation of plant traits has become much easier now due to advent of genetic engineering it would be possible to create many varieties of useful plants from the diverse naturally occurring varieties thus preserving and increasing the biodiversity.

## The Case of Grameen-Monsanto Joint Venture

The aborted Grameen-Monsanto joint venture demands particular attention in this occasion, for it was the only attempt so far to introduce the fruits, good or bad, of the technology to the agricultural farmers in Bangladesh. Time course of the abortion shows the strength of the anti-biotechnology activists in and over our country. Many organizations and individuals protested and pressured against Grameen to discard the project. Among them I would pick up two fairly representative organizations and analyze their arguments against the venture, in somewhat detail.

Dr. Vandana Shiva, Director, Research Foundation for Science, Technology and Ecology, and a renowned radical environmental activist from South Asia, wrote in a letter to Dr. Mohammad Yunus, the founder of Grameen Bank:

"Monsanto's skills in agriculture are in the field of genetically engineered crops. These crops are designed to use more agrichemicals like Round-up which is broad spectrum herbicide that kills anything green. Your microcredit venture with Monsanto will directly finance the destruction of the green vegetables that women collect from fields. Round-up also has negative impacts on fish which provide 80 percent of the animal protein in Bangladesh."

For such reasons Shiva concluded,

"Contrary to your announcement Monsanto's technologies are not environment friendly, or sustainable. They pose a threat to ecosystems and agriculture. ... Grameen-Monsanto Centre will become a partner in the destruction of biodiversity and farmers livelihoods supported by free access to biodiversity."

And finally she calls,

"to join growing world wide movement of people against Monsanto and against genetic engineering and patents on life." (Shiva 1998)

However, there were too many fallacies and a number of misinformation in this argument:

1. In the first sentence it appears that Monsanto's skill is limited to genetically engineered crops. That is not true. It is a transnational giant and has state of the art technological skills, good or evil, in many aspects of agriculture. It was more renowned as a fertilizer and insecticide company than a biotechnology one before very recent acquisition and merger with other biotechnology companies. In fact still it is the world's largest crop chemical company and the third largest seed company. Monsanto itself announced that it would initially supply "traditional" hybrid seed technology and stocks, since Bangladesh lacked a regulatory regime to deal with GM crops. It is not understandable why Dr. Shiva ignored the announced objectives. Introducing Monsanto only as an expert on genetic engineering might give the impression that it's only motive must be pushing genetically engineered seeds to the poor farmers of Bangladesh, the supply of hybrid seed is a bluff. Obviously, it is difficult to prove or disprove a motive until it is realized.

2. Even if it is assumed that Grameen would ultimately push Monsanto's genetically engineered herbicide resistant seeds, then also choice remains on the farmers that whether they would buy the herbicide chemical also from Monsanto or any other company or use their traditional means for weeding their farms. Again, if both the seed and the herbicide would have to be bought as package, then also it would not be a very difficult arithmetic on part of the farmers to calculate which would be more cost effective. If they finds that the combined use of Monsanto's genetically engineered seeds along with the herbicide is not cost-effective then they will simply refuse to buy it, and would go back to their traditional seeds and method of farming. In that case whether genetic engineering is a evil technology or not is a redundant question.

3. In the second sentence there are two confusions. First it is stated that Monsanto's genetically engineered crops "are designed to use more agrichemicals". It implies that with a sinister aim of necessitating more agrichemicals these plants are designed. The fact is that these crops are designed to TOLERATE the herbicides which normally kill them along with the weeds, but with the tolerant variety farmers would be able to use the herbicide killing the weeds but not the crops. Another misinformation in the same sentence is that Monsanto's herbicide kills "anything green". A scary statement indeed. No, herbicides are not "agent orange". Herbicides kills herbs or weeds;

obviously not anything green. In that case they could not have been used by farmers for the last few decades, before the advent of genetically engineered herbicide resistant crops.

It is not clear from Shiva's argument whether killing of the weeds per se is an environment unfriendly act resulting in loss of biodiversity. If it is meant so then the farmers also should be discouraged to clean up the weeds even manually. If the use of the chemical per se is the environment unfriendly act then the problem is not the loss of biodiversity, it is in some other effects of the chemical. If any herbicide creates unwanted toxicity to human, animal, plant, fish or anything, besides killing the weeds then that chemical must be controlled by law. Biotechnology has nothing to do with it and the call for standing against genetic engineering makes no sense.

4. In the third sentence it is claimed that application of the herbicide would result in “destruction of the green vegetables that women collect from the fields.” Another exaggerated and confusing statement. It appears that the farmers are going to spray even the vegetable fields with the herbicide, killing all the green vegetables. Why should one spray herbicide in a vegetable field ? Now, if the men want to grow cotton in the most cost-effective manner and the women want to pick some green vegetables growing under the cotton plant then the solution is simple - they have to sit together and do the arithmetic – whether concentrating exclusively on cotton or allowing some green vegetables to grow in the cotton field would be more cost-effective. If the latter is more cost-effective then why should one use genetically engineered crops with herbicide ?

However, if a radical environmentalist demands that cleaning up the weeds in the crop field is an environment unfriendly act of wiping out biodiversity, and the farmer has no right to do it, then that is altogether a different story and genetic engineering has got nothing to do with it.

5. Now, taking into account all the cost of the farmer if it appears to the farmer that the combined use of Monsanto's genetically engineered seeds along with the herbicide is the most cost-effective option then s/he would consider biotechnology as a boon. Therefore, the farmer should have the right and opportunity to test the new seeds and methods and be the judge for him/herself.

Irrespective of the benefit or harm of the Grameen-Monsanto joint venture, what has been definitely violated by the pressure groups is the farmers' right to choose what would be beneficial for them.

It appears that the arguments are based on twisted representation of facts, misinformation and a number of assumptions as - Grameen would trick or force farmers to buy Monsanto's genetically engineered herbicide tolerant seeds along with the herbicide, farmers would be unable to understand what is really cost-effective for them, social or legal regulatory mechanism would not be sufficient to control the presumed environmental disaster. On such assumptions it is concluded that the Grameen-Mosanto joint-venture has to be prevented, genetic engineering must be stopped, etc. These hardly make a case against Grameen-Mosanto joint venture or biotechnology.

Even if it is assumed that by some tricky mechanisms of loans the farmers would be forced to buy genetically engineered seeds despite it being not the most cost-effective one, then also the problem is not in genetic engineering. The problem lies in the law, regulations and government. Then also, the call for standing up against biotechnology would be misguided and destructive activism. Rather one needs to change the laws, regulations and government.

RAFI (Rural Advancement Foundation International), a Canada based NGO declaring conservation of agricultural biodiversity as one of its commitments, argued more within the context of the Grameen-Monsanto deal. About the declared introduction of hybrid seeds, it argued:

"Yunus and Shapiro have said, however, that the joint venture will begin by selling hybrid seeds to poor farmers. Hybrid rice and maize are biologically incapable of breeding "true" in the second generation. The seeds are either sterile or they produce often unwelcome genetic "throwbacks". Although some scientists regard hybrids as a boon to crop yields, there is a growing opinion that the real advantage is that farmers are forced back to the market every year to buy new seeds. Traditionally, Bangladeshi rice farmers - among the poorest of the poor - not only save seed for replanting, but women breed diverse seed types in order to have varieties suited to their immediate ecosystems and economies. Hybrid seeds could more than quadruple seed costs as well as end forever the process of poor farmers

adapting plants to their resource-poor soils. "It doesn't take many years of buying new seed before the traditional varieties lose their germination level or are eaten." (RAFI 1998a)

If the diverse seed varieties bred by women are more "suited to their immediate ecosystems and economics" than the foreign/artificial/hybrid varieties then why should the farmers go back to the market every year to buy new seeds with quadruple price? Unless one assumes the farmers to be idiots. A difficult choice would arise when a hybrid variety is suited to economics but not to the ecosystem. However, to consider such cases one needs to provide specific data about specific variety of crops. General sweeping out of all hybrid varieties, for the excuse that farmers have to go back to the market every year to buy new seeds, would be totally irrational.

Pat Mooney, RAFI's Executive Director notes, "Trying to get off the Grameen-Monsanto treadmill of seed purchases is impossible once the old seeds die." Hope Shand, RAFI's Research Director agrees, "We'll lose both farmers and a lot of crop genetic diversity." [Grameen Bank and the Monster, <http://www.rafi.org> 5 Aug 1998]

Well, if the "the Grameen-Monsanto treadmill of seed purchases" are more beneficial to the farmers then why should they care about the death of old seeds. Why should the poorest of poor farmers of Bangladesh have to lose their money to keep up the useless "genetic diversity"? On the other hand, if the diversity is useful then why would they let it die?

Now, my question is that whose purpose is served by this cry of "genetic diversity" ? Is it for the poor farmers of the "third world" or for the fashionable environmentalists of the "first world" ?

I would also add another point in favor of developing high-yielding variety of crops, hybrid or whatever. Say for example we are now sufficient in rice. Now, if another variety is generated that yields twice as high as the present one per acre of land then we have to cultivate half as much land as before for rice farming. That would release half of our lands free. This means chances of growing other varieties of plants would increase, resulting in increased biodiversity.

RAFI also argued from the suspicion, "While Monsanto has stated that it would not provide transgenic seed because Bangladesh does not have a regulatory framework for the approval of genetically-modified organisms, the Grameen/Monsanto announcement was expected to put political pressure on the government to adopt biosafety rules amenable to Monsanto's extensive line of herbicide-tolerant crops. (RAFI 1998b).

These arguments of "political pressure", "bribing the government", "revolving door tactics", are very popular among the radicals. These arguments, of course, have some truth in them. Private companies use every means to influence government. It is true from USA to Bangladesh. But no matter how much truth is there, the solution can not be in elimination or total blockage of the activity of private companies or government. That is a sort of a solution like cutting off your head when you have a headache. With regards to the Grameen-Monsanto biotechnology venture our radicals did exactly so.

If we resort to this sort of solutions then we have to eradicate all the private enterprises from our land, no matter indigenous or foreign, national or transnational. If killing is the solution against Monsanto then what would we do with Glaxo, Beximco, and so many others ? Are their profiteering characteristics any different from or are they more honest and philanthropic than Grameen and Monsanto ?

Private and semi-government enterprises, including Foreign Direct Investment (FDI), have gained now worldwide acceptance. Even countries like China and India gave up their conservative policies after half a century of trial. If we care anything about technological development of our country then we have to welcome and encourage partnership with technologically leading foreign companies. We have to deal with them. There is no alternative. We can not reinvent modern technologies all alone.

Therefore, for protection of our environment or for the development of our people, eradication of technologies and private enterprises is not the solution. The solution must lie in appropriate regulation.

## Regulating Biotechnology

Genetic engineering is a powerful technology and like any power it has to be regulated. As I mentioned before, the very inventors of this technology were so frightened with its power that they immediately went for a self-imposed regulation. Interestingly, in the USA the scientists and research organization themselves came forward first to regulate the technology. The regulation in the first decade of the technology, although most stringent, was totally self-imposed by the scientists and research agencies. In late seventies US National Institute of Health formed a Recombinant DNA Advisory Committee (NIH-RAC) to oversee development in recombinant DNA research and refine regulations. The NIH-RAC also had no legal status. The legally authorized regulatory agencies as FDA, USDA and EPA appeared in the scene much later. (Glick & Pasternak 1998: 593-609)

More interesting, NIH-RAC did not keep the matters confined to the molecular biologists themselves, it arranged open meetings to discuss its decisions, it published and distributed the minutes of its meetings, and allowed any nonmember the opportunity to address the committee on any issue pertaining to recombinant DNA research. The membership of the NIH-RAC, although consisted mostly of scientists, included ethicists and members of the general public. When USDA and USEPA came into the scene they also made broad public contact in issues relating to GM organisms. This way of dealing the matter by the US scientists and government agencies might be one of the reason of gaining higher trust from people, compared to that in Europe, regarding biotechnology issues (Gaskell et al. 1999; Glick & Pasternak 1998: 593-609)

Therefore, I also would request first and foremost the scientists themselves to come forward and through interaction with broad sections of people draft regulatory principles for biotechnology in Bangladesh. We definitely do not need to wait for the government to do it.

I would recommend that:

A. A committee for making regulation policies should immediately be made.

B. The committee should include biotechnologists from its main subdivisions, viz. microbial, plant, animal and medical (human). The committee should also include representations from others disciplines and interests, particularly environmental, agricultural, industrial, legal, political, business, investment and economics experts. I would recommend that half of the committee should be comprised of biotechnology professionals and the other half from other disciplines and interest groups.

C. The committee should prepare regulatory rules for:

1. Handling of genetically modified organisms and recombinant DNA experiments in laboratories.
2. Transport of genetically modified materials.
3. Approval and marketization of foods, food ingredients, drugs and products from genetically modified sources, including human gene therapy.
4. Deliberate release of genetically modified organisms, including hybrid seeds in the open environment.
5. Import and export of GM organisms and/or products there from.
6. Liability and compensation for any harm that could be done by GM organisms and/or products there from.

The above task, although looks enormous, yet we need not have to spend much time and effort on them at this stage of our technology. The “Guidelines for Research Involving Recombinant DNA Molecules” has already been worked out in detail for the USA by US-NIH (1999); regulations for approval and marketization of foods, food ingredients, drugs and products from genetically modified sources have been made by USFDA (Maryanski 1995) and USDA (1999); rules and protocols for deliberate release of genetically modified organisms by USEPA (1997). So have been done by the EU.

We just need to review the laws and regulations promulgated by US and other technologically advanced countries and make necessary modifications and adaptations suitable for our country.

Like regulation for any other environmental and other issues, in case of biotechnology too, the government should not be the sole authority of regulation. Sufficient power should be decentralized and handed over to the people, so that regional and local bodies of people, including individuals do have the right and control over their interests and well being; and could make deal with threatening companies and agencies. Sufficient leverage should also be handed over to the judicial system, so that people can sue against governmental negligence, irresponsibility and corruption.

This is the high time to set up our own regulatory laws, as we are fortunate enough at least in one respect that transnational biotech giants are not in yet in Bangladesh. Therefore, our people have to face a less uphill battle against corporate interest. The duty lies first and foremost on the people of science and technology.

## **Conclusion**

All these controversy and upheaval proves that biotechnology is indeed a very powerful and revolutionary invention. The most hopeful message for us is that the research and experiments in it is not that expensive as with many other conventional technologies. Since this technology is still in its infancy we can still catch it up with an all out effort.

We also have to keep in mind that absolutely environmentally safe technology would be an impractical dream. In most circumstances we have to find a balance between technological benefit and environmental cost. Since, both technology and environment are for the wellbeing of the people at first. Therefore, if the people be in control then they would find the appropriate balance between environmental cost and benefit of any technology or process, including biotechnology.

Moreover, venturing a new thing always involves a higher risk, but it has higher benefit too. Those who take too much risk loses everything, and those take no risk drag behind all others.

Once we be able to take the calculated risk , put the effort and posses this revolutionary technology then it would all depend on us how would we use it. Surely an

advanced technology will open more options for improving various aspects of our life, including the environment.

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