Can Life be *Made*?
Can Life be *Owned*?

Biodiversity, Biotechnology and Patents

Vandana Shiva

Parisar Annual Lecture 1994
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The ethical and ecological issues emerging from genetic engineering and patents on life

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What is life?

The capacity to self-organise is the distinctive feature of living systems. Self-organising systems are autonomous and self-referential. This does not imply that they are isolated and non-interactive. Self-organised systems interact with their environment, but in autonomy. The environment only triggers the structural changes; it does not specify or direct them. It is the living system which specifies its structural changes and which patterns in the environment will trigger them. A self-organising system knows what it has to import and export in order to maintain and renew itself. It needs nothing else but reference to itself.

Living systems are also complex. The complexity of their structure allows for self-ordering and self-organisation. It also allows for the emergence of new properties. One of the distinguishing properties of living systems is their ability to undergo continual structural changes while preserving their form and pattern of organisation.

Living systems are also diverse. Their diversity and uniqueness is maintained through spontaneous self-organisation. The components of a living system are continually renewed and recycled with structural interaction with the environment, yet the system maintains its pattern, its organisation, its distinctive form.

Self-healing and repair is another characteristic of living systems that derives from complexity and self-organisation.

The machine and the organism: Engineering Vs Growing.

The freedom for diverse species and ecosystems to self-organise is the basis of ecology. Ecological stability derives from the ability of species and ecosystems to adapt,
evolve, respond. In fact, the more the degrees of freedom available to a system the more the self-organising expression a system has.

External control reduces the degrees of freedom a system has and reduces its capacity to organise and renew itself.

Ecological vulnerability comes from the fact that species and ecosystems have been engineered and controlled to such an extent that they lose capacity to adapt and evolve.

The Chilean scientists, Maturana and Varela have distinguished between two kinds of systems—autoapoietic and allopoietic. A system is autoapoietic when its function is primarily geared to self-renewal. An autoapoietic system refers to the first line to itself and is therefore called self-referential. In contrast, an allopoietic system, such as a machine refers to a function given from outside, such as the production of a specific output.1

Self-organising systems grow from within. They shape themselves from within outwards. Externally organised mechanical systems do not grow, they are made. Things that are made are put together from the outside.

Self-organising systems are distinct and multidimensional. They therefore display structural and functional diversity. Mechanical systems are uniform and unidimensional. They display structural uniformity and functional one-dimensionality.

Self-organising systems can heal themselves and adapt to changing environmental conditions. Mechanically organised systems do not heal or adapt, they break down.

The more complex a dynamic structure is, the more endogenously it is driven. Its change depends not only on its external compulsions, but on its internal conditions. Self-organisation is the essence of health and ecological stability of living systems.

When organisms and systems are treated as if they were ma-chines, and are mechanically manipulated to improve a one-dimensional function, including the increase in one-dimensional productivity, either the organisms immunity can decrease, and it becomes vulnerable to disease and attack by other organisms, or the organism becomes dominant in an ecosystem, and displaces other species, pushing them into extinction. Ecological problems arise from applying the engineering paradigm to life. This paradigm is being deepened through genetic engineering, which will have major ecological and ethical implications.

**Genetic Engineering and the Construction of the Reductionist Paradigm.**

Genetic engineering is based on a machine view of organisms. Reductionism is essential to the engineering approach to living systems.

The reductionist paradigm reduces, both literally and metaphorically, both culturally and materially, the diverse productivities and creativities of complex, self-organising living systems. By reductionism we mean the belief that the world is made up atomised fragments, which associate mechanistically to make larger systems. The atoms determine the system. The individual properties of the constituents are the causes and properties of the whole are effects of these causes. The internal relations are not considered in determining properties and processes.

In the mechanistic, reductionist model, the building blocks are atoms or substances or matter in the Cartesian sense of res-extensa. They have no internal relations. They are the nuts and bolts that make a machine. Nuts and bolts cannot evolve, they can merely be rearranged. In biology the mechanistic model has taken genes to be the atoms that constitute living systems. In this billiard ball model, the genes are assumed to be

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particles located on chromosomes, the genes make proteins, proteins make us, and the genes replicate themselves. In 1996, Muller, a forerunner of molecular biology had said in “The Gene as the Basis of Life”, that “the gene can be viewed as a biological atom, solely responsible for the physiological and morphological properties of life forms”.

Reductionism in biology is multifaceted. At the species level, this reductionism puts value only on one species, the humans, and generates an instrumental value for all other species. It therefore displaces and pushes to extinction all species that have no or low instrumental value to man. Monocultures of species and biodiversity erosion is the inevitable consequence of reductionist thought in biology, especially when applied to forestry, agriculture and fisheries. We call this first order reductionism.

Reductionist biology is increasingly characterized by a second order reductionism - genetic reductionism - the reduction of all behaviour of biological organisms including humans to genes. Second order reductionism amplifies the ecological risks of first order reductionism, while introducing new issues like patenting of life forms.

Reductionist biology is also an expression of cultural reductionism, since it devalues all forms of knowledge and ethical systems related to living organisms that are not reductionist. This includes all non-western systems of agriculture and medicine as well as all disciplines in western biology that do not lend themselves to genetic and molecular reductionism but are necessary for dealing sustainably with the living world.

As David Ehrenfeld has stated in “Forgetting”.

“We are on the verge of losing our ability to tell one plant or animal from another, and of forgetting how the known species interact among themselves and with their environment”.

Reductionism was promoted strongly by August Weismann, who nearly a century ago postulated the complete separation of the reproductive cells - the germ line - from the functional body, or soma. According to Weismann reproductive cells are already set apart in the early embryo, and they continue their segregated existence into maturity when they contribute to the formation of the next generation. This supported the non-heritability of acquired traits with no direct feedback from environment to heredity. The mostly non-existent “Weismann barrier” is still the paradigm used to discuss biodiversity conservation as “germplasm” conservation. The germplasm, Weismann had earlier contended, was divorced from the outside world. Evolutionary changes toward greater fitness meaning greater capacity to reproduce were the result of fortuitous mistake that happened to prosper in the competition of life.

A classic experiment of August Weismann a century ago was taken as proving the noninheritance of acquired characteristics. He cut off the tails of 22 generations of mice and found that the next generation was born with normal tails. The sacrifice of hundreds of mouse tails only proved that this class of mutilation in mice was not inherited.

This proposition that information only goes from genes to the body was reinforced by molecular biology and the discovery in the 1950s of the role of nucleic acid, placing Mendelian genetics on a solid material basis. Molecular biology showed a means of transferral of information from genes to proteins but gave no indication - until recently - of any transfer in the opposite direction. The inference that there could be none became what Francis Crick called the “central dogma” of molecular biology: “Once ‘information’ has passed into proteins, it cannot get out again.”

DNA is a dead molecule, among the most non-reactive, chemically inert molecules in the world. It has no power to reproduce itself. Rather, it produced out of elementary materials by a complex cellular machinery of proteins. While it is often said that DNA produces proteins, in fact proteins (enzymes) produce DNA.
Reductionism and biological determinism go hand in hand. Isolating the gene as a “master molecule” is part of biological determinism. The “central dogma” that genes as DNA make proteins is another aspect of this determinism. This dogma is preserved even though it is known that genes “make” nothing. As Lewontin has stated, “DNA is a dead molecule, among the most non-reactive, chemically inert molecules in the world. It has no power to reproduce itself. Rather, it produced out of elementary materials by a complex cellular machinery of proteins. While it is often said that DNA produces proteins, in fact proteins (enzymes) produce DNA. When we refer to genes as self-replicating, we endow them with a mysterious autonomous power that seems to place them above the more ordinary materials of the body. Yet if anything in the world can be said to be self-replicating, it is not the gene, but the entire organism as a complex system.”

Genetic engineering is taking us into a second order reductionism because not only is the organism perceived in isolation of its environment, genes are perceived in isolation of the organism as a whole. The doctrine of molecular biology is modelled on classical mechanics. The central dogma is the ultimate in reductionist thought.

At the very time that Max Planck, Niels Bohr, Albert Einstein, Erwin Schrodinger, and their brilliant colleagues were revising the Newtonian view of the physical universe, biology was becoming more reductionist. reductions in science division. The term was intended to capture the essence of the Foundations programme; its emphasis on the ultimate minuteness of biological entities.

The cognitive and structural reconfigurations of biology into a reductionist paradigm were greatly facilitated through the economically powerful Rockefeller Foundation. During the years 1932-1959 the Foundation poured about $25 million into the molecular biology program in the United States, more than one-fourth of the Foundation’s total spending for the biological sciences outside of medicine (including, from the early 1940s on, enormous sums for agriculture). The force of the Foundations molecular biology programme set the trends in biology. During the dozen years following 1953 (the elucidation of DNA structure) Nobel prizes were awarded to 18 scholars for research into the molecular biology of the gene, and all but one were either fully or partially sponsored by the Rockefeller Foundation under Weaver’s guidance.

The motivation behind the enormous investment in the new agenda was to develop the human sciences as a comprehensive explanatory and applied framework of social control grounded in the natural, medical, and social sciences. Conceived during the late 1920s, the new agenda was articulated in terms of the contemporary technocratic discourse of human engineering, aiming toward an endpoint of restructuring human relations in congruence with the social framework of industrial capitalism. Within that agenda, the new biology (originally named “psychobiology”) was erected on the bedrock of the physical sciences in order to rigorously explain and eventually control the fundamental mechanisms governing human behaviour, placing a particularly strong emphasis on heredity.

Yet if anything in the world can be said to be self-replicating, it is not the gene, but the entire organism as a complex system.
Heirarchy and inequality were thus "naturalised", as Lewontin states in his *Doctrine of DNA*.

"The naturalistic explanation is to say that not only do we differ in our innate capacities but that these innate capacities are themselves transmitted from generation to generation biologically. That is to say, they are in our genes. The original social and economic notion of inheritance has been turned into biological inheritance".¹¹

The conjunction of cognitive and social goals in reductionist biology had a strong historical connection to eugenics. However, by 1930 the Rockefeller Foundation had supported a number of eugenically directed projects. By the time of the inauguration of the "new science of man," however, the goal of social control through selective breeding was no longer socially legitimate.

Precisely because the old eugenics had lost its scientific validity, a space was created for a new program that promised to place the study of human heredity and behaviour on rigorous grounds. A concerted physicochemical attack on the gene was initiated at the moment in history when it became unacceptable to advocate social control based on crude eugenic principles and outmoded racial theories. The molecular biology program, through the study of simple biological systems and the analyses of protein structure, promised a surer, albeit much slower, way toward social planning based on sounder principles of eugenic selection.¹²

Reductionism was chosen as the preferred paradigm to economic and political control of the diversity in nature and society.

Genetic determinism and genetic reductionism go hand in hand. But to say genes are primary is more ideology than science. Genes are not independent entities but dependent parts of an entirety that gives them effect. All parts of the cell interact, and the combinations of genes are at least as important as their individual effects in the making of an organism.

More broadly, an organism cannot be treated simply as the product of a number of proteins, each produced by the corresponding gene. Genes have multiple effects, and most traits depend on multiple genes.

However, the linear and reductionist causality of genetic determinism is held on to, even though the very processes that make genetic engineering possible run counter to the concepts of "master molecules" and the "central dogma". As Lewin has stressed,

"Restriction sites, promoters, operators, operons, and enhancers play their part. Not only does DNA make RNA, but RNA, aided by an enzyme suitably called reverse transcriptase, makes DNA".¹³

The weakness of the explanatory and theoretical power of reductionism is made up by its ideological power and its economic and political hacking.

Some biologists have gone far in exalting the gene over the organism and demoting the organism itself to being merely a machine. The purpose, the sole purpose of this machine is its own survival and reproduction, or perhaps more accurately put, the survival and reproduction of the DNA that is said both to program and to "dictate" its operation. In Dawkins's terms, an organism is a "survival machine" - a "lumbering robot" constructed to house its genes, those "engines of self-preservation" that have as their primary property inherent "selfishness". "They are sealed off from the outside world, communicating with it by tortuous indirect routes, manipulating it by remote control. They are in you and in me; they

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created us, body and mind; and their preservation is the ultimate rationale for our existence".14

**Genetic Engineering and Ethics.**

When organisms are treated as if they are machines, an ethical shift takes place from intrinsic value to the instrumental value of life. This shift to instrumental value has further ethical implications in terms of increasing the vulnerability of organisms to disease. The manipulation of animals for industrial ends has already had major ethical, ecological and health implications. The reductionist, machine view of animals removes all barriers of ethical concern for how animals are treated to maximise production in a reductionist paradigm. The mechanistic view is the dominant mode for the industrial livestock production sector. For eg., a manager of the meat industry states that

The breeding sow should be thought of as, and treated as, a valuable piece of machinery, whose function is to pump out baby pigs like a sausage machine.15

However, treating pigs like machines has major impacts on pig behaviour and pig health, because pigs are living organisms, not machines. Pigs in animal factories have to have their tails, their teeth, their testicles cut off because they fight with each other and resort to what the industry calls "cannibalism". 18% of piglets in factory farms are chocked to death by their mother. 2.5% are born with congenital defects such as sprayed legs, no anus, inverted mammary glads. They are prone to diseases, such as "banana disease" (because stricken pigs arch their backs into a banana shape) or PSS (Porcine Stress Syndrome).

These stresses and diseases are bound to increase with genetic engineering as is already signalled in the pig with the human growth hormone, whose body weight is more than its legs can carry, or cows injected with bovine growth hormone.

The issues of health and animal welfare are intrinsically related to the ecological impact of the new technologies on the capacity of self regulation and healing.

The issue of intrinsic worth is intimately related to the issue of self-organisation. This is in turn related to healing.

In the making of the organism, the multiplying cells seem to be instructed as to their respective destinies, and they become permanently differentiated to compose organs. But the pattern or instructions for making the whole structure remain somehow latent. When a part is injured, some cells become undifferentiated to make new specialised tissues.16

There is thus a self directed capacity for restoration of pattern. The faculty of repair is in turn related to resilience.

When organisms are treated like machines, and manipulated without recognition of their self-organisedness of the organism, their capacity to heal and repair breaks down and they need increasing inputs and controls to be maintained.

**Redefining Biodiversity as “Biotechnological Inventions” and “Gene Constructs”.**

In 1971, General Electric and one of its employees, Ananda Mohan Chakravarty applied to the U.S. patent on a genetically engineered Pseudomonas bacteria.

Taking plasmids from three kinds of bacteria he transplanted them into the fourth. As he explained ‘I simply shuffled genes, changing bacteria that already existed’.

Chakravarty was granted his patent on the grounds that the microorganism was not a product of nature, but Chakravarty’s invention and therefore patentable. As Andrew Kimbrell, a leading U.S. lawyer recounts ‘In coming to its
precedent shattering decision, the court seemed unaware that the inventor himself had characterised his “creation” of the microbe as simply “shifting” genes, not creating life.

On such slippery grounds the first patent on life was granted and in spite of exclusion of plants and animals in U.S. Patent Law, the U.S. has since then rushed on to grant patents on all kinds of life forms.

Currently, well over 190 genetically engineered animals, including fish, cows, mice and pigs are figuratively standing in line to be patented by a variety of researches and corporations.

According to Kimbrell, the Supreme Court’s Chakravarty decision has been extended to be continued, up the chain of life. The patenting of microbes has led inexorably to the patenting of plants, and then animals.17

Biodiversity has been redefined as “biotechnological inventions” and “gene constructs” to make the patenting of lifeforms appear less controversial. These patents are valid for 20 years and hence cover future generations of plants and animals. However, even when scientists in universities or corporations shuffle genes, they do not “create” the organism which they patent.

Referring to the landmark Chakravarty case in the U.S. in which the court found that Chakravarty “has produced a new bacterium with markedly different characteristics than any found in nature....”, Key Dismukes, Study Director of the Committee on vision of the National Academy of Sciences in the U.S. said:

“Let us at least get one thing straight: Anand Chakravarty did not create a new form of life; he merely intervened in the normal processes by which strains of bacteria exchange genetic information, to produce a new strain with an altered metabolic pattern. “His” bacterium lives and reproduces itself under the forces that guide all cellular life. Recent advances in recombinant DNA techniques allow more direct biochemical manipulation of bacterial genes than Chakravarty employed, but these too are only modulations of biological processes. We are incalculably far away from being able to create life de novo, and for that I am profoundly grateful. The argument that the bacterium is Chakravarty’s handiwork and not nature’s wildly exaggerates human power and displays the same hubris and ignorance of biology that have had such devastating impact on the ecology of our planet.”18

This display of hubris and arrogance becomes even more conspicuous when the reductionist biologists who claim patents on life declare 95% DNA as “junk DNA”. This is not taken to imply DNA that is useless, but it merely means DNA whose function is not known. When genetic engineers claim to “engineer” life, they often have to use this “junk DNA” to get their results.

Take the case of Tracy, a “biotechnological invention” of the Scientists of Pharmaceutical Proteins Ltd.(PPL). Tracy is called a “mammalian cell bioreactor” because through the introduction of human genes, her mammary glands are engineered to produce a protein, alpha-1-antitrypsin, for the pharmaceutical industry. As Ron James, Director of PPL states, “The mammary gland is a very good factory. Our sheep are furry little factories walking around in fields and they do a superb job”.

However, while it is claimed that genetic engineers have created the “biotechnological invention”, the scientists at PPL had to use “junk DNA”, (DNA which scientists thought had no function at all) to get high yields of alpha-1-antitrypsin. As Ron James says, “We left some of these random bits of DNA in the gene, essentially as God provided it and that produced high yield”. However, in claiming the patent, it is the scientist who becomes God, the creator of the patented organism.

Further, the future generations of the animal are clearly not “inventions” of the patent holder, they are the product of the regenerative capacity of the organism. Thus, though the metaphor for patenting is “engineers” who “make machines”, of the 550 sheep eggs injected with hybrid DNA,

When property rights to life forms are claimed, it is on the basis of them being new, novel, not occurring in nature.

However, when environmentalists state that being “not natural”, genetically modified organisms (GMOS) will have special ecological impact, which need to be known, and assessed and for which the “owners” need to take responsibility, the argument is that there is
499 survived. When these were transplanted into surrogate mothers, only 112 lambs were born. Only 5 of these had incorporated the human gene into their DNA, of which only 3 produced alpha-1-antitrypsin in their milk, two of whom only delivered three grams of proteins per litre of milk, but Tracy, PPL's "sheep that lays golden eggs" produces thirty grams per litre.

One of the characteristics of reductionist biology is to declare organisms and their functions useless on the basis of ignorance of their structure and function. Thus, crops and trees are declared "weeds". Forests and cattle breeds are declared "scrub". And DNA whose role is not understood is called junk DNA. To write off the major part of the molecule as junk because our ignorance is to fail to understand biological processes 'Junk DNA' is playing an essential role. When 95% of the DNA has been declared as "junk", it is a mistake to be allowing patenting of life forms. The fact the Tracy's protein production increased with the introduction of junk DNA is an illustration of the PPL scientists ignorance, not of their knowledge and creativity. While genetic engineering is modelled on determinism and predictability, undeterminism and lack of predictability is a characteristic of human manipulation of living organisms. In addition to the gap between the projection and practise of the engineering paradigm is the gap between owning benefits and rewards and owning hazards and risks.

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However, when environmentalists state that being "not natural", genetically modified organisms (gmos) will have special ecological impact, which need to be known, and assessed and for which the "owners" need to take responsibility, the argument is that there is nothing new, or unnatural about gmos. They are natural, and hence safe. The issue of biosafety is therefore treated as unnecessary. Thus, when biological organisms have to be owned, they are treated as not natural, when the responsibility for consequences of releasing genetically modified organisms is to be owned, they are treated as natural. These shifting constructions of "natural" show that the science that claims the highest levels of objectivity is actually very subjective and opportunistic in its approach to nature.

The inconsistency in the construction of the natural is well illustrated in the case of manufacture of genetically engineered human proteins for infant formula. Gen Pharm, a biotechnology company is the owner of the world’s first transgenic dairy bull, called Herman. Herman was bioengineered by company scientists when in embryo to carry a human gene for producing milk with a human protein. This milk is now to be used for making infant formula.

The engineered gene, and the organism of which it is a part are treated as non-natural when it comes to ownership of Herman and his offspring. However, when the issue is safety of the infant formula containing this bio-engineered ingredient extracted from the udders of Herman’s offspring, the same company says, "We’re making these proteins exactly the way they’re made in nature". Gen Pharm's Chief Executive Officer, Jonathan MacQuitty would have us believe that infant formula made from human protein bioengineered in the milk of transgenic dairy cattle is human milk. "Human milk is the gold standard, and formula companies have added more and more (human-elements) over the past 20 years". Cows, women and children are merely instruments for commodity production and profit maximization in this perspective.

As though the inconsistency between the construction of the natural and novel in the spheres of patent protection and health and environmental protection was not enough, Gen Pharm, the “owner” of Hermann have totally changed the objective for making a transgenic bull. They have now got ethical clearance for using him for breeding on grounds that the modified version of the human gene for lactoferin might be of benefit to patients with cancer or AIDS. This change of direction has brought heavy criticism of both the company and the committee.

Patents also have other environmental consequences. While patents as rewards for innovation invoke the image of the solitary inventor, the reality is that is the owners of capital, not the creators of knowledge who get the patent rights. Patents are rewards for investment of capital, not for creativity per se.
The levels of failures in “engineering” life indicate that living organisms are not mere “machines”, and scientists are not their “makers”.

Patents encourage two forms of violence against living organisms. Firstly, they are linked to the manipulation of the organisms as if they were merely machines thus denying their self-organising capacity. Secondly by allowing patenting of future generations of plants and animals, patents on life forms deny the self-reproducing capacity of living organisms.

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The “returns on investment” logic that has guided the granting of patents to corporations who have invested large sums of money in the manipulation of living organisms also pushes the corporations to increase their returns on investment by increasing the role of the patented life form in production in the agricultural and pharmaceutical sector. On the one hand this carries the risk of increasing uniformity and monocultures, thus accelerating genetic erosion and pushing more species to extinction. On the other hand, as in the case of Tracy, it will aggravate the ecological costs that have already been recognised to be associated with factory farming.

There are many reasons why the IPRs claims on life forms based on a reductionist paradigm of biology are false.

In the case of genetically engineered organisms, a patent claim is based on the false assumption that genes make organisms and therefore makers of transgenic genes make transgenic organisms. This is false because genes do not make organisms. Proteins are not made by genes but by a complex system of chemical production involving other proteins. They cannot make themselves any more than they can make a protein. Genes are made by a complex machinery of proteins. It is also not genes that are self-replicating but the entire organism as a complex system.

Since the entire organism is self-replicating, and not the genes alone, relocating genes does not amount to making an entire organism. The organism “makes” itself. To claim that an organism and its future generations are products of an “inventor’s mind” needing to be protected by IPRs as biotechnological innovations amounts to denying the self-organising, self-replicating structures of organisms. Put simply, it amounts to a theft of nature’s creativity.

In the case of plants that are not genetically engineered, patents given for medical and agricultural uses are often based on a theft of knowledge from non-western cultures using non-reductionist modes of knowing.

Sir Walter Bodmer, the Director of the Imperial Cancer Research Fund and a major actor in the Human Genome Project told the Wall Street Journal that “the issue of ownership is at the heart of everything we do”. IPRs determine the issue of ownership.

IPRs also became basis of substituting ecological systems of sustainable production with non-sustainable systems that are ecologically destructive and disruptive.

Genetic engineering is often offered as a green alternative to the “Green Revolution”. However, just as the green revolution was found to be not green in its impact, the gene revolution will also not be green. Most of the work on genetic engineering in agriculture is on herbicide and pesticide tolerance, so that more chemicals will be used, not less. Even where the objectives of genetic engineering are crop improvement and productivity increase, the ecological consequences are not necessarily positive, as can be seen by looking closely at the concrete implications of transgenic crops.

**Redesigning God’s grain** -
**The Genetic Engineering of Amaranth**

Amaranth is an amazing grain which has been called as “ramdana”, “rajgira” or God’s grain. Its name is derived from the root *amar* — eternal, deathless. It has been grown access the country in traditional farming systems. I have seen it in “Navdanya” (nine seeds) fields in South India, growing in associa-
tion with field barns, castor, ragi, sorghum. In the Himalayan
region it grows with (mandua/ragi) or as part of the
baranaja(twelve grain) system. The twelve crops are:

1. Phapra  Fagophrum tataricumlesculenium
2. Mandua  Eleusine coracana
3. Marsha  Amaranthus frumentaceous
4. Bhat  Glycine soja
5. Lobia  Vigna catiang
6. Moong  Phaseolus mungo
7. Cahath  Dolichos bilorus
8. Rajma  Phaseolus vulgaris
9. Jakhia
10. Navrangi
11. Jowar  Sorghum vulgare, and
12. Urad  Phaseolus mungo

Amaranth is the world’s most nutritious grain. Its seeds,
which come in black, brown, red, gold and white can be popped,
ground, baked and cooked. Its leaves and stems are also tasty and
nutritious.

Not only does amaranth have nearly twice as much protein as
other cereals, it contains more dietary fibre than wheat, corn, rice
or soybeans. It is these excellent food qualities that earned for
amaranth the status of God’s own grain.

Although amaranth seeds are tiny, they occur in large num-
ber - up to half million per plant, so that a single seed head can
yield as much as a kilo. The wild, uncultivated plants yield about 3
tonnes per ha of seeds and vegetable yield of 4-5 tonnes dry
matter per ha. The plant is environmentally very resistant, has
high resistance to drought and has less than half the water
requirement of other cereals. It is also resistant to pests. In fact,
seeds of amaranth or marsha are used to protect stored grains in
northern regions. Yields and nutritive value of amaranth com-
pared to other cereals are given in Tables 1 and 2.

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<th>Grain</th>
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Source: USDA Agricultural statistics (1974)

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<th>Calories (crude)</th>
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<td>366 4-14%</td>
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<td>Oats</td>
<td>4</td>
<td>50</td>
<td>14-16%</td>
<td>384 2%</td>
<td>6-9%</td>
<td>4-5%</td>
</tr>
<tr>
<td>Rice</td>
<td>3</td>
<td>10</td>
<td>8%</td>
<td>353 1%</td>
<td>2-4%</td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td>3</td>
<td>16-34</td>
<td>12%</td>
<td>353 2-3%</td>
<td>6%</td>
<td></td>
</tr>
</tbody>
</table>
Compared to other cereals amaranth is a much richer source of calcium, iron and protein. Popped amaranth is made into ‘laddoos and chikkis’. It is a pseudo cereal and is eaten as a ritual food in India during fast. It is also eaten as porridge and chappati in the regions where it is cultivated. 50 to 80 per cent of the amaranth plant is edible. The nutritional quality of amaranth greens is similar to that of other vegetables. Due to its high dry matter content, an equivalent amount of fresh amaranth provides 2-3 times the amount of nutrients found in other vegetables. It is an important source of Vitamin A, the deficiency of which is the most serious nutritional deficiency in the tropics and leads to blindness of nearly half a million children each year in India alone. Leafy amaranth is also high in calcium and iron, making it very important for diets of women and children.

Due to its high nutrition and its environmental prudence, amaranth is an important crop for the recovery of sustainability in agriculture.

Since water, rather than land is the main limiting factor in agriculture, and since nutritive value rather than grain weight is what matters in meeting people’s nutrition needs, if productivity is measured in terms of nutrition per unit of water consumed, amaranth emerges as nature’s miracle of meeting human food needs.

In the Green Revolution strategy, grains like amaranth which would have been the best solution to the problem of hunger and malnutrition, were not merely neglected, they were displaced. With the growing awareness of the value of biodiversity, ‘ramdana’ or ‘God’s grain’ can once again take its rightful place in meeting human needs.

There are, however, two divergent approaches in using the miraculous properties of amaranth.

The first is exemplified in Navdanya, the agricultural biodiversity conservation programme that we launched a few years ago in different parts of the country. We are trying to reintroduce amaranth with farming systems and into diets. We are trying to conserve its diversity, as well as its role in food production and consumption route in which we are trying to simultaneously conserve the earth, conserve plant diversity as well as to protect the livelihoods of small peasants and the health of consumers.

There is a second route for the properties of the amazing grain. This is the engineering route, exemplified by genetic engineering to make transgenic crops.

Prof. Asis Datta of Jawaharlal University has filed a patent for transferring the gene that codes for protein in amaranth to other cereals like rice and wheat. The patent is held jointly by the Department of Biotechnology and Prof. Asis Datta. The patent will cover the isolation of the gene and delivery/transfer or ‘construct’ for transferring the gene into other crops. It will be applicable in the U.S. and Europe.

What does the patent for a transgenic crop using amaranth genes imply for biodiversity and human health and nutrition?

It has been claimed that transgenic crop will “enhance the protein level of edible oils.

However, to assess the impact of genetically engineering the amaranth’s high protein characteristics into other crops it is necessary to compare the nutrition of the transgenic crop with nutrition available from polycultures based on amaranth as well as the nutrition available from the amaranth.

Amaranth is not just a source of high protein. It has high calcium and iron too. These multiple and complex nutritional properties do not get transferred to the transgenic crop.

THE GENETIC REDUCTIONISM ON WHICH GENETIC ENGINEERING IS BASED, BY PLACING THE VALUE ON THE GENE THAT CODES FOR PROTEIN, TAKES AWAY VALUE FROM THE AMARANTH PLANT.

AMARANTH IS NO LONGER A “SACRED SEED”, GOD’S UNIQUE GIFT, BUT MERELY A SOURCE OF THE GENE WHICH CAN BE TRANSFERRED TO OTHER CROPS.
The development of transgenic crop with amaranth genes will lead to the displacement of amaranth itself as companies with investments in research and patents will have to promote the spread of the transgenes.

The genetic reductionism on which genetic engineering is based, by placing the value on the gene that codes for protein, takes away value from the amaranth plant. Amaranth is no longer a "sacred seed", God's unique gift, but merely a source of the gene which can be transferred to other crops. Cultivation, production and consumption of 'ramdana' or amaranth is no longer necessary because ex-situ gene banks can supply the seeds, from which the gene sequence can be cloned and transferred. Genotyping engineering that extracts and relocates the gene, also makes the whole plant and its cultivation dispensable valuing the protein coding gene disvalues all the other aspects of amaranth, its pest resistance, its drought tolerance. Amaranth is not just a source of protein in its grain. Its leaves are also edible and it is a very important source of vitamin A. Transferring the amaranth protein gene to rice for example, thus does not increase overall nutrition, it decreases it. Higher levels of nutrition, and diverse sources of nutrition are available directly from the amaranth plant, and its many associates in mixed cropping systems. Table 3 gives the nutritional context of Amaranth (A) Rice (B) and Transgenic Rice (B1) with Amaranth genes. A shift from A to B1 does not lead to a net gain but a net loss in nutrition. In addition, the transgenic rice will have none of the built in resilience of amaranth. It will be vulnerable to disease, pests and drought, thus requiring intensive chemical and intensive water use. Genetically engineering amaranth genes in rice will add to the environmental costs of agriculture, instead of reducing them. It will make agriculture non-sustainable rather than sustainable.

Table 3

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>B1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>3-22</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Calcium</td>
<td>25-389</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Protein</td>
<td>16-19%</td>
<td>8%</td>
<td>16-19%</td>
</tr>
<tr>
<td>Calories</td>
<td>366</td>
<td>353</td>
<td>353</td>
</tr>
<tr>
<td>Fibre</td>
<td>4-14%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Total Dietary</td>
<td>16-17%</td>
<td>2-4%</td>
<td>2-4%</td>
</tr>
</tbody>
</table>

A ———> B1 is not a net gain but a net loss.

As a technique, genetic engineering is very sophisticated. But as a technology for using biodiversity to meet human needs sustainably, it is clumsy. It wastes resources and creates ecological vulnerability without adding to the available nutrition. When the biodiversity base and human needs are taken into account, transgenic crops give us less, not more. They reduce biodiversity by displacing diverse crops and they reduce nutrition availability by destroying the diverse crops which are diverse sources of nutrition.

It is also claimed that the genetic engineering make "transgenic plants with a balanced

As a technique, genetic engineering is very sophisticated. But as a technology for using biodiversity to meet human needs sustainably, it is clumsy. It wastes resources and creates ecological vulnerability without adding to the available nutrition. When the biodiversity base and human needs are taken into account, transgenic crops give us less, not more.

Genetically engineering amaranth genes in rice will add to the environmental costs of agriculture, instead of reducing them. It will make agriculture non-sustainable rather than sustainable.
protein composition”. However, as we have seen, the nutritive level of transgenic rice is not more than that of amaranth nor is there any guarantee than the composition of transgenic rice will be more balanced for the crop, or for those who eat it. In balanced diets all sources of nutrition cannot come from one crop. People do not eat only rice. They eat rice with dal. The balance comes from the rice and dal mixture, not from rice alone. By trying to increase the protein content of rice through genetic engineering, dal as source of a balanced protein composition is being negated. In addition new health risks are being introduced through the transgenic crops. Genetic engineered foods have the potential of introducing new allergies. In addition, genetically engineered crops carry the risk of “biological pollution”, of new vulnerability of disease, of species becoming dominant in ecosystems, and of gene transfer from one species to another.

An experiment is currently being carried out by a Dr. Bishop in U.K. who has introduced scorpion genes into a virus to make an insecticidal spray for killing caterpillars. The transgenic virus is being assumed to be safe on grounds that it will not cross species boundaries for its target. However, enough examples exist of viruses and disease organisms finding new target species. Scientific evidence also exists of the creating of super viruses because of genetic engineering. Complacency on biosafety issues is therefore not justified on the basis of available scientific evidence.

A clearance has been given for the first trial with genetically engineered crops in India. The crops include tomato engineered with bacillus thurengesia (Bt) and hybrid brassica. There is already enough evidence that genetic engineering with Bt is contributing to resistance and is therefore not a sustainable route for controlling plant pests and disease.

The promised benefits of genetically engineered crops and foods is therefore illusionary and its potential risks are real.

The illusion of genetic engineering is, however, not merely at the systems level in food production and consumption. It is also at the scientific level. Genetic engineering offers its promises on the basis of genetic reductionism and genetic determinism. However, both these assumptions have been proven to be false through molecular biology research.

Celebrating and Conserving Life.

In the era of genetic engineering and patents, life itself is being colonised. Ecological action in the biotechnology era involves keeping the self organisation of living systems free - free of technological manipulations that destroy the self healing and self organisational capacity of organisms, and free of legal manipulations that destroy the capacities of communities to search for their own solutions for human problems from the richness of biodiversity that we have been endowed with.

There are two strands in my current work that responds to the manipulation and monopolisation of life. Through Navdanya, a national network for setting up community seed banks to protect indigenous seed diversity. We have tried to build an alternative to the engineering view of life and its diversity. Through the work on protecting the intellectual commons, either in the form of Seed Satyagraha launched by the farmers’ movement or in the form of the movement for common intellectual rights that we have launched with the Third World Network, we have tried to build an alternative to the paradigm of knowledge and life itself as private property.

It is this freedom of life and freedom to live that I increasingly see as the core element of the ecology movement as we reach the end of the millenium. And in this struggle I frequently draw inspiration from the Palestinian poem:
THE SEED KEEPERS

Burn our land
burn our dreams
pour acid on to our songs
cover with saw dust
the blood of our massacred people
muffle with your technology
the screams of all that is free,
wild and indigenous.
Destroy
Destroy
our grass and soil
raze to the ground
every farm and every village
our ancestors had built
every tree, every home
every book, every law
and all the equity and harmony.
Flatten with your bombs
every valley; erase with your edits
our past,
our literature; our metaphor
Denude the forests
and the earth
till no insect,
no bird
no word
can find a place to hide.
Do that and more.
I do not fear your tyranny
I do not despair ever
for I guard one seed
a little live seed
that I shall safeguard
and plant again

References:

5. Ibid p. 11.
11. Lewontin opcit p. 22.
15. L.J. Taylor, Export Development Manager, Wall Meat Co., Ltd in David Coats, Old MacDonald’s Factory Farm, p. 32.
20. RAFI Communicute, June 1993, Ontario, Canada.
Dr. Vandana Shiva is perhaps one of the most acclaimed environmentalists in the country today. She was born in 1952, did her schooling in Chandigarh, Punjab and obtained an MSc in Particle Physics from the Punjab University. She then moved to Canada, where she did her doctoral work in the Philosophy of Science at the University of Ontario in 1978. Dr. Shiva has held various appointments since then in India and abroad, including teaching positions at the Universities of Guelph and Ontario, Canada. The Schumacher College, The Oslo University, The United Nations University, The Indian Institute of Management Bangalore. At present she heads the Research Foundation for Science, Technology and Natural Resource Policy at Dehra Dun, U.P.

Dr. Vandana Shiva has eleven books and over seventy papers to her credit. “Staying Alive: Women, Ecology and Survival in India” and “The Violence of the Green Revolution: Ecological Degradation and Political Conflict in Punjab” are among her most widely read books. She has travelled extensively and contributed to numerous national and international conferences on environment and development. She has won many honours, including the prestigious Alternative Nobel Peace Prize and the Order of The Golden Ark in 1993.

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