Seedling

Biodiversity, Rights and Livelihood

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GRAIN
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Genetic Resources Action International (GRAIN) is an international non-profit organisation which promotes the sustainable management and use of agricultural biodiversity based on people's control over genetic resources and local knowledge. To find out more about GRAIN, visit our website at www.grain.org

Seedling

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Back cover picture: © Crispin Hughes / Panos Pictures. Near Ntcheu, Malawi. Farmer waiting for the rains in order to sow her seeds.

Blinded by the gene

GRAIN

Earlier this year, the scientific community celebrated the 50th anniversary of the discovery of the structure and function of DNA by Watson and Crick. There was a host of parties, conferences and special issues. Fifty years ago when the 'secret of life' was unveiled, expectations were high that this milestone discovery had given us the key to understanding the laws of heredity …. and the power to change them. Fifty years later, many believe we have now reached that point. Scientists are now able to move genes – and the inherited traits they code for – with apparent ease between species, families and kingdoms.

Watson and Crick's interpretation of how genetic information is translated and passed on is simple and straightforward: DNA is the master molecule that embodies all genetic information of any living being – be it a bacterium, an animal or human being – and rules its expression in the organism and its transmission to the next generation. Inheritance is a simple and unidirectional process, with DNA as the master-molecule transmitting and directing the biological functions of all living beings. The developers of this theory coined it the *"Central Dogma"*, and this Dogma is still the backbone of molecular biology today. It is also the basis on which today's multi-billion genetic engineering industry is built. If genes form the universal code of life, they can surely be slotted into plants, animals and – yes, why not? – humans, to produce the desired effect. Scientists went to work to develop techniques to move genes around. So now we have pigs with genes from cows producing bovine growth hormone, plants with genes from bacteria producing natural pesticides, and bacteria with human genes to produce insulin. So if the trick works, what is the problem?

The problem is that the trick doesn't work. Or at least not the way it should. As Barry Commoner explains on page 6 in this *Seedling*, the incompleteness of the Central Dogma became dauntingly clear when the deciphering of the human genome was finally published in 2001. It turns out that the entire human genome consists of 30,000 genes, less than one third of the number originally calculated to take into account the number of different proteins and inherited traits that humans have. So we have more proteins than genes. If that is the case, what instructs the building of proteins that do not have a corresponding gene? The only logical conclusion is that each gene is responsible for a whole range of different proteins and traits and/or that other regulatory mechanisms exist in protein production.

Recent research has shown that both these conclusions are true. It is now known that proteins themselves help define what other proteins are going to do by influencing their three dimensional structure. It has also been established that there are many other types of genetic interactions in the cell, including those where proteins feed back information to DNA. It was also recently found that the parts of DNA that did not seem to code for any protein production (and therefore arrogantly called 'junk DNA' by the decoders of the human genome), do produce molecules that interfere with protein production and are therefore an essential part of the cell's regulatory system.

Death of the Dogma?

The Central Dogma was useful to explain the basic functioning of the DNA 50 years ago, but is totally outdated in the light of recent research in the areas of molecular biology, cell physiology and other scientific disciplines. This conclusion should have delivered a devastating and mortal blow to the Central Dogma on its 50th anniversary. We should have seen a challenging discussion amongst scientists on how to move on from here – how to further our understanding of the complexities of the functioning of the cell and the laws of hereditary. And we should have seen a final and collective funeral of the Central Dogma, which was long overdue. But this did not happen. Why?

"We should have seen a final and collective funeral of the Central Dogma, which was long overdue"

Because there is a multi-billion dollar industry that clings tightly to the 50-year-old Dogma as the fundamental principle on which it generates its revenues. Genetic engineering – the moving of genes from one organism to another – only makes sense if you believe in the sole supremacy of DNA, in the dominance of the gene. It only makes sense if you discount all other scientific observations which complicate the hereditary process as interesting but irrelevant. And it only makes sense if you are prepared to consider the thousands of 'abnormalities' resulting from genetic engineering as the consequence of the usual margin of error in research, rather than an indication that something might be fundamentally wrong with the theory.

Private interests take over

If the main objective of research is not to further scientific knowledge but to make money, complexities in the functioning of genes are unwelcome distractions. Companies involved in genetic engineering need to be able to assure their clients and regulatory authorities that the transgenic crops and animals they sell will do exactly what they were designed to do: tolerate herbicides, kill off insect pests or produce specific molecules. They need a theoretical foundation that explains precisely – and predictably – how the new gene will behave in the new host. They need the Central Dogma.

This is probably the main reason why the mounting evidence that questions the simplistic 'one gene, one trait' logic is still being ignored by the majority of the scientific establishment.

At the time that Watson and Crick published their findings, the vast majority of plant breeders were working in the public sector. This is a situation that has drastically changed in the past few decades. By the mid-1990s in the US, there were twice as many plant breeders active in the commercial sector than in universities and government agencies combined. This imbalance is fast shifting further towards the private sector: in that same period public plant breeding lost 2.5 scientists per year, while the private sector witnessed a growth of 32 scientists per year[1] – a process that has only accelerated since then. Meanwhile, the corporations behind genetic engineering moved into high gear. Since the mid-1990s a tremendous wave of corporate concentration means that now a mere handful of corporate giants – Monsanto, Syngenta, Bayer and Dupont – control the bulk of all commercial crop research and development This shift has had an important impact on agricultural research more broadly, with scientists in public and private research looking to the enticing shortcuts offered by genetic engineering, to the detriment of conventional plant breeding.

Most people in the private sector are quick to point out that genetic engineering needs plant breeding to deliver the seeds to the farmer, and that it is just one tool in the toolbox of the plant breeder. But there is an ever-widening gap between the worlds of genetic engineering and plant breeding, and plant breeders are becoming an endangered species. Funding for conventional plant breeding is drying up fast, especially in industrialised countries. *"Plant breeding is getting dumped along the wayside for not being sexy enough"* claims Greg Traxler, a US agricultural economist.[2] It is the combination of a ruthless privatisation process and a reckless betting on an outdated Central Dogma that now diverts the bulk of the financial and intellectual investment in crop improvement towards genetic engineering.

The adoption of increasingly strict Intellectual Property Rights (IPR) regimes – especially in industrialised countries – has been the crucial enabling factor in this process. Both a cause and a consequence of the privatisation process, the introduction of plant variety protection regimes in the 1970s and the awarding of patents on life forms in the 1990s transformed genes into commodities by allowing companies to own and monopolise them. Initially applauded by many plant breeders as due recognition of their hard work, their mood

[1] Steven Price, *Nature Biotechnology*, No. 10, p 938, October 1999.

[2] Jonathan Knight, "Crop improvement: a dying breed," *Nature* 412, pp 568-570, 6 February, 2003.

is now turning as the consequences become clear: *"Plant variety protection was the death knell for public breeding programmes"* now admits Michael Gale of the John Innes Centre, Britain's leading public plant-science research institute.[3]

The situation is getting to a point where even highly respected and otherwise conservative institutions such as the Royal Society – the UK's National Academy of Science – are raising the alarm. In presenting their report on the impact of IPRs on scientific development, they denounce the 'gold rush mentality' that now dominates in genetic research.[4] The new slogan of molecular geneticists seems to be 'Who gets there first, gets the gene'. In this climate of rampant privatisation, monopoly control and the staking of the claims to the genome, scientists seem to have lost the interest or capacity to incorporate the latest scientific developments into their thinking. Neither do they seem to recognise that the push towards transgenic agriculture is based on an outdated theory of the laws of heredity.

Solving the hunger problem

With the scientific basis of their work flawed, and hardly any practical results to show off, the gene giants urgently needed an ideological basis to defend their investments in genetic engineering. They found it in the 800 million or so people that go hungry every day. Coming from nowhere – the role of the private sector in agricultural research in developing countries has traditionally been close to zero[5] – a battle is now being waged to conquer the markets and the farmers fields in the Third World for transgenic agriculture. The argument being put forward is that we now finally have a great new tool – genetic engineering – to help combat hunger.

Hardly a week goes by without some flashy conference in some capital city in the South that bring together the nations scientists and policy makers to discuss how to reap the benefits of this new revolution for the poor. Invariably a small army of scientists from Monsanto, Syngenta or some US or European research centre paint a rosy international picture. National scientists are brought in to tell the story of how genetic engineering should be applied at the national level. Complementing this is a bewildering myriad of new acronyms, (ABSP, ABSF, BIO, ISAAA….the list goes on) representing institutions funded by industrial interests specifically set up to impose genetic engineering on the South.

Solving hunger has never been the business of the transnational corporations now behind genetic engineering, and never will be. A simple reminder about where and how transgenic crops are being used – and who is behind them – shows what is really at stake (see box). The picture emerging is one of a handful of extremely powerful corporations developing less than a handful of crops in a handful of countries, mostly for animal feed and export markets. Hardly a picture that addresses the complexity of the world food problem.

An accompanying and worrisome trend is that the world's public agricultural research institutions are increasingly getting pulled into these developments. Strapped for cash through budget cuts and structural adjustment programmes, they are increasingly joining the flight towards genetic engineering. The International Agricultural Research Centres – the movers and shakers behind the Green Revolution – are now looking for a place to hide in the genetic turmoil. Their stated mandate *is* to deal with hunger around the world. But after decades of failing to link in with the concerns and needs of peasant farmers that produce most of the food in the South, and after many years of resulting budget cuts from their donors, the only place they have left to go is to cut deals with corporations to get a slice of the biotech cake. By doing this, they risk not only becoming even less relevant to farmers in the South, but also becoming part of the problem rather than the solution.

The same is happening with the UN agency responsible for food and agriculture around the world: the Food and Agriculture Organisation (FAO). Traditionally a place where developing country governments had a political platform to debate issues of their concern, this agency is fast succumbing to pressure from industrialised governments and corporations alike (see box over page). The FAO seems more focused on organising flashy conferences on biotechnology co-hosted by the major chemical companies, rather than searching

[3] *ibid.*

[4] The Royal Society, *Keeping Science Open: the effects of intellectual property policy on the conduct of science.* London, April 2003. www.royalsoc.ac.uk/

[5] According to an IFPRI study, on average private agricultural R&D in developing countries amounts to less than 6% of the total R&D in agriculture. See: PG Pardey and NM Beintema, *Slow Magic – Agricultural R&D a Century After Mendel?* IFPRI, Washington 2001.

The state of GM crops in 2002:

- More than 90% of commercially grown GM crops represented just 4 crops: canola, soybean, cotton and maize – the bulk of which are being grown for export, not for food.
- More than 90% of commercially grown GM crops in the world are grown in just 4 countries: the US, Canada, China and Argentina – largely serving (with the possible exception of China) the export and cattle feed market.
- Virtually all commercially grown GM crops come from one corporation – Monsanto - which together with a few other gene giants (Dupont, Syngenta, Bayer and Dow) command most of all crop transgenic research in the world.
- Virtually all these crops are engineered for just two traits: resistance to herbicides and the incorporation of the toxic Bt gene – supposedly to hive off insects.

"No single organisation is capable, single-handedly, of meeting the challenge of feeding the planet's 840 million hungry. Public and private sectors must join forces with national and international organisations. We must be willing to share responsibilities, risk and resources to achieve shared objectives. There is now both a moral imperative and an economic obligation to build a joint coalition, where international organisations, governments and the private sector work side by side to span the divide between rich and poor."
Jacques Diouf, Director-General of FAO. FAO Press release June 2003

for sustainable alternatives. The FAO is increasingly becoming a central conduit for the entry of genetic engineering and the corporations behind it to developing countries. A similar trend can be seen at the national level in many countries in the South, where agricultural research institutions – stripped of cash and recognition – are increasingly entering into 'partnership' agreements with corporations and foreign research partners. Who can blame them for getting sucked into the glamorous world of genetic engineering where funding is abundant and international recognition is assured?

Apart from sidestepping the real causes of hunger in the world – and by drawing away political attention and funding from them – these initiatives that push genetic engineering do something even more alarming: they bring a potentially dangerous technology based on an outdated genetic theory into the heart of the world's centres of crop diversity.

Broaden the focus

We cannot escape the conclusion that marriage between a simplistic, outdated concept of genetics and a powerful capital-driven conglomerate of industrial interests is propelling us speedily away from much-needed efforts to develop solutions with farming communities and policy makers to address the food problem.

We need to refocus. We need to get beyond our obsession with the gene. An increasing number of scientists are arguing that it is time to move away from the Mendelian pedigree breeding approach, which focuses on uniform varieties carrying specific genes to the next generation and eliminating others. Instead, the starting point should be the farmer's field, where desired traits are incorporated into all the plants of a crop, in all its genetic diversity. The entire population is screened to isolate a small majority of plants with the best traits to be used in the next breeding cycle. This *"population breeding"* approach – which is actually something that farmers have been doing for millennia – is often considered a nightmare by industrial plant breeders who are used to working with uniform pure lines. But it is an approach that delivers durable genetic improvement – more durable than single gene approaches, be they genetically engineered or not. And it is an approach that costs nothing. Farmers don't need a company to do the breeding for them, they can do it on their own farms.

One of the pioneers in this field was Melaku Worede, who back in the 1980s led Ethiopia's National Genetic Resources Centre towards an innovative approach that consisted of giving the materials in his genebank back to farmers for them to experiment with. It yielded spectacular results.[6] More recently, scientists have further developed the argument against single gene breeding approaches, because of their role in drastically increasing pesticide use around the world. Farmers in Mexico managed to triple bean yields using basic population breeding methodologies within just two breeding cycles, and managed to eliminate the use of pesticides in the process.[7] The key element in this strategy was to keep biodiversity in the farmer's field and work with it there.

But the question we really need to ask ourselves goes beyond the issue which type of plant breeding to apply. It is about addressing the whole gamut of issues that peasant farmers face – in all its complexity – in their food production systems. In most cases the challenges they face have nothing to do with agronomy, but are about access to land, markets and credit, or are framed by labour issues and gender aspects. But when agronomic questions do come in to play, it is very often not the genetic potential of the crops and animals that is the most limiting factor. Instead farmers talk about soil fertility, agroecology, integrated crop management, or water retention and supply.

Genetic myopia

The focus on genetics has made many scientists and policy makers blind to other approaches and technologies to work on productivity problems on the farm. This 'genetic fix' has dominated agricultural development thinking since the Green Revolution – and is now being reinforced by the hype around genetic engineering. We are being blinded by the gene.

The 'genetic trap' is probably a better description of that thinking. It has lead us to a situation where molecular genetics has become the King of Science – and biotechnology the Mother of all Technologies – to the detriment of other much needed scientific disciplines and technological approaches. Go and visit some of the national agricultural research institutes across the world in Kampala, Los Baños,

[6] Melaku Worede, "Ethiopia: a genebank working with farmers." In: David Cooper *et al Growing Diversity,* IT publications, London, 1992

[7] Raoul Robinson, *Return to Resistance: Breeding Crops to Reduce Pesticide Dependence,* IDRC, Canada, 1995. For the Mexico case, see: www.idrc.ca/books/reports/1996/18-01e.html

Lima, or Wageningen. Talk to the people working on soil fertility, rotation techniques, crop ecology, multicropping, integrated past management, or farming systems. Most likely, you will hear them complaining bitterly about not being able to move on, having no staff, no budget for field work, and no research equipment. If you press them a bit, you'll also hear that they feel they have no status, that their work is being looked down on.

Then cross the campus and visit the molecular biology department or the recently opened biotechnology division. You'll be greeted by fully stocked and staffed laboratories, researchers busy writing for prestigious scientific journals or running around to international conferences. You'll probably see large logos and advertisements from some of the big biotech companies in recognition of a joint project or funding agreement. The atmosphere will be bubbling with energy and swimming in support. But it is the agroecologists, the soil fertility scientists and the researchers looking into integrated pest management that are likely to make a more relevant contribution to make to farmers in their country. Especially if they work with farmers using participatory methodologies (see p 23). Hidden from the gene glamour, this is where some of the most spectacular results are being achieved (see box). And it is here that, intellectually and scientifically, the most exciting discoveries are being made.

The picture emerging is one of two totally different ways of doing agriculture, of producing the food we eat – one led by corporations and one by farmers. There are also two totally opposed ways of supporting that agriculture with research. The gap between them is increasing, to the extent that there are hardly any crossover points left. We have some important choices to make before the foundations of agriculture crumble beyond repair.

Increasing productivity ... sustainably

A few years ago, Jules Pretty and his colleagues from the Essex University in the UK launched an ambitious project to audit progress towards sustainable agriculture in the world. They compiled a database of 208 cases from 52 countries, involving 9 million farmers and 29 million hectares – all involved in sustainable agriculture projects and experiments. The documentation shows that, without genetic engineering or institutional plant breeding, tremendous achievements in productivity and sustainability can be made. Examples include:

- Some 223,000 farmers in southern Brazil using green manures and cover crops of legumes and livestock integration have doubled yields of maize and wheat to 4-5 tons per hectare.
- Some 45,000 farmers in Guatemala and Honduras have used regenerative technologies to triple maize yields to 2 - 2.5 tons per hectare and diversify their upland farms, which has led to local economic growth and encouraged migration back from the cities;
- More than 300,000 farmers in southern and western India farming in dryland conditions are now using a range of water and soil management technologies, have tripled sorghum and millet yields to 2 - 2.5 tons/hectare.
- Some 200,000 farmers across Kenya, as part of various government and non-government soil and water conservation and sustainable agriculture programmes, have more than doubled their maize yields to about 2.5 - 3.3 tons per hectare and substantially improved vegetable production through the dry seasons.
- 100,000 small coffee farmers in Mexico who have adopted fully organic production methods and increased yields by half.
- A million wetland rice farmers in Bangladesh, China, India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand and Vietnam have shifted to sustainable agriculture, where farmers at farmer-field schools have learnt about alternatives to pesticides while still increasing their yields by about 10%.

Source: Jules Pretty, 'Feeding the world' – In: 'SPLICE', August/September 1998, Volume 4, Issue 6. For the full study, see: www2.essex.ac.uk/ces/ResearchProgrammes/CESOccasionalPapers/SAFErepSUBHEADS.htm

There is a crucial problem in molecular genetics and in its applications to agriculture, medicine and the production of pharmaceutical drugs. This science is based on a 50-year old theory that says DNA alone governs inheritance. Molecular genetics is now confronted with a growing disjunction between this widely accepted premise and an array of discordant experimental results that contradict it. But this disparity remains largely unacknowledged and experiments with transgenic plants and animals (many of which are not even recognised to be experiments) continue on a massive scale.

Unravelling the DNA myth

BARRY COMMONER

Biology once was regarded as a languid, largely descriptive discipline, a passive science that was content, for much of its history, merely to observe the natural world rather than change it. No longer. Today biology, armed with the power of genetics, has replaced physics as the Science of the Century, and it stands poised to assume godlike powers of creation, calling forth artificial forms of life. The initial steps toward this new Genesis have been widely touted in the press. It wasn't so long ago that Scottish scientists stunned the world with Dolly,[1] the fatherless sheep cloned directly from her mother's cells; these techniques have now been applied, unsuccessfully, to human cells. ANDi, a photogenic rhesus monkey, recently was born carrying the gene of a luminescent jellyfish.[2] Pigs now carry a gene for bovine growth hormone and show significant improvement in weight gain, feed efficiency, and reduced fat. Most soybean plants grown in the US have been genetically engineered to survive the application of powerful herbicides.

Our leading scientists and scientific entrepreneurs (two labels that are increasingly interchangeable) assure us that these feats of technological prowess, though marvellous and complex, are nonetheless safe and reliable. We are told that everything is

[1] I Wilmut *et al*, "Viable offspring derived from fetal and adult mammalian cells". *Nature* 385(6619):810-3, 1997.

[2] Chan *et al*, "Transgenic monkeys produced by retroviral gene transfer into mature oocytes". *Science,* 291:309-312, 2001.

under control. Conveniently ignored, forgotten, or in some instances simply suppressed, are the caveats, the fine print, the flaws and spontaneous abortions. Most clones exhibit developmental failure before or soon after birth, and even apparently normal clones often suffer from kidney or brain malformations.[3] ANDi, perversely, has failed to glow like a jellyfish. Genetically modified pigs have a high incidence of gastric ulcers, arthritis, enlarged hearts, dermatitis, and renal disease. Despite the biotechnology industry's assurances that genetically engineered soybeans have been altered only by the presence of the alien gene, the plant's own genetic system has been unwittingly altered as well, with potentially dangerous consequence.[4] The list of malfunctions gets little notice; biotechnology companies are not in the habit of publicising studies that question the efficacy of their miraculous products or suggest the presence of a serpent in the biotech garden.

The mistakes might be dismissed as the necessary errors that characterise scientific progress. But behind them lurks a more profound failure. The wonders of genetic science are all founded on the discovery of the DNA double helix – by Francis Crick and James Watson in 1953 – and they proceed from the premise that this molecular structure is the exclusive agent of inheritance in all living things: in the kingdom of molecular genetics, the DNA gene is absolute monarch. Known to molecular biologists as the *"Central Dogma,"* the premise assumes that an organism's genome – its total complement of genes – should fully account for its characteristic assemblage of inherited traits.[5] Since Crick first proposed it forty-four years ago, the Central Dogma has come to dominate biomedical research. Simple, elegant, and easily summarised, it seeks to reduce inheritance to molecular dimensions. The molecular agent of inheritance is DNA, deoxyribonucleic acid, a very long, linear molecule tightly coiled within each cell's nucleus (see diagram opposite). DNA is made up of four different kinds of nucleotides, strung together in each gene in a particular linear order or sequence. Segments of DNA comprise the genes that, through a series of molecular processes, give rise to each of our inherited traits.

But the premise of the Central Dogma, unhappily, is false. Tested between 1990 and 2001 in one of the largest and most highly publicised scientific undertakings of our time, the Human Genome Project, the theory collapsed under the weight of fact. There are far too few human genes to account for the complexity of our inherited traits or for the vast inherited differences between plants, say, and people. By any reasonable measure, the finding (published in February 2001) signalled the downfall of the Central Dogma. It also destroyed the scientific foundation of genetic engineering and the validity of the biotechnology industry's widely advertised claim that its methods of genetically modifying food crops are *"specific, precise, and predictable"*[6] and therefore safe. In short, the most dramatic achievement to date of the $3 billion Human Genome Project is the refutation of its own scientific rationale.

In 1990, James Watson described the Human Genome Project as *"the ultimate description of life"*. It will yield, he claimed, the information *"that determines if you have life as a fly, a carrot, or a man."* How could the minute dissection of human DNA into a sequence of 3 billion nucleotides support such a claim? Crick's crisply stated Central Dogma attempts to answer that question. It hypothesises a clear-cut chain of molecular processes that leads from a single DNA gene to the appearance of a particular inherited trait. Crick's second hypothesis neatly links the gene to the protein. This *"sequence hypothesis"* states that the gene's genetic information is transmitted, altered in form but not in content, though RNA intermediaries, to the distinctive amino acid sequence of a particular protein. It follows that in each living thing there should be a one-to-one correspondence between the total number of genes and the total number of proteins. The entire array of human genes must therefore represent the whole of a person's inheritance. Finally, because DNA is made of the same four nucleotides in every living

"Crick's theory is based on an extravagant proposition: that genes have unique, absolute, and universal control over the totality of inheritance in all forms of life"

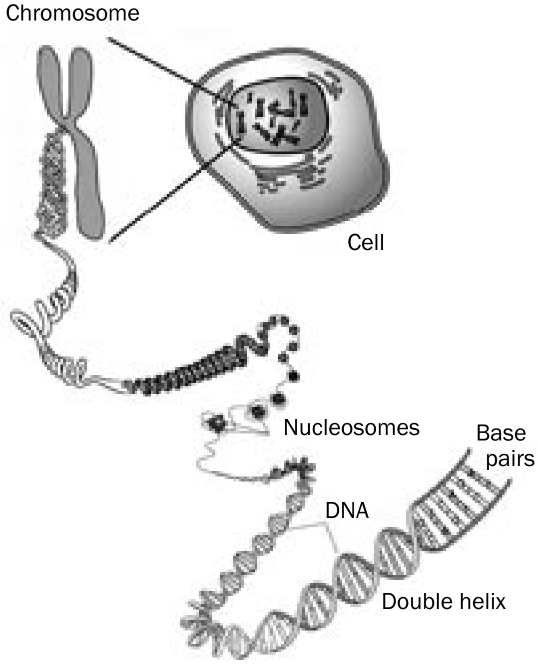


Diagram showing the organisation of DNA within a chromosome

[3] R Jaenisch and I Wilmut, "Don't clone humans". *Science* 291:2552, 2001.

[4] P Windels *et al*, "Characterisation of the Roundup Ready soybean insert". *Eur. Food Res. Technol.* 213:107-112, 2001.

[5] FHC Crick, "On Protein Synthesis". In: *Symposium of the Society for Experimental Biology XII,* p153. New York: Academic Press, 1958.

[6] P Gorner and R Kotulak, "Life by Design". *Chicago Tribune,* April 8, 1990

thing, the genetic code is universal, which means that a gene should be capable of producing its particular protein wherever it happens to find itself, even in a different species.

Crick's theory is based on an extravagant proposition: that genes have unique, absolute, and universal control over the totality of inheritance in all forms of life. According to Crick, genetic information originates in the DNA nucleotide sequence and terminates, unchanged, in the protein amino acid sequence. The pronouncement is crucial because it endows the gene with undiluted control over the identity of the protein and the inherited trait that the protein creates. To stress the importance of this genetic taboo, Crick bet the future of the entire enterprise on it, asserting that *"the discovery of just one type of present-day cell"* in which genetic information passed from protein to nucleic acid or from protein to protein *"would shake the whole intellectual basis of molecular biology."*[7] Crick was aware of the brashness of his bet, for it was known even then that in living cells proteins come into promiscuous molecular contact with numerous other proteins and with molecules of DNA and RNA. He insisted that these interactions are genetically chaste.

In February 2002, Crick's gamble suffered a spectacular loss. In the journals *Nature* and *Science* and at joint press conferences and television appearances, the two genome research teams reported their results. The major result was *"unexpected."*[8] Instead of the 100,000 or more genes predicted by the estimated number of human proteins, the gene count was only about 30,000. By this measure, people are only about as gene-rich as a mustard-like weed (which has 26,000 genes) and about twice as genetically endowed as a fruit fly or a primitive worm.[9] The surprising results contradicted the scientific premise on which the genome project was undertaken and dethroned its guiding theory, the Central Dogma. After all, if the human gene count is too low to match the number of proteins and the numerous inherited traits that they engender, and if it cannot explain the vast inherited difference between a weed and a person, there must be much more to Watson's *"ultimate description of life"* than the genes alone can tell us.

Scientists and journalists somehow failed to notice what had happened. The project's scientific reports offered little to explain the shortfall in the gene count. One of the possible explanations for why the gene count was *"so discordant with our predictions"* was described in *Science* as follows: *"nearly 40% of human genes are alternatively spliced."*[10] Properly understood, this modest, if esoteric, account fulfills Crick's dire prophecy: it *"shakes the whole intellectual basis of molecular biology"* and undermines the scientific validity of its application to genetic engineering. Alternative splicing is a startling departure from the orderly design of the Central Dogma, in which a single gene encodes the amino acid sequence of a single protein. In alternative splicing, the gene's original nucleotide sequence is split into fragments that are then recombined in different ways to encode a multiplicity of proteins, each of them different in their amino acid sequence from each other and from the sequence that the original gene, if left intact, would encode. Alternative splicing can have an extraordinary impact on the gene/protein ratio. The current record for the number of different proteins produced from a single gene by alternative splicing is held by the fruit fly, in which one gene generates up to 38,016 variant protein molecules.[11]

Alternative splicing thus has a devastating impact on Crick's theory: it breaks open the hypothesised isolation of the molecular system that transfers genetic information from a single gene to a single protein. It also contradicts the theory that proteins cannot transmit genetic information to nucleic acid (in this case, messenger RNA).[12] The discovery of alternative splicing also nullifies the exclusiveness of the gene's hold on the molecular process of inheritance. The gene's effect on inheritance thus cannot be predicted simply from its nucleotide sequence – the determination of which is one of the main purposes of the Human Genome Project.

By 1989, when the Human Genome Project was still being debated among molecular biologists, its champions were surely aware that more than 200 scientific papers on alternative splicing of human genes had already been published.[13] The shortfall in the human gene count could – and indeed should

[7] FHC Crick, The Central Dogma of Molecular Biology, *Nature* 227:561-563 (see p 563), 1970.

[8] International Human Genome Sequencing Consortium. "Initial sequencing and analysis of the human genome". *Nature* 409(6822): 860-921, 2001.

[9] C Venter *et al*, "The Sequence of the Human Genome". *Science* 291:1304-1351, 2001.

[10] *ibid*, p 1345.

[11] D Schmucker *et al*, "Drosophila Dscam is an axon guidance receptor exhibiting extraordinary molecular diversity". *Cell*, 101(6):671-84, 2000.

[12] CA Collins and C Guthrie, "Allelespecific genetic interactions ....." *Genes Dev*, 13(15):1970-82, 1999.

[13] Results of PubMed search for articles cont-aining "alternative splicing" AND "human".

– have been predicted. It is difficult to avoid the conclusion – troublesome as it is – that the project's planners knew in advance that the mismatch between the numbers of genes and proteins in the human genome was to be expected, and that the $3 billion project could not be justified by the extravagant claims that the genome would tell us who we are.[14]

Alternative splicing is not the only discovery over the last forty years that has contradicted basic precepts of the Central Dogma. Other research has tended to erode the centrality of the DNA double helix itself, the theory's ubiquitous icon. In their original description of the discovery of DNA, Watson and Crick commented that the helix's structure *"immediately suggests a possible copying mechanism for the genetic material."* Such self-duplication is the crucial feature of life, and in ascribing it to DNA, Watson and Crick concluded, a bit prematurely, that they had discovered life's magic molecular key.[15]

Biological replication does include the precise duplication of DNA, but this is accomplished by the living cell, not by the DNA molecule alone. In the development of a person from a single fertilised egg, the genome is replicated many billions of times, its precise sequence of three billion nucleotides retained with extraordinary fidelity.[16] The rate of error – that is, the insertion into the newly made DNA sequence of a nucleotide out of its proper order – is about one in 10 billion nucleotides. But on its own, DNA is incapable of such faithful replication. In a test-tube experiment, a DNA strand, provided with a mixture of its four constituent nucleotides, will line them up with about one in a hundred of them out of its proper place. On the other hand, when the appropriate protein enzymes are added to the test tube, the fidelity with which nucleotides are incorporated in the newly made DNA strand is greatly improved, reducing the error rate to one in 10 million. These remaining errors are finally reduced to one in 10 billion by a set of *"repair"* enzymes (also proteins) that detect and remove mismatched nucleotides from the newly synthesised DNA.[17]

Thus, in the living cell the gene's nucleotide code can be replicated faithfully only because an array of specialised proteins intervenes to prevent most of the errors – which DNA by itself is prone to make – and to repair the few remaining ones. In this sense, genetic information arises not from DNA alone but through its essential collaboration with protein enzymes – a contradiction of the Central Dogma's precept that inheritance is uniquely governed by the self-replication of the DNA double helix.

Another important divergent observation that in order to generate the inherited trait, the newly made protein, a strung-out ribbon of a molecule, must be folded up into a precisely organised ball-like structure. The biochemical events that give rise to genetic traits – for example, enzyme action that synthesises a particular eye-colour pigment – take place at specific locations on the outer surface of the three-dimensional protein, which is created by the particular way in which the molecule is folded into that structure. To preserve the simplicity of the Central Dogma, Crick was required to assume, without any supporting evidence, that the nascent protein – a linear molecule – always folded itself up in the right way once its amino acid sequence had been determined. In the 1980s, however, it was discovered that some nascent proteins are on their own likely to become misfolded – and therefore remain biochemically inactive – unless a special type of *"chaperone"* protein properly folds them.[18]

By the mid 1980s, long before the $3 billion Human Genome Project was funded, and long before genetically modified (GM) crops began to appear in our fields, a series of protein-based processes had already intruded on the DNA gene's exclusive genetic franchise. An array of protein enzymes must repair the all-too-frequent mistakes in gene replication and in the transmission of the genetic code to proteins as well. Certain proteins, assembled in spliceosomes, can reshuffle the RNA transcripts, creating hundreds and even thousands of different proteins from a single gene. A family of chaperones, proteins that facilitate the proper folding – and therefore the biochemical activity – of newly made proteins, form an essential part of the gene-to- protein process. By any reasonable measure, these results contradict the Central Dogma's cardinal maxim: that a DNA gene exclusively governs the molecular processes that give rise to a particular inherited trait. The DNA gene clearly exerts an important influence on inheritance, but it is not unique in that respect and acts only in collaboration with a multitude of protein-based processes that prevent and repair incorrect sequences, transform the nascent protein into its folded, active form, and provide crucial added genetic information well beyond that originating in the gene itself.

The credibility of the Human Genome Project is not the only casualty of the scientific community's stubborn resistance to experimental results that contradict the Central Dogma. Nor is it the most significant casualty. The fact that one gene can give rise to multiple proteins also destroys the theoretical foundation of a multi-billion dollar industry, the genetic engineering of food crops. In genetic engineering it is assumed, without adequate

[14] C Venter *et al,* "The Sequence of the Human Genome". *Science* 291:1304-1351, 2001.

[15] JD Watson and FHC Crick, "Molecular structure of nucleic acids: A structure for DNA". *Nature* 171:737-738, 1953.

[16] M Radman and R Wagner, "The High Fidelity of DNA Replication". *Scientific American,* August:40-46, 1988.

[17] B Commoner, "Failure of the WatsonCrick theory as a chemical explanation of inheritance". *Nature* 220:334-340, 1968.

[18] RJ Ellis and SM Hemmingsen, "Molecular chaperones", *Trends Bioch Sci.* 14(8):339-42, 1989.

experimental proof, that a bacterial gene for an insecticidal protein, for example, transferred to a maize plant, will produce precisely that protein and nothing else. Yet in that alien genetic environment, alternative splicing of the bacterial gene might give rise to multiple variants of the intended protein – or even to proteins bearing little structural relationship to the original one, with unpredictable effects on ecosystems and human health.

> **"The delay in dethroning the all-powerful gene led in the 1990s to a massive invasion of genetic engineering into American agriculture"**

The delay in dethroning the all-powerful gene led in the 1990s to a massive invasion of genetic engineering into American agriculture, though its scientific justification had already been compromised a decade or more earlier. Nevertheless, ignoring the profound fact that in nature the normal exchange of genetic material occurs exclusively within a single species, biotech-industry executives have repeatedly boasted that, in comparison, moving a gene from one species to another is not only normal but also *more* specific, precise, and predictable.

That the industry is guided by the Central Dogma was made explicit by Ralph Hardy, president of the US' National Agricultural Biotechnology Council and formerly director of life sciences at DuPont, a major producer of GM seeds. In 1999, in Senate testimony, he succinctly described the industry's guiding theory this way: *"DNA (top management molecules) directs RNA formation (middle management molecules) directs protein formation (worker molecules)."* [19] The outcome of transferring a bacterial gene into a maize plant is expected to be as predictable as the result of a corporate takeover: what the workers do will be determined precisely by what the new top management tells them to do. This version of the Central Dogma is the scientific foundation upon which each year billions of transgenic plants of soybeans, maize, and cotton are grown with the expectation that the particular alien gene in each of them will be faithfully replicated in each of the billions of cell divisions that occur as each plant develops; that in each of the resultant cells the alien gene will encode only a protein with precisely the amino acid sequence that it encodes in its original organism; and that throughout this biological saga, despite the alien presence, the plant's natural complement of DNA will itself be properly replicated with no abnormal changes in composition.

In an ordinary unmodified plant the reliability of this natural genetic process results from the compatibility between its gene system and its equally necessary protein-mediated systems. The harmonious relation between the two systems develops during their cohabitation, in the same species, over very long evolutionary periods, in which natural selection eliminates incompatible variants. In other words, within a single species the reliability of the successful outcome of the complex molecular process that gives rise to the inheritance of particular traits is guaranteed by many thousands of years of testing, in nature. In a genetically engineered transgenic plant, however, the alien transplanted bacterial gene must properly interact with the plant's protein-mediated systems. Higher plants, such as maize, soybeans, and cotton, are known to possess proteins that repair DNA miscoding;[20] proteins that alternatively splice messenger RNA and thereby produce a multiplicity of different proteins from a single gene;[21] and proteins that chaperone the proper folding of other, nascent proteins.[22] But the plant systems' evolutionary history is very different from the bacterial gene's. As a result, in the transgenic plant the harmonious interdependence of the alien gene and the new host's protein-mediated systems is likely to be disrupted in unspecified, imprecise, and inherently unpredictable ways. In practice, these disruptions are revealed by the numerous experimental failures that occur before a transgenic organism is actually produced and by unexpected genetic changes that occur even when the gene has been successfully transferred.[23]

Most alarming is the recent evidence that in a widely grown genetically modified food crop - soybeans containing an alien gene for herbicide resistance – the transgenic host plant's genome has itself been unwittingly altered. Monsanto admitted in 2000 that its soybeans contained some extra fragments of the transferred gene, but nevertheless concluded that *"no new proteins were expected or observed to be produced."* [24] A year later, Belgian researchers discovered that a segment of the plant's own DNA had been scrambled. The abnormal DNA was large enough to produce a new protein, a potentially harmful protein.[25]

One way that such mystery DNA might arise is suggested by a recent study showing that in some plants carrying a bacterial gene, the plant's enzymes that correct DNA replication errors rearrange the alien gene's nucleotide sequence.[26] The consequences of such changes cannot be foreseen. The likelihood in GM crops of even exceedingly rare, disruptive effects of gene transfer is greatly amplified by the billions of individual transgenic plants already being grown annually in the US. The degree to which such disruptions do occur in GM crops is not known at present, because the biotechnology industry is not required

[19] RWF Hardy, In "Agricultural Research and Development", *Hearing before Senate Committee on Agriculture, Nutrition and Forestry.* Oct 6, 1999.

[20] N Tuteja *et al*, "Molecular mechanisms of damage and repair: progress in plants". *Crit Rev Biochem Mol Biol.* 36(4): 337-97, 2001.

[21] P Comelli *et al*, Alternative splicing of two leading exons partitions promoter activity....". *Plant Mol Biol.* 41(5):615-25, 1999.

[22] AA Lund *et al*, "Heat-stress response of mito-chondria", *Plant Physiol.* 116(3):1097-110, 1998.

[23] VG Pursel *et al*, "Integration, expression and germ-line transmission of growth-related genes in pigs". *Reprod Fertil Suppl.* 41:7787, 1990.

[24] Monsanto Product Safety Center. Confidential Report (MSL-16712). *Updated Molecular Characterisation & Safety Assessment of Roundup Ready Soybean Event 403-2.* Monsanto Company. St Louis, Missouri.

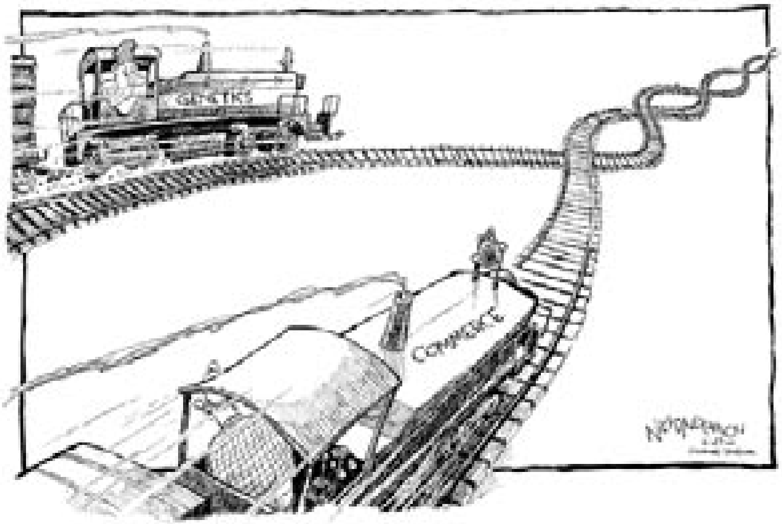
[25] P Windels *et al*, "Characterisation of the Roundup Ready soybean insert", *Eur Food Res Technol.* 213:107-112, 2001.

[26] A Kohli *et al*, "Transgene organisation in rice ....." *Proc Natl Acad Sci USA* 95(12): 7203-8, 1998.

to provide even the most basic information about the actual composition of the transgenic plants to the regulatory agencies. No tests, for example, are required to show that the plant actually produces a protein with the same amino acid sequence as the original bacterial protein. Moreover, there are no required studies based on detailed analysis of the molecular structure and biochemical activity of the alien gene and its protein product in the transgenic commercial crop. Given that some unexpected effects may develop very slowly, crop plants should be monitored in successive generations as well. None of these essential tests are being performed, and billions of transgenic plants are now being grown with only the most rudimentary knowledge about the resulting changes in their composition. Without detailed, ongoing analyses of the transgenic crops, there is no way of knowing if hazardous consequences might arise. Given the failure of the Central Dogma, there is no assurance that they will not. The GM crops now being grown represent a massive uncontrolled experiment whose outcome is inherently unpredictable. The results could be catastrophic.

Crick's Central Dogma has played a powerful role in creating both the Human Genome Project and the unregulated spread of GM food crops. Yet as evidence that contradicts this governing theory has accumulated, it has had no effect on the decisions that brought both of these monumental undertakings into being. It is true that most of the experimental results generated by the theory confirmed the concept that genetic information, in the form of DNA nucleotide sequences, is transmitted from DNA via RNA to protein. But other observations have contradicted the one-to-one correspondence of gene to protein and have broken the DNA gene's exclusive franchise on the molecular explanation of heredity. In the ordinary course of science, such new facts would be woven into the theory, adding to its complexity, redefining its meaning, or, as necessary, challenging its basic premise. Scientific theories are meant to be falsifiable; this is precisely what makes them scientific theories. The Central Dogma has been immune to this process. Divergent evidence is duly reported and, often enough, generates intense research, but its clash with the governing theory is almost never noted.

Because of their commitment to an obsolete theory, most molecular biologists operate under the assumption that DNA is the secret of life, whereas the careful observation of the hierarchy of living processes strongly suggests that it is the other way around: DNA did not create life; life created DNA.[27] When life was first formed on the earth, proteins must have appeared before DNA



because, unlike DNA, proteins have the catalytic ability to generate the chemical energy needed to assemble small ambient molecules into larger ones such as DNA. DNA is a mechanism created by the cell to store information produced by the cell. Early life survived because it grew, building up its characteristic array of complex molecules. It must have been a sloppy kind of growth; what was newly made did not exactly replicate what was already there. But once produced by the primitive cell, DNA could become a stable place to store structural information about the cell's chaotic chemistry, something like the minutes taken by a secretary at a noisy committee meeting. There can be no doubt that the emergence of DNA was a crucial stage in the development of life, but we must avoid the mistake of reducing life to a master molecule in order to satisfy our emotional need for unambiguous simplicity. The experimental data, shorn of dogmatic theories, points to the irreducibility of the living cell, the inherent complexity of which suggests that any artificially altered genetic system, given the magnitude of our ignorance, must sooner or later give rise to unintended, potentially disastrous, consequences. We must be willing to recognise how little we truly understand about the secrets of the cell, the fundamental unit of life.

"Most molecular biologists operate under the assumption that DNA is the secret of life, whereas careful observation strongly suggests that it is the other way around: DNA did not create life - life created DNA".

Why, then, has the Central Dogma continued to stand? To some degree the theory has been protected from criticism by a device more common to religion than science: dissent, or merely the discovery of a discordant fact, is a punishable offence, a heresy that might easily lead to professional ostracism. Much of this bias can be attributed to institutional inertia, a failure of rigor, but there are other, more

[27] B Commoner, "Relationship between biological information and the origin of life". In: K Matsuno *et al*, eds. *Molecular Evolution and Protobiology*, p 283, Plenum Press. New York. 1984.

insidious, reasons why molecular geneticists might be satisfied with the status quo; the Central Dogma has given them such a satisfying, seductively simplistic explanation of heredity that it seemed sacrilegious to entertain doubts. The Central Dogma was simply too good not to be true.

"The Central Dogma provided such a satisfying, seductively simplistic explanation of heredity that it seemed sacrilegious to entertain doubts. The Central Dogma was simply too good not to be true"

As a result, funding for molecular genetics has rapidly increased over the last twenty years; new academic institutions, many of them *"genomic"* variants of more mundane professions, such as public health, have proliferated. At Harvard and other universities, the biology curriculum has become centred on the genome. But beyond the traditional scientific economy of prestige and the generous funding that follows it as night follows day, money has distorted the scientific process as a once purely academic pursuit has been commercialised to an astonishing degree by the researchers themselves. Biology has become a glittering target for venture capital; each new discovery brings new patents, new partnerships, new corporate affiliations. But as the growing opposition to transgenic crops clearly shows, there is persistent public concern not only with the safety of GM foods but also with the inherent dangers in arbitrarily overriding patterns of inheritance that are embedded in the natural world through long evolutionary experience. Too often those concerns have been derided by industry scientists as the *"irrational"* fears of an uneducated public. The irony, of course, is that the biotechnology industry is based on science that is forty years old and conveniently devoid of more recent results, which show that there are strong reasons to fear the potential consequences of transferring a DNA gene between species. What the public fears is not the experimental science but the fundamentally irrational decision to let it out of the laboratory into the real world before we truly understand it.

Barry Commoner has a long and rich history in environmental science and social activism. After gaining his PhD in biology from Harvard University in the US, he spent 34 years at Washington University in St Louis, Missouri, There he explored viral function and led cellular research with implications for cancer diagnosis. In the 1950s, Commoner was heavily involved in the debates on nuclear weapons, and in the 1960s, he became involved in other environmental issues including pollution and energy sources.

In 1980, Commoner set up and headed the Center for the Biology of Natural Systems at Queens College, New York. He now directs the Critical Genetics Project there (www.criticalgenetics.org), which aims to look at new ways of understanding the roles of the living cell's molecular constituents, such as DNA, RNA and protein, in the biology of inheritance. Barry Commoner is the author of nine books and has served on numerous advisory and editorial boards. He can be reached by email at commoner@criticalgenetics.org.

Farmers in Warangal district in Andhra Pradesh were excited about planting Bt cotton, which they saw as a way out of the trap of pests, pesticides and debt they were stuck in. At the start of the season in 2002, many were optimistic and hopeful about the new crop, but as the season progressed their enthusiasm was transformed into disappointment and, for some, despair. Meanwhile, many women already disillusioned with Green Revolution agriculture, are rediscovering the virtues of biodiverse cropping systems and sharing their results with their neighbours.

The Bt gene fails in India

ABDUL QAYAM AND KIRAN SAKKHARI

Cotton is an important commercial crop in India. It ranks second among cotton-producing countries, with around 8.9 million hectares of land under cotton cultivation. Cotton is a big money-spinner for the corporations selling seeds, pesticides and non-formal credit supplies, which are often bundled together under the term *"input dealer"*. Cotton cultivation has rapidly expanded in Warangal District in Andhra Pradesh over the past two decades, and this has coincided with a marked increase in the frequency and intensity of insect pest incidence, characterised by high levels of pest resistance to even the latest pesticides. Two recent bollworm (*Helicoverpa sp.*) epidemics in 1997 and 2000 broke the backbone of the farming community in the district. More than 200 cotton farmers, trapped in the vicious cycle of pests, pesticides and debt, committed suicide.

This crisis drew a lot of attention to the region, both from NGOs and corporations. For Mayhco-Monsanto[1], it provided an ideal opportunity to promote its bollworm-resistant, genetically modified (GM) Bt cotton. Following approval from India's Genetic Engineering Approval Committee, the company released two Bt cotton hybrids in the state of Andhra Pradesh in 2002, where it was sown on approximately 3,800 ha. Andhra Pradesh is the third biggest cotton-producing state in India, but tops the ranks with respect to pesticide use in cotton production. When the cotton was planted in Warangal district, a study was initiated by two local NGOs to monitor the progress of the GM crop and to compare all aspects of its production with popular hybrids.[2]

A season-long study (August 2002 - April 2003) was initiated in two villages in the district where 22 farmers had planted Bt cotton. Two farmers were selected randomly from the villages and were interviewed each month and were captured on video. A mid-season study involving 21 farmers spread across 11 villages in the district was also conducted in November 2002. While these 21 farmers were the primary respondents, more than 200 were consulted altogether. Other stakeholders (such as scientists and the manager of the ginning mill) were also included. At the end of the cropping season, a survey was conducted of 225 out of the

[1] A joint venture of the Indian seed company Mahyco and Monsanto, the multinational seed and agrochemical company.

[2] See end for more details of the study.

12,000 farmers (ie 20%) who took up Bt cotton production in Warangal district. All the farmers in the study that chose to plant Bt cotton had been cultivating all the important crops including cotton for the last 15-20 years. They were well aware of popular varieties and hybrids of cotton, its pests and diseases, and had access to print and electronic media.

The findings

Table 1 outlines the different qualitative characteristics of the Bt and non-Bt cotton grown in Warangal district. The Bt hybrid was most affected by the prevailing weather conditions (hot and dry). It was also evident that though the Bt cotton plants produced more bolls, these suffered from heavy premature drying as well as boll shedding. MECH Bt 162, which constituted 98% of the Bt cotton grown, appears to be characterised by small boll size and short staple length, which affected market preference as well as the price of seed cotton. Another important finding was Bt cotton contained more seeds than non-Bt hybrids, which affected the lint to seed ratio as well as its price. In addition, pickings from the non-Bt crop extended till March, as compared with late December/early January for the Bt cotton in most areas, which reduced the yield of the Bt cotton crop.

Early sucking pests like aphids and jassids were absent in both the Bt and non-Bt plants during the first 30 to 35 days after germination, as all the hybrid seed sold in the market is pretreated with the pesticide *Imidachloprid*. But, from early October, when the crop was 80 to 90 days old, moderate to heavy infestation of aphids and white flies was reported throughout the area, more prominently on Bt than on non Bt crop.

Table 1: Qualitative differences in Bt and non-Bt cotton crops

Characteristic	Bt cotton	Conventional hybrid
Flowering	15-20 days earlier	15-20 days later
Plant height	90-110cm	115-130 cm
Boll size	Smaller	Larger
Number of bolls/plant	40-45 more	40-45 less
Premature drying and shedding of bolls	More	Less
Tolerance to abiotic stress	Poor	Moderate
Staple length	Short	Long
Number seeds/boll	30-35	16-20
Pest incidence * Bollworm * Sucking pests	 71% 29%	 81% 19%
Number of pickings	Less	More

Pink bollworm is the biggest pest for cotton farmers in India.

There was unanimous agreement amongst all the group meetings and individual interviews that the pest load was lower than usual until the end of September. Even the much dreaded pink bollworm pest (*Helicoverpa armigera*) was at the lowest level till that time. Scientists opined that the dry and hot season suppressed this pest. But from November, the bollworm infestation increased in both the Bt and non-Bt crops, with 81% of non-Bt and 71% of Bt farmers pointing the finger at the bollworm as the pest that did the most damage to their crop. Most farmers concurred that sucking pests attacked the Bt crop more than the non-Bt crop. So even though there was some reduction in the incidence of the bollworm in Bt cotton, there was a simultaneous increase in the incidence of sucking pests on Bt crop. This meant that the level of pesticide use was almost identical for Bt and non-Bt farmers.

A hard look at the economics

The economics of Bt and non-Bt production are presented in Table 2 (over page). Bt cotton cultivation cost $10/ha more than non-Bt cultivation. Farmers who cultivated Bt cotton spent 15% of the total cost of cultivation on the seed as against 5% in case of non-Bt farmers, in the hope that it would reduce their spending on pesticide sprays and improve their yields substantially. But in reality, expenditure on plant protection was only $1/ha less for Bt cotton farmers. Non-Bt cotton farmers averaged a yield of 276 kg/ha compared with 180 kg/ha for Bt cotton farmers, which represents a net 35% decrease in yield. So, in spite of spending 3.5 times more on pesticide-resistant seed, a Bt farmer had only a 4% reduction in pesticide costs, and ended up with a 35 % loss in final yield.

These losses were compounded by the fact that the market value of Bt cotton was lower than non-Bt. To offset the reduction in the price of Bt seed cotton, almost all farmers resorted to mixing both Bt and non-Bt cotton before marketing, but they

Rescuing the crops of truth

After some disappointing experiences with Green Revolution-style farming, many women farmers in Medak district in Andhra Pradesh returned to their *satyam pantalu* (crops of truth), a rich array of traditional crops that are ideally adapted to the climatic and geological conditions of the arid region in which they live. These remarkable crops include a millet that grows on dew and sorghum that *"lives off the moisture in the air".* Over the last 20 years, many of the crops making up the *satyam pantalu* have disappeared (or *"drowned"* as local farmers put it) and replaced with what the women refer to as *"government seed."* These hybrids of sorghum, wheat and rice distributed by state agricultural advisors make the soil *"lifeless",* according to the women. Moreover, white rice does not give you enough strength to work in the fields and wheat flour causes itchy skin and rashes, they say.

Chinna Narsamma

Inspecting the sorghum crop: women are responsible for seed selection and storage.

The women's disillusionment with the new seeds prompted a renewed interest in the *pannendu pantalu*, a well-developed mixed cultivation system, which combines risk reduction with the optimum use of scarce resources. Turning the almost barren soil into fertile fields was a considerable challenge given that the poor soils of the region had turned into some of the most degraded agricultural lands in the country. In the *pannendu pantalu*, at least twelve different crops, including forage crops, oilseeds and pulses, ensure a balanced, diverse diet and improve the quality of the soil. In this way, even poor soils yield something and there is always an emergency harvest even with little rainfall. Added to the crops are numerous wild vegetables, medicinal herbs, fruit trees and forage grasses. A proportion of every harvest is stored for the next sowing, in a natural breeding process in which varieties with special properties selected and developed further. Food security is the primary objective, not high yields or income.

In Humnapur village, Laxmamma and her mother treasure the seeds of more than 85 varieties in an array of small, brightly painted clay pots, stored carefully in a wooden box. Laxmamma recalls how five or six years ago she got a particular variety of green gram which doesn't need much water from a neighbouring district. She and other women started to sow these rare crops in their fields and today they have retrieved 50-60 varieties that had almost been lost forever. Laxmamma's collection has grown from 6 to 85 varieties. Now gene banks have been established and seeds are given out to other people from their own or neighbouring villages.

Masangari Yesu

This mandala celebrates all the elements used in the women's production systems.

The work has drastically improved the status of these 'poorest of the poor' women, and people of all castes come and ask for advice and to share in the seed bounty. A new 'seed economy' has sprung up in which farmers pay for the seeds they receive with seeds from their harvest – to the tune of one and a half or two times as much as they received in the first place. The communities are also working on developing processing facilities and local markets. Everyone recognises that the cash economy is hard to ignore. Cash is needed for school, salt, soap and saris. Some traders are willing to give the local fare a spot in their stores, but it is hard for it to compete with pizzas and potato chips given the *"fast food"* mood that now prevails throughout much of India. But the vision of these women farmers is strong and offers the potential for safer and healthier food, greater economic dependence, and a solid, biodiverse agricultural base for the future.

Source: Meena Menon, The crops of truth, www.ddsindia.com/cropstruth; EED, Fruits of Diversity: Global Justice and Traditional Knowledge, Church Development Service, 2002, www.eed.de/en.home/en.publications; Carinne Pionetti and Suresh Reddy, "Diversity on the Deccan Plateau, Seedling, April 2002, www.grain.org/seedling/seed-02-04-en.cfm

Table 2: The economics of cultivating Bt and non-Bt cotton

Characteristic	Bt	Popular hybrids
Total cost of cultivation/ha	Rs 4,262 ($92)	Rs 3,825 ($82)
Cost of seed/ha	Rs 640 ($14)	Rs 180-200 ($3.8-4.3)
Expenditure on pesticides/ha	Rs. 1,164 ($25)	Rs. 1,188 ($26)
% of total expenditure spent on plant protection	27 %	31 %
Average yields/ha	180 kg	276 kg
Market price/100 kg seed cotton	Rs 2,080 ($45)	Rs 2,164 ($47)
Net returns/ha at the end of cropping season	Rs 518 ($11)	Rs 2147 ($46)
No of farmers who profited	65 (29%)	185 (82%)
* Up to Rs 5,000 ($108)	39 (17%)	67 (30%)
* Rs 5,000-7,500 ($108-162)	4 (2%)	28 (12%)
* Rs 7,500-10,000 ($162-216)	9 (4%)	20 (9%)
* Rs >10,000 (>$216)	13 (6%)	70 (31%)

still only received $45/100kg for the mixed seed versus $47/100kg for the non-Bt cotton. In the end, non-Bt cotton farmers netted four times as much as Bt farmers from their 2002-2003 cotton crop. Some 71% of Bt cotton farmers experienced losses, compared with 18% of non-Bt farmers.

Biosafety issues

All farmers professed compliance to Mahyco-Monsanto's refuge guidelines, which required planting border rows of non-Bt hybrids in 3 to 5 lines. This was conveyed to them through audiocassettes and product literature supplied with the seed packets. But farmers were not clear about what the purpose of the refuge was. Most thought it was to serve as a barrier or trap for the migrating moths and caterpillars or to prevent the transfer of pollen to other plants and varieties. The real purpose of the refuge is to serve as a host for susceptible bollworms to mate with resistant insects to delay the development of resistance. Mayhco-Monsanto abdicated any responsibility for monitoring the enforcement of refuges. The study team could not easily identify the refuge crop from the main crop. This mixing of seed that occurred when farmers resorted to mixing their non-Bt and Bt cotton crop in order to get a better price for the Bt cotton paved the way for GM crops to enter the food chain. Cotton seed oil is used in cooking in India and the seed is used to make cattle fodder, which enters the human food chain through dairy products. This is an extremely critical biosafety concern, and it indicates the total failure of regulatory mechanisms.

Does Bt cotton have a future in Warangal?

When asked about what their future preference would be for their cotton crop, farmers offered a variety of answers:

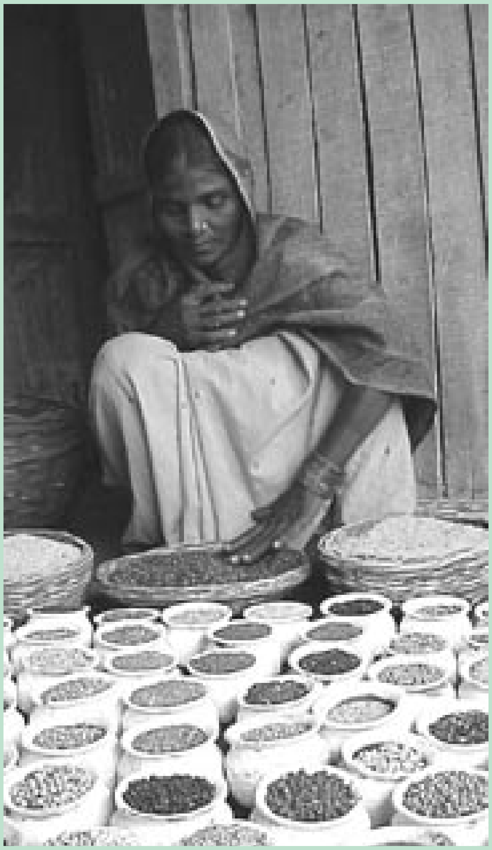
- 51% said categorically that they would not plant Bt cotton again.
- 13 % said they will not grow Bt again because of the reduced yield.
- 11% said they would not grow Bt in the next year because of the higher cost of cultivation.
- 4% would grow the Bt crop again without hesitation.
- 8% said that they would see how Bt cotton. performs in a *"normal"* season.
- 9% said that they would try Bt again if a better hybrid with good boll size were available.

The study team concluded that the GM hybrids are not a desirable proposition at present. The faltering toxin content of the plant and seed during the crop period is likely to encourage the development of resistance among *Helicoverpa* and other Lepidopteran pests. Indeed, it has already been reported in some countries that the toxin is not effective against the 3rd and 4th generation of *Helicoverpa*. This should be a warning signal.

The development of resistance would create a more serious problem than the pesticides currently used, and will lead to an unavoidable war between GM hybrids and the pest complex. As in the case of pesticides, wherein pests have been successful in developing resistance to the most toxic of pesticides, they are also likely to succeed in overcoming the toxins produced by the genes, warranting ever more aggressive toxins to achieve the kill. This is a dangerous trend fraught with dreadful environmental consequences, including the devastation of natural predators and soil-borne pest pathogens by the toxins produced by the GM cotton plant.

The farmer will have no security of seed and will also lose control over her/his own seed because of the restrictions placed on seed saving, breeding and seed sharing by the corporations. The indebtedness of farmers will also increase because of the greater dependence on external resources needed for the cultivation of the GM crop. This study emphasises the need for a wholesome review and critical examination of the policy of encouraging genetically modified cotton from the point of view of the environment, diversity and health.

Anjamma's story



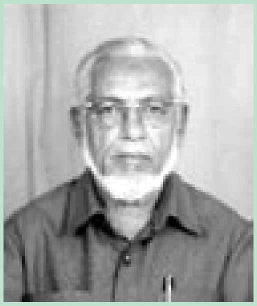
Anjamma, a Dalit woman (of the 'untouchable' caste), has achieved what seemed the impossible. Married at the age of nine, her life was one of relentless hard work. She raised four children as a sharecropper and now is devoted to popularising traditional crops, acting as a permaculture consultant to other villagers. *"The upper castes lost all the traditional crops because they switched to sugarcane",* she says. *"Now they come to me for seeds of millet, sorghum and black gram."*

On her four-acre plot, Anjamma has planted more than 30 varieties of crops. These include four different varieties of millet, two varieties of red gram, lentils, beans and two oilseed varieties. *"This means that even if I lose 10 crops, I get the produce of 20",* she says. Anjamma and her husband have worked hard for a long time. When they got married they only owned a sickle. First they worked as day labourers and then as sharecroppers who had to hand over half the yield to the landowner. After a while they had their own team of oxen that they hired out. Finally they bought this plot, some of it even with fertile black earth.

Anjamma has her own seed store, comprising more than 60 varieties and species. She makes up her own *"plant cocktail"* depending on how good the first rain is, for different soil types and changing according to the seasons, for food, animal feed and cooking oil. Her collection includes some plants that provide a yield even when there is little rain and one variety that *"not even the crows touch."* She grows mung bean and green gram for sale.

Sources: Meena Menon, The Crops of Truth, www.ddsindia.com/cropstruth; EED, Fruits of Diversity: Global Justice and Traditional Knowledge, Church Development Service, 2002, www.eed.de/en.home/en.publications.

The study report, *Did Bt Cotton Save Farmers in Warangal?* was written by two local scientists. Mohammed Abdul Qayum (top) is a retired agricultural scientist trained in soil, water and fertiliser analysis and who worked for many years for the Government of Andhra Pradesh. Sakkhari Kiran (bottom) is an agricultural scientist has who worked with the International Crop Research Institute for the Semi-Arid Tropics studying seed production storage techniques with tribal farmers, and is now Project Co-ordinator for the Permaculture Association of India. The study was commissioned by the Andhra Pradesh Coalition in Defence of Diversity, a four-year old network of more than 140 civil society groups in Andhra Pradesh that promotes agrobiodiversity and ecological agriculture, and the Deccan Development Society (DDS), which works with more than 5,000 women farmers in Andhra Pradesh to support their communities and their farming systems.



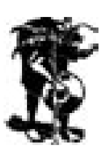
The full report is available in PDF form from www.ddsindia.com and in print from DDS: Flat 1, Kishan Residency, 1-11-242/1, Street No.5, Shyamlal Building, Begumpet, Hyderabad – 500 016, Andhra Pradesh, India. Tel : +91 40 277 64577, +91 40 277 64744. Email: ddshyd@hd1.vsnl.net.in.

A 23-minute film following the trials and tribulations of the farmers in the study, made by local women from the Community Media Project in Pastapur is available from the same sources.

Public research theoretically offers considerably more potential than the corporate, gene-focused approach to generate crops that meet the needs of farmers. But in practice, much public research, especially that undertaken by the world's international research centres, has also been blinded by the gene. *Aaron deGrassi* and *Peter Rosset* assert that farmers need to be returned to centre-stage to re-assume their central role as custodians of the world's agricultural resources and the directors of research and innovation.

Public Research: which public is that?

AARON DEGRASSI AND PETER ROSSET



For many years, the International Agricultural Research Centres (IARCs)[1] focused their research efforts almost exclusively on three crops: maize, wheat and rice. The many varieties they developed were grown under controlled environments with regular inputs of water, fertiliser, pesticides and labour. This strategy was heavily criticised in the 1970s and 1980s for ignoring the many so-called *"minor crops"* that poor farmers depend on in the uncertain, resource-poor environments where they often live. This led the IARCs to expand their menu to include new criteria and new crops, such as roots and tuber, legumes, and other critical sources of calories and protein. But this list still falls short of the real crop diversity farmers use, and the emphasis in breeding continues to be on improving one or a small number of traits applicable to broad ranges of farmers, whilst farmers have multiple, location-specific criteria.

Mainstream research and development, as practised by the IARCs, depends on natural scientists (and occasionally social scientists) evaluating new technologies, sometimes with the use of farmer surveys. However, scientists' evaluations become rather complex and difficult when there are numerous characteristics to compare and correlate. In the midst of such complexity, many researchers attempt to evaluate the performance of new technologies and traits by using a relatively restricted criterion: yield. *"Yield"* refers to the output of a single crop measured in weight per hectare, for a single season, without regard to the cost of the inputs required to obtain it or the market price the crop fetches. Because the notion of yield reduces the evaluation of the value of a variety to a single variable, it can be termed a *reductionist* measure.

Reductionist measurements are severely inadequate as a basis upon which to judge whether one variety

[1] The IARCs are a group of 16 publicly funded research institutes that claim to *"work in more than 100 countries to mobilise cutting-edge science to reduce hunger and poverty, improve human nutrition and health, and protect the environment".* The IARCs are the biggest institutional force guiding research and development for the crops that feed people in the South.

is superior to another, precisely because such measures fail to incorporate other variables crucial to farmers' production. The unstated assumption of conventional breeding is that *"local"* and *"improved"* varieties perform exactly the same in all respects but the one variable in question. A typical study claims that *"by simply switching to the new variety – with no change in crop management – small-scale farmers can increase yields by 10-30%."*[2] Researchers assume that characteristics can be treated in isolation, and breeders can 'turn the knob up' on, say, disease resistance, without affecting other characteristics, like taste. Yet varieties often contain multiple, linked characteristics that change during breeding, and do not remain constant.

For starters, reductionist yield measures all too often do not take into account the costs of labour or capital inputs required by a variety: a high maize yield per hectare means little if it entails proportionately higher costs to farmers (in fertiliser, hybrid seed, extra labour for row planting, for example).[3] Norman Borlaug's Sasakawa 2000 (SG 2000) programme to promote Green Revolution technology failed to adjust the amount of fertiliser it was recommending in Ghana, despite an increase of the price of fertiliser by several hundred percent.[4]

Simplistic conventional analysis frequently also fails to seriously address how marketing opportunities affect the profitability of new technology packages. In Mozambique an SG 2000 project advocating a package of improved varieties and purchased inputs characteristically stated: *"The large **yield** differences between the traditional plots and those cultivated with the improved technologies … clearly demonstrates the role improved inputs lay in augmenting maize yields"*[5] (emphasis added). However, the *"yield advan-tage"* looks very different if we take into account economic factors such as how crop prices vary at different times of the year, and in particular how prices drop during the harvest season. In the SG 2000 example, farmers adopting the package of technology may have had higher yields, but adopter-farmers who sold their harvest during the market glut did not have a substantially higher net return on their investment than non-adopters, and, moreover, risked having substantially lower net returns than non-adopters.[6] In other words, a new set of technology may raise physical yields of food per hectare for a single season (the concern of reductionist research), but that does not necessarily make it more profitable for farmers.[7]

Mainstream researchers are unable to see how the circumstances at research stations where crops are tested differ greatly from the (varying) conditions poor farmers face. Such incongruity between station and fields encompasses *biophysical* settings (topography, soil type and condition, macro/micronutrient deficiencies, plot size and shape, hazards, pests and diseases, water supply, natural vegetation, crop mixtures) as well as *socio-economic* constraints (timely and affordable access to purchased inputs, seeds, credit, labour, extension consultation).[8] Not only do typical reductionist analyses obfuscate yield and farmers' profitability, but gene-environment interactions make yields attained on-station hard to reproduce in the face of real-world variation.[9] What seem like good seeds at the station often turn out to be inadequate in many farmer's fields. At a research station at Cinzana, Mali, soil fertility discrepancies caused intercropping techniques to yield two to three tons on station, but only one ton off station, and *"many millet and sorghum varieties developed on station gave significantly lower yields than local varieties."*[10]

The SG 2000's own data show *"larger variations, for both 'traditional' and 'improved,' among farmers and between years, than the mean differences between 'traditional' and 'improved' yields in a single year"* – that is, there is often a bigger difference between farmers using the same technology package than between the packages themselves. Even on-farm trials, when conducted under the purview of reductionist science, can mislead if the uniqueness of the (usually wealthier, male) farmers involved goes unnoticed. For example, the farmers participating in an on-farm SG 2000 trial in Ethiopia were said to *"cultivate more land (both absolutely and per capita), have larger household sizes (ie more available labor), appear to be wealthier (more livestock and traction animals), and have better educated household heads than they typical households."*[11] Such specificity renders obsolete the relatively broad, uniform recommendations developed by research stations operating under privileged conditions.

In summary, most conventional research and evaluation structures are premised upon three underlying assumptions:

(1) Crop varieties are best evaluated on the basis of one variable – absolute, short-term output per hectare – or, occasionally, several variables;

(2) The new varieties developed by centralised rese-archers perform better in this respect;

(3) Such varieties will thus be readily adopted by farmers if only they are made *"aware"* of them.

This reductionist approach is ill-equipped indeed to cope with the complex, diverse and risk-prone nature of smallholder production in Africa. Many

[2] SMIP, *New Horizons for Research Partnership: the SADC/ICRISAT Sorghum and Millet Improvement Program,* 1999, www.cgiar.org/icrisat/text/research/networks/gnet5

[3] HCC Meertens *et al, Dynamics in Farming Systems: Changes in Time and Space in Sukumaland, Tanzania,* Netherlands: Kit Press, 1995.

[4] MJ Yudelman *et al, An Evaluation of the Sasakawa-Global 2000 Project in Ghana.* In, NC Russell and CR Dowswell (eds.), Africa's agricultural development in the 1990s: Can it be sustained? : Proceedings of a Workshop, Arusha, Tanzania, Mexico, D.F: CASIN/SAA/Global 2000, 45-56, 1992

[5] JA Howard *et al,* "An Appraisal of the Inputs Subsector and the 1996/97 DNER/SG2000 Program". *USAID-MSU Food Security II Cooper-ative Agreement Policy Synthesis No. 38,* Michigan State University, 1998.

[6] The yield difference was 4.1 tons/ha vs 2.5. Of those who sold late, farmers who adopted the package received a net benefit of $58-$197 per hour while non-adopting farmers received $142-$185 per hour.

[7] This might be obvious to economists, but they are frequently sidelined in agricultural research, or releg-ated to after-the-fact impact evaluations.

[8] R Chambers, "Farmer-First: A Practical Paradigm for the Third Agriculture", In: M Altieri and SB Hecht (eds.), *Agroecology and Small Farm Development,* p 239, Ann Arbor: Uni. of Michigan Press, 1990.

[9] IITA, *Sustainable Food Production in Sub-Saharan Africa: IITA's Contribution,* Ibadan, Nigeria: IITA, pp 91-104, 1992.

[10] See ISNAR *et al, Lessons Learned: A private-sector foundation's support to devel-oping country agricultural research,* ISNAR, 1995.

[11] JA Howard *et al*, 1998, see above.

experiments and projects have been repeatedly confounded by the diversity of environments, farmers and criteria.[12] Yet, after research and evaluation structures have failed to transplant standardised seeds into the cropping systems of farmers, sometimes these seeds are subsequently crossed by the farmers themselves with indigenous varieties with hardy traits, producing new varieties of interest to them.[13] This strongly suggests that participatory testing and breeding can better take into account multiple characteristics of varieties and farmers priorities farmers.

Limiting access and undercutting farmers

In addition to its incapacity to devise appropriate varieties, conventional research and extension will not meet new pro-poor and environmental objectives because it also works to substitute – rather than facilitate – vitally important farmer-to-farmer networks of innovation and exchange. Farmers often possess dynamic seed saving and exchange systems that extend out in nested or concentric arenas, from households, villages, districts, countries and even regions, providing access to seeds and producing innovations. When cassava was introduced in the 1500s by the Portuguese, it spread across the African continent and was adapted in numerous different ways. Likewise, farmers have shared and adapted maize varieties with extraordinary skill. Farmers networks intersect to provide key points of innovation, diffusion, and adaptation.[14]

Loans, exchanges, gifts, and purchases are all key ways farm families exchange seeds. At the same time, there is abundant evidence that smaller or poorer farmers rarely get formally developed seeds at all, even less so through formal institutions of seed distribution. For example, in two districts in Kenya the use of 'improved' varieties was significantly associated with having attained secondary education, ownership of cattle, use of hired labour, location, and access to extension – all class-based variables. In the central highlands of Ethiopia, both the private sector and state extension systems are relatively ineffective for wheat: *"the formal sector produces and distributes only 15% of the improved seed requirement of the country. Most farmers rely on other farmers and local markets to replace seed, obtain new seed, and obtain information on wheat varieties."*[15]

Centralised research works to subvert farmer-based networks, in part because seeds are collected to deposit in gene banks – based at the IARCS and National Agricultural Research Systems – where only researchers and companies with financial means have access to them.[16] The top-down nature and limited value of genebanks is exemplified by the fact that researchers collect seeds without collecting commensurate information on how such seeds are used, by whom, under what conditions. Rather, seeds are collected and valued only for use by researchers to conduct standardised mass trials or virtually random crosses.[17] Sometimes gene banks are seen almost as making it unnecessary to preserve 'living varieties' in the field. For example, a recent evaluation panel recommended that *"due to the extension of new 'NERICA' upland rice varieties which will lead to loss of indigenous genetic resources, the research institute that developed the new varieties, WARDA, should intensify the collection and conservation of indigenous upland rice varieties."*[18] But such efforts to ensure genetic diversity would be misplaced to focus only on salvaging seeds that are soon to be lost from farmers' fields, because it is the living seed systems that characterise active communities and farmer networks where varieties are continually adapted to changing conditions.

Proponents of the 'Green' and impending 'Double Green' revolutions claim that new varieties actually add genetic diversity, by bringing new genetic material to farmers' fields.[19] However, the genetic depth of new varieties is vastly overstated, and, more importantly, these assertions emphasise the additive nature of new seeds that, in practice, are a promoted as *replacements* – farmers are effectively urged to ditch old seeds and praised for devoting all of their fields to one variety from a research station. This process of genetic erosion inevitably leads to the loss of vital genetic resources – and the IARCs are contributing to it in a big way.

ICRISAT/SADC proudly states that, *"In Zimbabwe, SV 2, released in 1987, is now grown on 30% of the country's sorghum area; PMV 2, released in 1992, occupies 25% of the pearl millet area. In Namibia, Okashana 1 covers an estimated 45-49% of the pearl millet area. In Zambia, four recently released varieties cover 35% of the sorghum area."*[20] Much of the improved maize in West Africa derives from only two initial populations from Nigeria and Mexico (TZB and Tuxpeño, respectively).[21] WARDA advocates that all farmers grow the same kind of rice on all their fields continuously, rather than the diverse mosaic farmers currently have, with different kinds of rice and diverse non-rice crops (such as sorghum, peral millet, groundnuts, chillies, etc). Already, one WARDA variety (Sahel 108) makes up 75% of the irrigated rice grown dry season in the Senegal River Valley.[22] Between replacement and gene flow – pollen from widespread new varieties can inundate the flowers of traditional varieties, diluting their genes – the Green Revolution extinguishes the base from which it was built.

12 B de Steenhuijsen Piters, *Diversity of fields and farmers: explaining yield variations in northern Cameroon.* Dissertation No. 1892, Wageningen Ag. University, 1995

13 eg, JH Sanders *et al, The Economics of Agricultural Technology in Semiarid Sub-Saharan Africa,* Johns Hopkins Uni. Press, 1996, for sorghum; IITA, *Sustainable Food Production in Sub-Saharan Africa: IITA's Contribution,* IITA, Ibadan, Nigeria,1992 for maize.

14 C Reij and A Waters-Bayer. Farmer Innovation in Africa: *A Source of Inspiration for Agricultural Development,* London: Earthscan, 2001; P Richards, "Toward African Green Revolution: An Anthropology of Rice Research in Sierra Leone", In, AE Nyerges (ed.), *The Ecology of Practice: Studies in Food Crop Production in Sub-Saharan West Africa,* India: Gordon and Breach Publishers, pp. 201-252, 1997.

15 BDS Salasya *et al, An Assessment of the Adoption of Seed and Fertilizer Packages and the Role of Credit in Smallholder Maize Prod-uction in Kakamega and Vihiga Districts, Kenya,* CIMMYT and KARI, 1998.

16 See www.etcgroup.org and www.grain.org.

17 P Richards and G Ruivenkamp, *Seeds and Survival: Crop Genetic Reso-urces in War and Reconstr-uction in Africa,* Rome, Italy: IPGRI, 1997.

18 TAC, Report of the Fourth External Programme and Management Review of WARDA, Mid-Term Meeting, Dresden, Germany, CGIAR, 2000, p xvi.

19 L Harrington, "Diversity by Design: Conserving Biological Diversity Thro-ugh More Productive & Sustainable Agroecosys-tems". In, *Swedish Scientific Council on Biological Diversity, Bio-Diversity and Sustainable Agriculture,* Ekenas: Swe-den, Mexico: CIMMYT, 1996.

20 SMIP, *New Horizons for Research Partnership: the SADC/ICRISAT Sorghum and Millet Improvement Program,* 1999, www.cgiar.org/icrisat/text/research/networks/gnet5

21 J Smith *et al*, "The Role of Technology in Agricultural Intensification: The Evolution of Maize Production in the North-ern Guinea Savanna of Nigeria", *Economic Development and Cultural Change* 42(3): 309-341, 1994; CIMMYT Review (various yrs).

Researchers are perhaps less concerned by the loss of field diversity because they have been able to store the diversity they need and want in centralised gene banks. This is not done conspiratorially, but inadvertently when researchers are schooled in reductionist science to believe that they can devise appropriate improved varieties that will meet all needs of all farmers and environments for all time. The resources at the gene banks are available to commercial breeders, but not to the communities who have long (but invisible) investments in those seeds. More recently gene banks have gained increased prominence, as private biotechnology companies view them as sources of raw materials to be strip-mined for the value of their genes for genetic engineering. Yet private companies – who, unlike farmers, have the means to access farmers' innovations enclosed in such repositories – are very unlikely to seriously address the needs of the poor (see box on p 31).

In conventional research and evaluation, new seeds are promoted to uniformly replace ones, and this is often depicted as a one-time event. The mentality is that of *"command and control,"* yet without the omniscience, the rationality, nor the capacity to determine optimal arrangements and actions for all actors. But farmers need to be able to constantly change, innovate, update, and adapt the varieties they use according to their changing biophysical and socio-economic realities. Hence, access to a diverse cache of human skill and knowledge, and a healthy pool of genetic resources is vitally important. Varietal development should be seen as a continual process, not a one-off 'out with the old, in with the new' kind of transfer. Farmers must take the lead and be involved at each stage.[23]

When the locus of innovative energy is moved from farmers to distant researchers in research stations, farmers and their innovating networks lose access to genetic resources, and are left with the varieties that researchers develop. Vital resources and power for responding, experimenting, innovating, coping, and diversifying are removed from farmers' control and placed in the hands of unaccountable, unrepresentative and unresponsive personnel. Giving privilege to formal centralised systems like these effectively disempowers farmers and their social networks.

There is a fundamental issue of flexibility and self-sufficiency here. If farmers are used primarily in utilitarian ways to extract information (eg about which characteristics of a variety are important), they are placed in a relationship of dependency. Increasing the list of crop breeding criteria from, say, three to eight variables, as is sometimes done, is not enough to meet everyone's needs. It is not simply that mainstream researchers fail to understand different farmers' different priorities, they also are blind to the diverse mechanisms by which farmers understand and undertake selection and prioritisation. Farmers do not just need better products, they must be able to confront new challenges (like a new pest or disease) as they arise, independently of researchers who will not always be there, and this involves coordinating amongst themselves. What is needed is to empower farmers and strengthen their networks to be able to cope, adapt and anticipate, rather than relying on researchers as the sole source of innovation.

To be productive, farmer-innovators need to have access to genetic repertoires from which they can draw, to take advantage of variation in biophysical and socioeconomic conditions and to protect against unexpected shocks. Broad *access* to appropriate genetic resources – judged according to multiple linked criteria by diverse farmers – is key to meeting the needs of farmers. This can be done through decentralised networks with farmers in the driver's seat, and with scientists and extensionists as facilitators and in other supportive roles.

This article is based on the manuscript for Aaron deGrassi and Peter Rosset's forthcoming book, ***A New Green Revolution for Africa? Myths and Realities of Agriculture, Technology and Development*** *(Food First Books, 2004).*

[22] TAC, *Report of the Fourth External Programme and Management Review of WARDA, Mid-Term Meeting,* Dresden, Germany, CGIAR, 2000, p 10.

[23] See for example E Weltzien *et al,* "Technical and Institutional Issues in Participatory Plant Breeding", *Working Document No. 3,* Cali, Colombia: CGIAR Systemwide Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation, p 14, 2000.

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Peter Rosset is co-director of Food First/The Institute for Food and Development Policy (www.foodfirst.org), based in Oakland, California. He is an agroecologist and rural development specialist, and author of many books, including "Agroecology" (1990) and "World Hunger: Twelve Myths" (1998).

Sprouting Up...

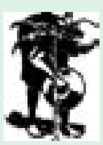
Farmers' privilege under attack

GRAIN

Intellectual property rights (IPR) applied to seeds give breeders, or whoever claims to have discovered or developed a new plant variety, an exclusive monopoly right in relation to the seed. Under patent law, that monopoly right is very strong. It will generally prevent anyone from using, selling or producing the seed without the patent holder's permission. Under a typical *sui generis* plant variety protection law – an IPR system designed specifically for plant varieties – there are usually a few exceptions to this powerful right built in. One of those exceptions is that farmers may be allowed to save, exchange, sell or reuse part of their harvest as a new batch of seed.

The legal ability to reuse IPR-protected seed is called the *"farmers' privilege"*. This a terrible misnomer. Saving seeds is as natural and essential as eating – that's how we are able to produce crops. Under plant variety protection (PVP) law, this totally ordinary act becomes a privilege, a legal exception. The breeders are granted the rights, while farmers are allowed to do something despite that right – and only under certain conditions. Breach those conditions and you breach the breeder's rights, for which you have to pay economic or legal consequences.

Cutting out the competition



The farmers' privilege is a hot issue because the seed industry wants to control who produces seeds – they want to control the market. Current world seed sales of US$30 billion a year should jump to US$90 billion soon. But a substantial part of world food production is based on farm-saved seed – as much as 90% in sub-Saharan Africa and 70% in India. Even in industrialised countries, farmers also save seed rather than buy a fresh batch, if it makes sense for them and they can. So there's still a sizeable market out there for the industry to get a grip on.

It's also a hot issue because the seed industry is working hard to secure legal systems that restrict seed saving by farmers, be it through the World Trade Organisation (WTO), bilateral trade agreements or direct lobbying of governments. PVP or plant breeders' rights legislation is all about taking power away from farmers to produce and reproduce seeds. And these laws are gaining ground. Governments caving in to the pressure often say, *"Don't worry, we will protect the rights of the farmers at all cost!"* They swear that nothing will prevent farmers from continuing their *"traditional"* and *"historic"* practice of conserving, exchanging and further developing seeds. And so they write into their law this *"farmers' privilege".* Yet the fact is, the farmers' privilege is a legal *"yes, but"* on seed saving – with the *"but"* getting bigger by the day.

Country after country that has established a PVP law has progressively made the farmers' exception more and more restricted. To the point that it becomes meaningless. Why? Because the breeders keep asking for stronger and stronger rights. Tightening the loophole that allows farmers to save seeds is the easiest way to give more power to the breeders. Restrictions on the farmers' privilege in PVP law come in several forms, often combined in one mixture or another:

- farmers are prohibited from saving seeds of *certain crops*
- only *certain farmers* (e.g. those with a specific farm size or income level) can enjoy the privilege
- farmers *have to pay* an additional royalty to the breeder for any seed that they save on the farm
- farmers can save seed, but *not exchange* it (they can only grow it on their own farm)
- farmers can save seed and exchange it, but they can *not sell* it
- farmer can save, exchange and sell seeds, but only *without using the name* of the variety

In addition, governments are increasingly telling farmers that, as part of this privilege, they have to provide accounts to the breeders about what seed they saved. This is to better enforce the restrictions. Governments are also debating whether to let the seed industry circumvent the farmers' privilege through sales contracts – in other words, allow companies to impose specific restrictions on saving seeds, printed on the bag, despite whatever the PVP law says. What is the purpose of all this cracking down on farmers? "To finance research!" the industry proclaims. Not quite. It's to control the market, the competition, full stop.

A raw deal turning rotten

If this seems like a total injustice, it is. But it is very real and it is important not to be fooled by glittery promises of protection for farmers' rights under *sui generis* plant variety laws. The WTO recently published an update of where countries are in implementing its agreement on Trade-Related Aspects of Intellectual Property Rights, including the question of the farmers' privilege. To see a country by country account drawn from that report and from several other government sources, go to www.grain.org/publications/bio-ipr-fp-june-2003-en.cfm

The result is sobering, to say the least. In country after country, the historic and supposedly untouchable right of farmers to save and reuse seeds is under attack. But this is not where the story ends – it is where it starts. Intellectual property rights for plant breeders, once adopted, are always being strengthened at the expense of farmers. So PVP laws, and their imposition on virtually all countries through the WTO, really serve as a springboard towards accepting full-fledged industrial patents on all forms of life.

Technical advances in breeding – however impressive – are meaningless without farmers. The corporate research model seeks to turn farmers into serfs in a feudal agricultural system, a move which will be devastating to our future food supply. *Michel Pimbert* identifies some of the reforms needed to encourage democratic participation and more genuine local control in the management of agricultural biodiversity. Emphasis is placed on strengthening diversity, decentralisation and democracy through the regeneration of more localised food systems and economies.

The Promise of Participation

Democratising the management of biodiversity

MICHEL PIMBERT

Despite repeated calls for peoples' participation in conservation and development over the last thirty years, the term *"participation"* is generally interpreted in ways which cede no control to local people. It is rare for professionals (agronomists, foresters, plant breeders, and so on) to relinquish control over key decisions on the design, management and evaluation of local or community based management of agricultural biodiversity. The thinking, values, methods and behaviour dominant in their profession or discipline tends to be stable and conservative and are concerned with *"the needs and interests of the rich."*[1] While recognising the need for peoples' participation, many professionals place clear limits on the form and degree of participation that they tolerate in local contexts. Participation is still largely seen as a means to achieve externally-desirable goals.

The concept of *"participatory development"* has gained new vigour over the last two decades, partly as a result of the evident failures of top down, standardised development, the retreat of governments in service and technology delivery, and the emphasis on market-based solutions in a globalised economy. The reasons given for professional re-orientation and organisational transformation vary and are not necessarily the same for all actors. They include the need for flexibility and cost effectiveness, the need to respond adaptively to dynamic change and to a diversity of social and ecological conditions, the recognition that human needs differ in time and place, and the need to deal with open ended uncertainties. Because of this, the meanings given to *"participation"* and *"participatory development"* vary considerably (see Table 1 over page). The divergences highlight the ideological framework which actors consciously or unconsciously adopt in their work.

[1] R Chambers, *Challenging the Professions. Frontiers for rural development.* IT Publications, London, UK, 1993.

Table 1: Participatory Development Paradigms

	Business as usual	Technical fix - the market is the solution	Structural change
Goal	Making projects more efficient	Making projects more effective	Multiple economic, ecological and social goals
Target	Singling out 'target groups' as objects of development projects	Reforming policies and instituti-ons to allow for regulation by the market	Multiple linkages with diverse actors; broad coalitions and alliances for social change
Principal methods for analysis and planning	Logframes, Rapid Rural Apprais-als (RRA), questionnaires, beneficiary assessment, cost-benefit analysis	Logframes, RRA, participatory Rural Appraisals (PRA), cost benefit analysis, market surveys	Participatory Learning and Action (PLA) and complementary participatory methodologies, deliberative democracy, advocacy, coalition building, direct action
Dominant role and relationships	Enlightened technocrat and benevolent paternalism	Provider of market-based solutions	Genuine partnerships and power sharing
Boundary conditions	Broader context unacknowled-ged - everything remains as is: property rights, land tenure, social relations, decision-making structures & processes	Broader context unaddressed: everything beyond the interven-tion remains as is; economy and markets treated as given, but subject to some intervention	Explicitly concerned with changing the broader context of people's lives: social and ecological goals, many futures possible
Development goal	Improved products and services	More kinds of interventions mediated through the market	Minimise the need for external intervention, self reliance
Diversity (social and ecological)	Low	Low to medium	High

Deliberative democracy

Seven different types of participation are shown in Table 2. The implication of this typology is that the *meaning* of participation should be clearly spelt out in all community-based programmes. To achieve sustainable and effective management of biological resources and effective agricultural research, nothing less than functional participation will suffice. Participatory Rural Appraisal (PRA) describes one group of a growing family of methods ands ways of working that enable local people to share, enhance and analyse their knowledge of life and conditions, to plan and act. Deliberative and Inclusive Processes (DIPs) are also increasingly being used in the North and the South to give the historically excluded a voice in decisions. Some of these methods and processes include citizens' juries[2], consensus conferences, scenario workshops, multi-criteria mapping, participatory learning and action (PLA), visioning exercises and deliberative polling. Many of these participatory processes have been developed in an attempt to move beyond traditional forms of consultation.[3] These approaches require self critical awareness of the facilitators' own attitudes and behaviour towards local people. The implementation of codes of conduct and research agreements between local communities and outsiders – as has been done by the Kuna of Panama and the Inuit Tapirisat of Canada – can enhance reciprocal accountability by spelling out the roles, rights, responsibilities and distribution of costs and benefits among actors.[4]

Decentralisation policies generally offer a more enabling context for deliberative and inclusive processes in decision making. The democratic potential of decentralisation is usually greatest when it is linked with the institutionalisation of local level popular participation and community mobilisation. In several municipalities in Brazil where participatory budgeting was introduced in the 1990s, public spending priorities changed significantly, reducing inequalities in some places. The improvement of the quality of life was evident, as it was the first time that the local government had taken into account the needs of the poorest sectors of the population. Participatory budgeting has not only meant a much greater involvement of citizens and community organisations in determining priorities but also a more transparent and accountable form of government. The potential of participatory budgeting in community based or local management of agricultural biodiversity needs to be more fully explored.

However, decentralisation does not always equate with increased democratic participation. It does not necessarily break power structures or lead to a

[2] MP Pimbert and T Wakeford, Prajateerpu. *A citizens jury/ scenario workshop on Food and Farming Futures in Andhra Pradesh,* APCDD, NBSAP, The University of Hyderabad, IDS and IIED. IIED, London, 2002.

[3] MP Pimbert and T Wakeford, "Deliberative democracy and citizen empowerment - an over-view". *PLA Notes* 40: 23-28. IIED, London, 2001.

[4] D Posey and G Dutfield, *Beyond intellectual prop-erty rights. Towards trad-itional resource rights for indigenous peoples and communities.* IDRC and WWF International, Ottawa and Gland, 1996.

Table 2: Different forms of Participation

Passive Participation	People participate by being told what is going to happen or has already happened. It is unilateral announcement by an administration or project management without any listening to people's responses.
Participation in Information Giving	People participate by answering questions posed by extractive researchers and project managers using questionnaire surveys or similar approaches. People do not have the opportunity to influence proceedings, as the findings of the research or project design are neither shared nor checked for accuracy.
Participation by Consultation	People participate by being consulted, and external agents listen to views. These external agents define both problems and solutions, and may modify these in the light of people's responses. Such a consultative process does not concede any share in decision-making and professionals are under no obligation to take on board peoples's views.
Participation for Material Incentives	People participate by providing resources, for example labour, in return for food, cash or other material incentives. Much in-situ research and bioprospecting falls in this category, as rural people provide the fields but are not involved in the experimentation or the process of learning. It is very common to see this called participation, yet people have no stake in prolonging activities when the incentives end.
Functional Participation	People participate by forming groups to meet predetermined objectives related to the project, which can involve the development or promotion of externally initiated social organisation. Such involvement does not tend to be at early stages of project cycles or planning, but rather after major decisions have been made. These institutions tend to be dependent on external initiators and facilitators, but may become self-dependent.
Interactive Participation	People participate in joint analysis, which leads to action plans and the formation of new local groups or the strengthening of existing ones. It tends to involve interdisciplinary methodologies that seek multiple perspectives and make use of systematic and structured learning processes. These groups take control over local decisions, and so people have a stake in maintaining structures or practices.
Self-Mobilisation	People participate by taking initiatives independent of external institutions to change systems. Such self-initiated mobilisation and collective action may or may not challenge existing inequitable distributions of wealth and power.

Modified from J Pretty, Alternative systems of inquiry for sustainable agriculture. IDS Bulletin, 25(2):37-48, 1994.

redistribution of resources, but may only result in de-concentration with a transfer of power to another level of the bureaucracy (see box over page).

The participatory process – and the political negotiation over what constitutes valid knowledge in a particular context (see box adjacent) – deeply challenges bureaucracies and professionals to assume different roles and responsibilities. In particular, existing bureaucracies and professionals will often need to shift from being project implementers and deliverers of standard services and technologies to new roles that facilitate local people's analysis, deliberations, planning, action, monitoring and evaluation. The whole process should strengthen local groups and institutions, so enhancing the capacity of citizens to take action on their own. This implies changes in organisational cultures and the adoption of new professional skills and values. The adoption of participatory methodologies calls for a greater emphasis on training in communication rather than technical skills. Outside professionals must learn to work closely with colleagues from different disciplines or sectors, as well as with rural people themselves. Professional agencies need to set aside time for field experiential learning for their staff, so that they can see, hear, and understand the reality of local people, and then work to make it count.

With real commitment and work, truly participatory approaches can yield impressive results, as in the

Knowledge and power

"Contests for knowledge are contests for power. For nearly two centuries that contest has been rigged in favour of scientific knowledge by the established power structures. We should ask why it is that scientists' endeavours are not seen to be on a par with other cultural endeavours, but have come to be singled out as providing the one and only expert route to knowledge and guide to action. We need to confront the question of what kinds of knowledge we want to produce, and recognise that that is at the same time a question about what kinds of power relations we want to support - and what kind of world we want to live in... We are all involved in the production of knowledge about the world - in that sense, there is no single group of experts"

H Kamminga, "Science for people?", in T Wakeford and M Walters (eds), *Science for the Earth*, Wiley: Chichester, 1995.

Deconcentration, not Decentralisation

In the late 1970s and early 1980s, the International Agricultural Research Institutes made significant efforts to reform the methods and topics of crop breeding to meet new pro-poor and environmental objectives. However, these reforms eventually fell short because they were confined to a new methodology called Farming Systems Research and Extension (FSRE). FRSE was a conscientious attempt to grapple with the multiple characteristics of crops and farming systems that make analyses by remote researchers very difficult. But the analysis and process remained extremely hierarchical.

The move towards FSRE was a small but real advance over older strategies because researchers did start taking into account more variables and adapting technologies to suit specific local conditions. It was thought that by using the new methodologies of FSRE to determine the concerns of small farmers, researchers and extensionists could adapt technologies to their benefit by reworking options that had either been developed but not-adopted ('on the shelf'), or had benefited only better-off farmers (trying to achieve a spill over from larger to smaller farmers).

The key steps in the FSRE process include:

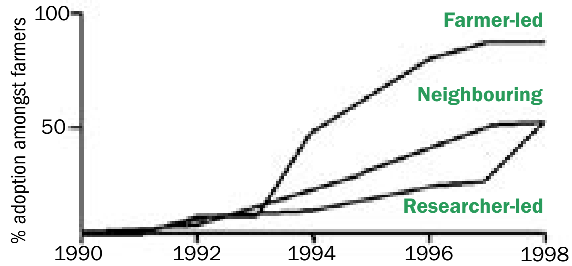
1. Conducting *surveys* of farmer preferences of a given *"type"* and collecting data on sets of homogenous farming systems
2. Taking the information back to the research station for *diagnosis* (usually via statistical analysis) of farmer problems to determine research priorities.
3. Station-based crop *breeding* and technology development according to those priorities.
4. Station-based design of *experiments* to be conducted on-farm to test the new technologies.
5. Collecting /analysing farmers' *responses* to those experiments.
6. Making *adjustments* to the technologies.
7. Preparing the final recommendations for *extension* to farmers.

Unfortunately this new methodology did not fundamentally change the existing structure of research and extension. Farmers' were still considered as inert *"targets"* rather than active and collegial partners of the research and evaluation apparatus, and were involved only in a few stages of the research process (steps 1 and 5 above). Surveys were increasingly utilised, but were suited to meet tight-budgeted researchers' demands for 'quick and cheap' appraisal. Resources and knowledge were not extended to farmers, rather, scientists and extensionists retained their roles as the primary agents of technology change — collecting data, analysing it, developing technologies and modifying them. The real change was that they extended the research arena into farmers' fields.

What FRSE represented was a *deconcentration* of research and crop breeding through an expanded role of unrepresentative actors who are upwardly accountable to central institutes, rather than a *decentralisation*. In the end, FSRE was better at making minor adaptations to prior technologies and recommendations. Because the hierarchical nature of research and extension remained unchanged, farming systems work generated interesting, but not very productive, analyses.

Source: Aaron deGrassi and Peter Rosset, A New Green Revolution for Africa? Myths and Realities of Agriculture, Technology and Development, Food First Books, USA (in press).

Impact of participatory breeding on bean variety adoption



Source: A deGrassi/P Rosset (see box opposite), after CIAT

case of particpatory bean breeding undertaken by the International Centre for Tropical Agriculture (see above). In this example, the adoption rates of conventionally bred varieties were compared with those generated by 'farmer research committees'. These committees used the same original germplasm as formal sector breeders, but performed their own selections under their own conditions, changing traits and the genetic make-up according to their own perceived needs. As the graph shows, communities with farmer committees, and their neighbouring communities, had dramatically accelerated rates of adoption of the new varieties. Not surprisingly, the results suggest that the more farmers are involved in breeding and selecting, the more they will actually use the varieties generated, and more quickly.

Training in participatory principles, concepts and methods must be viewed as part of a larger process of reorienting institutional policies, organisational cultures, procedures, financial management practices, reporting systems, supervisory methods, reward systems and norms.[5] Institutional mechanisms and rewards must be designed to encourage the spread of participatory methods within the organisation. Without this support from the top, it is unlikely that deliberative and participatory approaches will become core professional activities.

Transformation and citizen empowerment

It is not enough to focus on a re-invigorated *political* democracy to mainstream local control and participation in the management of agricultural biodiversity. Widening *economic* democracy is also key. The structural reforms needed for more political *and* economic democracy are best seen from a broader food system and livelihood perspective.[6] Some of the reversals, issues, relationships and processes that need to be addressed in this context are summarised in Table 3.

Broadly speaking, the blueprint approach is associated with the increasingly global food system based on the principles of uniformity, centralisation, control and coercion. The learning

Table 3: Two approaches to sustaining food systems, diversity and livelihoods

	Blueprint	Process
Point of departure	Nature's diversity and its potential commercial values	The diversity of both people and nature's values
Keywords	Strategic planning and trade liberalisation	Participation and local definitions of well being
Locus of decision making	Centralised, ideas originate in capital city	Decentralised, ideas originate in village and municipalities
First steps	Data collection and plan	Awareness and action
Design	Static, by experts. Design of technologies and systems reflect and reinforce priorities of more powerful actors	Evolving, people involved. Broad citizen control on design of technologies and systems
Main resources	Central funds and technicians	Local people and their assets
Methods, rules	Standardised, universal, fixed package	Diverse, local, varied basket of choices
Analytical assumptions	Reductionist (natural and economic science bias)	Systems, holistic
Management focus	Spending budgets, completing projects on time, market performance and shareholders assets	Sustained improvement and performance, focus on right to food, health and other indicators of locally defined well being
Communication	Vertical: orders down, reports up	Lateral: mutual learning and sharing experience
Evaluation	External, intermittent	Internal, continuous
Error	Buried	Embraced
Relationship with people	Controlling, policing, inducing, motivating, dependency creating. People seen as beneficiaries and consumers	Enabling, supporting, empowering. People seen as actors and citizens
Associated with	Normal professionalism and corporate power	New professionalism and democratic decision making
Outputs	Diversity in conservation, and uniformity in production	Diversity as a principle of production and conservation
	The empowerment of professionals and corporations	The empowerment of citizens and local communities

process approach is associated with more localised food systems[7] that are grounded in the principles of diversity, decentralisation and dynamic adaptation. Localised food systems *potentially* offer a more enabling context for democratic participation than the global food system which relies on technologies designed to enhance both profits and centralised political control over key links in the food chain.

A radical shift is required from a largely corporate-led development which aims to retain external control on the management and end uses of food systems (including agricultural biodiversity) to an approach which devolves more responsibility and decision making power to local communities and citizens. The whole process should lead to local institution building or strengthening, so enhancing the capacity of people to take action on their own. This implies the adoption of 1) a learning process approach, 2) new professional values, participatory methodologies and behaviour, and 3) enabling policies aimed at re-localising food systems and economies, and cultural values that emphasise more direct citizen participation in determining research agendas, regulations and policies (see box over page).

Perhaps more than ever before, the growth of democratic participation in the management of agricultural biodiversity depends on expanding spaces for autonomous action by civil society. It is also dependent on a process of localisation and reversals that regenerates a diversity of localised food systems, economies and ecologies. The unprecedented imbalances of power induced by corporate-led globalisation challenge us to engage with these conceptual and methodological frontiers. Now is a time for bold and extraordinary initiatives to ensure that participation does not become a forgotten human right in this century.

[5] IIED and IDS, *Transforming bureaucracies. Institution-alising participation in natural resource manage-ment. An annotated biblio-graphy.* London, 2002.

[6] MP Pimbert *et al*, "Global restructuring, agri-food systems and livelihoods". *Gatekeeper Series no 100,* IIED, London, 2002.

[7] Localised food systems start at the household level and expand to neighbourhood, municipal and regional levels. Food systems include not just the production aspects of food but also processing, distribution, access, use, food recycling and waste.

Democratising R&D and policy making

1. Open up decision making bodies and governance structures within R&D organisations to allow a wider representation of different actors and greater transparency, equity and accountability in budget allocation and decisions on R&D priorities in the life sciences. Throughout the world, there is a dire need for much wider and more gender balanced representation of different citizens in these institutions – small farmers, tribal people, forest dwellers, fisherfolk, healers, and also farm workers, small food processors, retailers and consumers. These bodies should set the agenda for the design of food and farming technologies. They broadly decide which technologies will ultimately be developed, why, how and for whom.

2. Reorganise conventional scientific and technological research to encourage participatory knowledge creation and technological developments that combine the strengths of farmers and scientists in the search for locally adapted solutions and food systems. An important goal here is to ensure that both knowledge and technologies are tailored to the diversity of human needs and situations in which they are to be used – and this on the basis of an inclusive process in which the means and ends of R&D are primarily shaped *by* and *for* citizens through conscious deliberation and negotiation.

3. Ensure that genetic resources on which transgenic and other technologies are based remain accessible to all as a basic condition for *economic* democracy and the exercise of human rights, including the right to food and participation. Decisions to issue patents on genetic resources and national intellectual property right legislation require more comprehensive public framing of laws and policies based on deliberative and inclusive models of *direct* democracy.

4. Include the full diversity of interests and values in technological risk assessments by running consensus conferences, citizen juries, focus groups and referendums on a regular basis. These deliberative and inclusive democratic procedures need to be linked into the formal policy process through appropriate reforms that allow citizens to more directly frame policies and regulations. Participatory democracy can help re-frame policies on the future of food and farming to reflect broader social interests

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This article is taken from a longer paper entitled *"Towards Democratic Control and Participation in the Management of Agricultural Biodiversity"* which was presented at the Growing Diversity conference in Rio Branco, Brazil in May 2002. The full paper is available from www.amazonlink.org/gd/diversity/event or on request from GRAIN.

Johnson Ekpere

There is a tremendous push for Africa to apply genetic engineering to solve its food production problem. What is your opinion on this?

There is a lot of pressure to accept biotechnology from the countries with big biotechnology interests. This is manifested in a number of different ways – political, economic, and scientific. Political pressure is the biggest – accepting biotech is now often a condition for qualifying for other aid money. But most African countries have enough technology to deal with the food production problems they face. If such technologies were put into practice by only half the farmers in those countries, it would resolve their food security problems. If countries would put their money into agricultural science research and extension services instead of armaments, they would not be in the food deficit situation they are in now. It is all a matter of focus and intent. The International Agricultural Research Institutes (IARCs) are replete with high-yielding varieties of crops like maize, cassava, rice, yams, and potatoes. In Liberia, the Africa Rice Centre (WARDA) has just developed a new variety of rice (NERICA)[1] that has the potential to revolutionise production if only it could be extended to and adapted by farmers. But few people are talking about WARDA's rice. If existing technologies were being promoted as effectively as GM crops are, a lot more could be achieved.

What are the implications of the global push to shift the funding of agricultural research and development from the public to the private sector in Africa?

For almost all sub-Saharan Africa, it would be suicidal to shift from public sector funding of agricultural R&D to the private sector. Because private sector R&D is profit-motivated and development is secondary, corporations couldn't care less about the small farmer. Corporate agriculture will just exacerbate the poor situation of these farmers, many of whom are already resorting to gutter-digging in the cities for a livelihood, and contribute to the existing problems of unrest, theft and displacement. Household food security has to be the goal for working with small farmers. Once you take their food from them and the private sector controls not only their seeds, but their land, then the whole system will break down.

I was trained in the US. I remember the courses I took at the undergraduate level at Madison State University in the 1960s. I can still recall a few years after I graduated how many farmers in the US were rendered bankrupt by the shift towards corporate agriculture. That was in a country where less than 20% of the farmers were small farmers. You can imagine what will happen in African countries where 70-80% are small farmers. If they lose their livelihoods, there is nothing to replace them. If there is to be a shift towards private sector funding of research, then let the countries that have the capacity do it, and not do it hook, line and sinker, but do it for specific crops in which they have comparative advantage. To come with a blanket statement that the best thing that African countries can do is to privatise research is to create the greatest problem that sub-Saharan Africa will face in the years to come.

I don't actually worry too much about the corporations introducing GM products if Africa has appropriate biosafety regulations and their products are labelled. I know they will go bankrupt. Let them come and sell their transgenic fruits, trees and crops, and see what happens. But don't use government funds to do this, don't use government money to create policies to support transgenic products.

But what about the strength of the biotech lobby's propaganda and the fact that farmers desperately want to believe that GM technologies will work?

[1] This new rice for Africa (NERICA) is an Afro-Asian cross. Its African parentage means that it smothers weeds and resists drought, pests and problem soils. It also inherited higher productivity from its Asian parent, and is reported to double production *"with just a few inputs"*.

Professor Johnson Ekpere is the former Secretary-General of the Scientific, Technical and Research Commission of the Organisation of African Unity (OAU/STRC). In this capacity, he was the leading light behind the development of two African model laws on community rights and biotechnology, which woke a number of African governments up to the impact a number of global agreements would have on African countries and communities. Trained as an agronomist in the US, for many years he was Professor of Agriculture at the University of Ibadan, Nigeria. Now retired, he continues to act as a consultant on agricultural and rights-related issues in Africa.

This is the danger. Some of these companies have budgets for promotion that far exceed national budgets of many African countries. But the Green Revolution failed to solve Africa's food problem because it was ill-conceived. As a graduate in agronomy, I knew that monocropping would not work on this continent, but few people would listen, not even our own ministers of agriculture. In the same way, the concept of GM will die a natural death, because it is not predicated on the needs of small African farmers. If anything can be done, it has to be done with those who have the technical capabilities to help the African farmer.

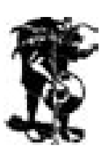
People are saying that all it takes is genetically modified crops to feed the world. But the transgenic seed is just one component of a complex production system. We need to address all the other components. The IARCs, which are predicated on the philosophy of the Green Revolution, created some problems for farmers. But they did help to develop technologies that the National Agricultural Research Systems took up for adaptive research to tailor the seeds to local environments. If we follow on that process – properly – and work with the farmers, a lot can be done. The IARCs have developed technologies that will better serve farmers needs than GM crops.

What is your vision for the future?

When we finished the Model Law, we started on the need to create a better understanding of the document and what it would achieve. That was necessary because at every step in the process I was told that I had embarked on coordinating an effort in futility, and what I was getting all the lawyers and scientists to do would not see the light of day. But it did. What is required now beyond adoption of the model law is needed a popularisation programme to ensure that as many politicians, scientists, social scientists, agriculturalists, etc. would read and process it. But this period coincided with a time when the Organisation of African Unity was restructuring – perfect timing to destroy a piece of good work. And so none of that follow-up promotion has happened – except in an individual, ad hoc way. I would prefer to see this document discussed at national levels and at The New Partnership for Africa's Development[2]. The two model laws need to be looked at side by side with what they are being told by the life science industries, which will exert the same kind of extraneous pressures that African countries faced in the 1950s and 1960s, which created the debt burden that is their biggest problem today. Corporations want to add on to that a technology burden predicated on lack of food, which would be a disaster. People here need to know what food aid is, what the World Food Programme is, the advantages of growing their own food, figuring out what to do with drought and so on. The African continent needs to search inward to address these problems. This document can help in poverty alleviation and food security.

Education, higher education and research are on the decline on this continent. Very few Africans are discussing this problem. One supposed solution is privatising agricultural research, but it is not really a solution.

This continent needs to sit down and look very critically at itself, and ask, *"Where did we go wrong, and what do we need to do?"* The young scientists here are going into the new emerging sciences. I don't blame them – if I was young I might do the same thing. But there are other scientists who are not emigrating yet, who are knowledgeable and who know what happened 15-20 years ago with the Green Revolution. Governments need to get these people together, give them proper funding and challenge them to come up with solutions in a set period of time. I bet they will succeed. And some of the young scientists may realise that they are heading down a dead end and will return to help reinvigorate agricultural research on this continent. We are all too busy theorising, and too few are practising. The key to success is building on what is here, not bringing in exotic science to solve predominantly local problems. I am optimistic that it can be done.



[2] The New Partnership for Africa's Development (NEPAD) was set up in 2001 to provide a vision and a programme of action for the redevelopment of the African continent on the basis of Africa's agenda. For more info, go to www.avmedia.at/nepad/

International agribusiness cannot and will not help Africa

Private investment by international business in African agriculture has been limited to well-established commercial farming areas, or areas where businesses are assured of large returns. The World Bank and other donors and analysts suggest that the solution is to subsidise such businesses.[1] However, there is good reason to believe that even with such support, large agribusiness will not contribute varieties that are well-suited to the needs of poor and diverse small farmers.

Benefits from large agribusiness are precluded by two inherent contradictions having to do with their economic organisation and incentives: (1) adaptation to niche conditions versus economies of scale; and (2) mobile profit-seeking versus committed poverty alleviation. In the first instance, the diverse physical and socioeconomic conditions of agriculture in Africa make it highly unlikely that large, profit-seeking companies will develop specific varieties tuned to farmers needs. Nearly all companies work only with cereal hybrids (maize, rice, or sorghum), rather than open-pollinated varieties or any of the many other crops (e.g. cassava or cowpeas) important to the poor. Because it is costly to develop specific varieties and conduct transactions with farmers in marginal areas, even smaller companies are unable to reach them, often depending on subsidised distribution through national extension. On the other hand, companies that are large enough to cover wide areas cannot adequately address the specific needs of the majority of small farmers. For instance, Pioneer, a major international agribusiness, operated out of the capitals of African countries with large, accessible, commercial farmers. In Tanzania, Pioneer began testing maize hybrids in 1993, but has not sold any because *"distribution channels and effective demand are lacking"*.[2] Furthermore, there is increasing concentration in the agribusiness industry, with Pioneer purchased by DuPont, Cargill's African operations purchased by Monsanto, and Ciba Geigy having formed Novartis. Cargill has also become the majority shareholder of Malawi's national seed producing enterprise.[3]

Secondly, agribusiness companies, by their *modus operandi*, do business only in those areas where they can make the highest returns. While private enterprise is certainly not *always* at odds with social and environmental agricultural objectives, breeding seeds for sustainable, poverty alleviating agriculture is not a lucrative enough market to entice large agribusiness. Where such firms are able to operate, it is by shirking environmental and social costs. When Cargill works with food crops, normal business principles mean a focus on non-reproducing hybrids for large commercial areas on favorable land with good transport. Companies are ready for a quick exit if profits are not high enough. Pioneer entered into sorghum markets in the Sudan after droughts induced higher prices for seeds, but quickly abandoned the country when prices dropped. In 1993, unable to make profits quickly enough, Pioneer closed operations in seven other African countries, writing off $54 million in investments in seed distribution and oilseed processing.[4] Because of their organisation and incentives, large agribusiness cannot and will not assist in crop variety development for sustainable agriculture and small farmers, despite the rosy self-congratulating pictures periodically presented to us by well-financed advertising campaigns.

Footnotes

[1] *"While the policy reform process is certainly not complete, there is growing recognition that such reforms alone will not generate an efficient and broad-based supply response by private traders and processors. This is leading both African governments and international donors to move toward more direct measures to promote private sector agribusiness development."* World Bank, "Promoting private agribusiness activity in Sub-Saharan Africa", *Findings, Africa Region 50*, 1995.

[2] J Rusike and CK Eicher, "Institutional innovations in the maize seed industry", In D Byerlee and CK Eicher (eds*), Induced Innovation: Technology, Institutions and Development*, Baltimore: Johns Hopkins Press, pp 358-408.

[3] For two examples of buyouts by Monsanto South Africa, see R Wynberg, *Privatising the Means for Survival: The commercialisation of Africa's biodiversity,* 2000, www.grain.org/publications/issue5-en.cfm.

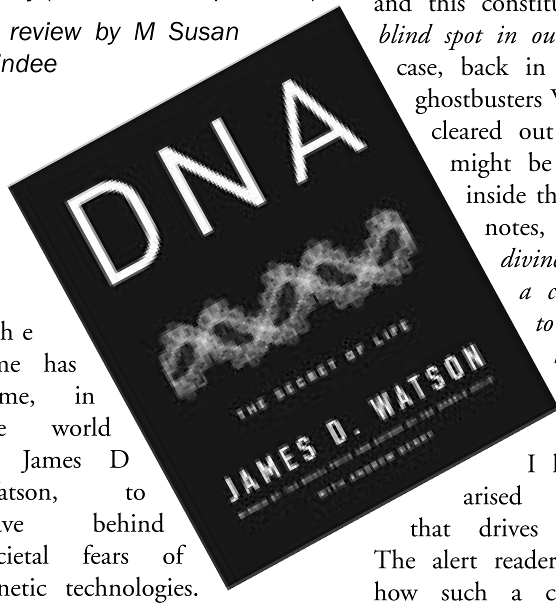
[4] Nigeria, Morocco, Cote d'Ivoire, Ethiopia, Sudan, Egypt, Zambia and Cameroon.

This box is taken from A deGrassi and P Rosset's forthcoming book, *A New Green Revolution for Africa? Myths and Realities of Agriculture, Technology and Development* (Food First Books, 2004).

DNA: The Secret of Life

by James D Watson, with Andrew Berry (New York: Knopf, 2003)

A review by M Susan Lindee



The time has come, in the world of James D Watson, to leave behind societal fears of genetic technologies. It is time to start using genetic engineering to make people who are more intelligent, more attractive, and resistant to HIV. It is time to use genetically modified organisms to improve the environment and end world hunger. And it is time for everyone to contribute their DNA to databases, both private and public. Fortunately, there is no need to worry too much about abuse, injustice, commodification, technical error, or social stratification grounded in biological difference. Such worries are groundless because science shows that people are biologically inclined to care about one another and to care about building a good society. But despite their propensity for caring, people are often fanatical, unscientific, ignorant, dishonest, irrational, and unwilling to accept the true facts that science reveals. So Watson notes in his latest public promotion of genomics, *DNA: The Secret of Life*.

People just need to stop worrying so much about power and money, says Watson. It is true that politics and economics do drive science, but this should be irrelevant to its assessment. And people also need to stop worrying so much about *"the human spirit."* The idea that there *"is no gene for the human spirit"* reflects irrational prejudice. People wish that there were no such gene and this constitutes *"a dangerous blind spot in our society."* In any case, back in 1953, molecular ghostbusters Watson and Crick cleared out any spirits that might be hanging around inside the cell. As Watson notes, *"Is there something divine at the heart of a cell that brings it to life? The double helix answered that question with a definitive No."*

I have just summarised the framework that drives Watson's book. The alert reader might well ask how such a convoluted nexus of belief and prophecy could gain cultural legitimacy, or even a sympathetic publisher. What forces made this incoherent tangle of mysticism, historical ignorance, religiosity, corporatism, exaggerated technocratic rationality, intemperance, and social naïveté plausible to so many people? Or even to James D Watson?

Throughout his account, Watson is unconstrained by either evidence or logic. For example, he invokes the existence of a bioethics industry to suggest that there is no reason to get too worked up about ethical concerns: The ethicists are on the job; the public can relax. But the reason ethicists have taken an interest in genomics is that it is an endeavor that could lead to practices devastating to human rights, a potential exacerbated by the pronouncements such as Watson's. The bioethics industry built around genomics is a sign not that the public should be complacent, but that it should actively resist the kinds of answers provided in Watson's book.

If Watson, for example, wants to theorise about world hunger, perhaps he should consult the work of his fellow Nobelist Amartya Sen. Sen has demonstrated, (through finely textured, detailed, specific, and data-rich accounts of major famines since 1943) that famines are not simply the result of inadequate food supplies. They are the result of economic systems.[1] People can starve when the grain elevators are full; they can have enough to eat when crop yields are disastrous. Promoters of genetically modified organisms often claim that anyone opposed to transgenic crops is turning a blind eye to the needs of those who are starving. But anthropologist Glenn Davis Stone has suggested that the real moral outrage is the strategic use of hungry people to justify corporate programs to develop these crops. *"Malthusian biotechnologists need to explain why crop genetic modification will feed hungry Indians when 41.2 million tons of excess grain will not."*[2]

When Watson turns to the Icelandic genome, he again gives the story a meaning that the details cannot sustain. The Icelandic genome was sold to investors on the premise that Icelanders were a uniquely homogeneous population. deCODE Genetics arranged a deal with Iceland's parliament to construct and market to pharmaceutical companies a database that combined Icelandic genotypes, medical records, and genealogies. These companies could then study genetic predispositions to common conditions such as cancer and heart disease. But if Icelanders were no more homogeneous than any other population, they would be far less valuable commercially and scientifically. Einar Arnason, at the University of Iceland, has demonstrated that Icelanders are among the most genetically heterogeneous populations in Europe.[3] Those who calculated Icelandic homogeneity in the early promotional years were using public databases of mitochondrial DNA, databases now known to be filled with errors. Like the investors and the buyers, the Icelanders themselves were conned into a corporate scheme that has profoundly compromised their

James Watson (left) and Francis Crick in their scientific hey day in 1959

privacy. Watson uses the deCODE story to hint at the promise that complex, multifactorial disease genes will soon be tracked down, profiting both patients and the biotech industry. But the deCODE story is also about speculative hype; rapid profits based on inaccurate information; and disadvantaged, ill-informed patient consumers.

Now that the sequencing of the human genome is essentially 'finished', Watson proposes that there is a new Holy Grail – the transcriptome – that will elucidate how all genes are expressed. Developing the transcriptome will, of course, cost a lot of money. But like the mapping of the human genome, it will supposedly lead to medical breakthroughs and cures.

Meanwhile, genetic disease continues to be controlled almost entirely through the selective abortion of affected fetuses, which in Watson's world is conflated quietly with compassionate medical and educational intervention. So, for example, Watson suggests that the controversial testing of school children for fragile X syndrome is intended solely to help *"tailor"* educational plans to their needs. But he also immediately points out that each of these children costs at least $2 million more in health care expenses than would a child without fragile X. Watson's invocation of health care costs to justify testing and selective abortion is vintage eugenics. Watson urges biologists to *"stand tall"* and *"not be intimidated by the inevitable criticism"* that will come with promoting germ-line gene therapy to *"redress genetic injustice."* Injustice comes in many forms, of course. For most people on the globe today, germ-line gene therapy to improve their children is not remotely possible – their pressing health care needs are for vaccines, nutrition, and environmental justice. An argument could be made that health care expenditures should reflect human needs, rather than potential corporate profits.

Celebrations these last few months mark both the discovery of the helical structure of DNA and the completion of the sequencing of the human genome. Both events should be celebrated. DNA is an important and interesting molecule, and the map of the human genome does provide a baseline for the elucidation of crucial questions about evolution, development, disease, and health. The gene map does not, however, solve all social and economic problems or transform clinical care, and the exaggerated promotions and insupportable claims are becoming tiresome.

Watson is fond of saying that mapping the human genome reveals *"what makes us human"* and on this point I have to agree. The genome project does reveal our extraordinary ability to imagine and create institutions and ideologies that reflect our social organisation, our practices of commerce and trade, and our needs. Perhaps someday, when the body's complex operations are better understood, the knowledge the project has produced will appear as quaint as phlogiston[4] or mesmerism.[5] But its organisational and ideological qualities are timeless testimony to the nature of the human species. They reveal our tendency to elevate what we craft into the realm of neutral, absolute truth, and make manifest our vulnerability to propaganda. Watson has been the genome project's marketing director and prime salesman. His latest promotional brochure is not worth anyone's time.

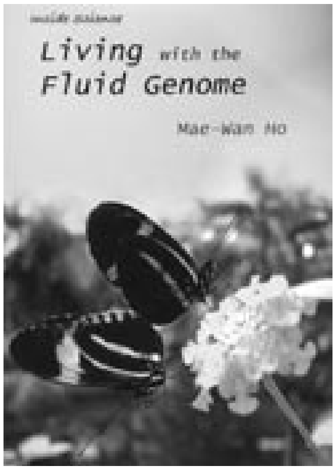
Footnotes

[1] K Sen, *Poverty and Famines: An essay on entitlement and deprivation* (Oxford: Clarendon, 1981).
[2] GD Stone, *Current Anthropology* 43, p 611, 2002.
[3] E Arnason and F Wells, "Iceland and deCODE: A Critique," in D Cooper, ed., *Encyclopedia of the Human Genome*, (Macmillan, London, in press).
[4] Phlogiston theory, put forward in the late 17th century, was a theory of combustion which postulated that in all flammable materials there is present phlogiston, a substance without color, odor, taste or weight that is given off in burning.
[5] Mesmerism is the art of inducing an extraordinary or abnormal state of the nervous system, in which the actor claims to control the actions, and communicate directly with the mind, of the recipient.

Susan M Lindee is in the Department of History and Sociology of Science, at the University of Pennsylvania, USA. E-mail: mlindee@sas.upenn.edu, *The review is shortened from a longer review that appeared in Science Vol. 300, No. 5618, April 18, 2003.*

Living with the Fluid Genome

By Mae-Wan Ho, ISIS/TWN



This book beckons us to *"find out what it means to be liberated from the genetic determinist myth, and to be living with the fluid genome".* It tells the story of how geneticists came face to face with scientific findings that completely undercut the genetic determinist paradigm. It is a science book, but Wan-Ho makes a good attempt at making it accessible to those with a limited science background. The book focuses most on explaining why genetic engineering will fail to give its promised results from a scientific perspective, but also examines how and why science that goes against the Watson and Crick model of heredity (see p 7) is being suppressed and misrepresented. The book also talks about the mechanics of genetic engineering, the problem of horizontal gene flow and explains what makes the genome 'fluid' rather than static, as it is often represented.

Price: £10 including postage
Web: www.i-sis.org.uk/onlinestore.php#books
Email: sam@i-sis.org.uk
Mail: The Institute of Science in Society, PO Box 32097, London NW1 OXR, UK

Local Seed Systems for Genetic Conservation and Sustainable Agriculture Sourcebook

Edited by Pamela Fernandez *et al,* Mercado, UPLB-CA, 2002, 678pp.

This sourcebook is a collection of symposium presentations, field visit discussions, workshop outputs and exhibit materials from a 10-day National Congress on Local Seed Systems for Genetic Conservation and Sustainable Agriculture in the Philippines held in April 2001. The congress brought together a diverse group of would-be practitioners, practitioners and advocates of sustainable agriculture throughout the Philippines.

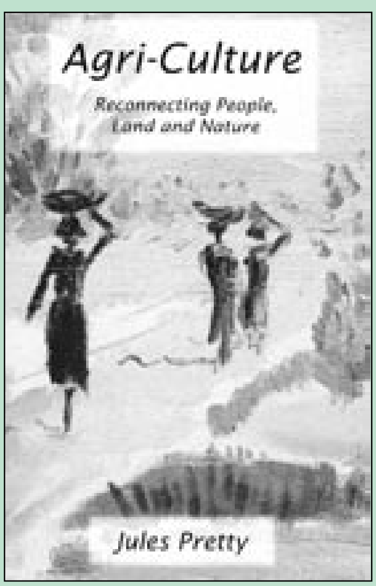
The diversity in experiences is highlighted in more than 30 concrete grassroots experiences and ground level initiatives on sustainable agriculture presented in the congress and contained in the

Agri-Culture: Reconnecting people, land and nature

By Jules Pretty, Earthscan, 2002, 261 pp.

Jules Pretty's latest book envisages the expansion of a new form of food production and consumption founded on ecological principles and embedded in the cultures of the producers themselves. Pretty has made a deliberate attempt to make this more of an essay than a text book, in order to popularise the issues more widely. The text is engaging and easy to read without becoming 'fluffy', and much hard data has been relegated to a comprehensive 'notes' section at the end of the book. Familiar Pretty themes dominate the book (such as dispelling myths about the low productivity of biodiverse farming systems – see p 5), but he extends the discussion to address the wider context of the global food system.

The book starts by emphasising the importance of agricultural landscapes to communities all around the world, reminding us that agriculture's roots are in both 'agri' and 'culture'. He moves on to talk about *"monoscapes"* and how industrial agriculture marginalises poor in particular, and brings together some staggering statistics to illustrate the real costs of our current food system. Pretty then goes on to talk about the myriad of benefits sustainable agriculture offers, and the need to reconnect whole food systems and develop social learning systems to increase ecological literacy (see p 23). The text is supported throughout by concrete and convincing examples of how individuals and communities around the world are turning conventional farming wisdom on its head and transforming the food system.



Pretty concludes by saying, *"There really is no alternative to the radical reform of national agricultural, rural and food policies, and institutions. The need is urgent, and this not the time to hesitate. The time has come for the next agricultural revolution."* His book makes such dramatic transformation seem possible, rather than merely a nice idea.

Price: £10
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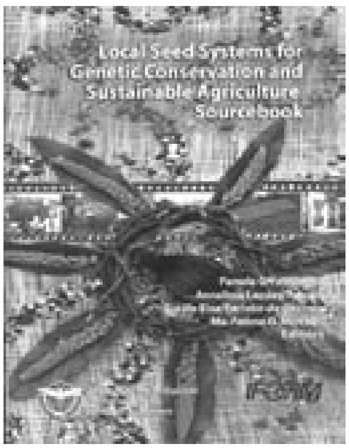
sourcebook. Although some sections are written in mixed English-Filipino language, readers can still get some valuable insights from the discussions and exchanges during the field visits and workshops which were also captured in the sourcebook. Readers may find information on some of the issues affecting sustainable agriculture a bit out to date, but overall the sourcebook offers a wealth of information for sustainable agriculture practitioners and advocates alike. It will be especially valuable to those who are involved in grassroots works and just beginning to shift to more sustainable farming systems. The sourcebook is a bit bulky (more than 650 pages!) but it is also available in CD format at half the paper price (8 US$).



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Eldis – A gateway to development information

Eldis (www.eldis.org) is an internet-based information service which provides filtered, structured information on development and environment related subjects to, and from, practitioners, activists, academics and policy makers around the world. For many in the south accessing the internet is difficult, slow and expensive. The Eldis website is designed with this in mind providing quick fast access through to the latest information. Regular subject focused bulletins provide updates by email meaning that users don't have to spend long periods online.

The core of Eldis is a vast database of over 12,000 editorially selected and summarised online documents from over 4,500 development and environment related organisations. But Eldis isn't just a library. From agricultural policy reform to critical commentaries on World Bank strategy the Eldis team structures this information into subject-based guides on more than 25 major policy areas. Features provide analysis on topical issues with links to the key resources and country profiles allow users to access regionally specific information on a range of issues.

Equally important to the Eldis team is that research produced by organisations in the south gets out to as wide an audience as possible. To facilitate this Eldis is involved in a range of partnerships with organisations of all shapes and sizes. If you would like to now more about how you can get your own research featured on Eldis please email a.stanley@ids.ac.uk

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IPR: Is a world patent system on the way? www.eldis.org/ipr

Conservation and Sustainable Use of Agricultural Biodiversity: A Source Book

By CIP-UPWARD, 2002, 3 volumes,

This simple and easy-to-read sourcebook was designed for rural development practitioners, local administrators, trainers and educationalists involved in agricultural biodiversity related work. It provides a snapshot of some of the local and institutional initiatives worldwide. Though very much geared towards crops and cropping systems, the book also addresses aquatic and livestock resources. A section is also devoted to introducing readers to some of the policy and legal frameworks affecting the conservation and sustainable use of agricultural biodiversity, although the impact of emerging technologies such as genetic engineering has not been covered. The sourcebook consists of 75 articles packaged in three volumes: 1) understanding agricultural biodiverity, 2) strengthening local management of agricultural biodiversity, and 3) ensuring an enabling environment for agricultural biodiversity. Articles can also be accessed via the web at www.eseap.cipotato.org/upward/Abstract/Agrobio-sourcebook.htm.

This sourcebook was produced by the Users' Perspectives With Agricultural Research and Development (UPWARD) Network of the International Potato Center (CIP), in partnership with Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), International Development Research Centre (IDRC) of Canada, International Plant Genetic Resources Institute (IPGRI) and Southeast Asia Regional Initiatives for Community Empowerment (SEARICE).

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CGIAR: Sowing the Seeds of Discontent

By MASIPAG, 2003

This 27-minute video showcases the events which unfolded during the People's Street Conference organised by MASIPAG and RESIST (Resistance and Solidarity Against Agrochemical Transnational Corporations) alongside the 2nd Annual General Meeting of the Consultative Group on International Agricultural Research (CGIAR) in the Philippines in October 2002 (see *Seedling*, January 2003, p 25). With strong support from peasant groups, people's movements, students and other local and international organisations, the street conference demonstrated the discontent felt by these groups towards the CGIAR. The video introduces viewers to some of the impacts the CGIAR has had on farming communities in particular and food security in general.

Price: $US 3 to cover the cost of reproduction and handling
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Via Campesina launches seed campaign

Via Campesina has launched a campaign to defend seeds as peoples´ heritage for the service of humankind. The international campaign was launched at the World Social Forum, in a massive gathering where more than 5000 persons committed themselves to defending seeds as a collective heritage, the basis of cultures, farming and food sovereignty.

The campaign is seen as a decentralised but concerted effort to keep, utilise, exchange and improve local seeds, or any seeds that farmers see as important to their livelihoods, as a way to confront the many threats that seeds face from privatisation, commoditisation, cultural erosion and genetic engineering. The campaign stresses both the existence of clear obligations and rights towards seeds, and it opposes intellectual property rights - or other propriery rights - over seeds.

Action is already taking place at the local level, with a very active and often leading role played by women. Some fundamental concepts and principles for the campaign have already been laid out, and future activities are expected to lead to an ethical framework and a code of conduct regarding seeds:

"Seeds are the work of small farmers and indigenous peoples, a collective creation that reflects the history of peoples and specially of their women, who where their creator from the beginning and have remained their guardians and breeders".

"..Seeds cannot be claimed as property, and must be sustained at all times as a collective heritage....Therefore, the Campaign is opposed to intellectual property rights affecting seeds and against any form and every aspect of property over life".

"The Campaign will be based on the many forms and instances of indigenous and farmers knowledge about seeds, farming and biodiversity.... Farmers and indigenous peoples´ experts and specialists will be the key and central actors of this campaign, specially the women experts and specialists".

The campaign will attempt to involve as many social sectors as possible. It will *"involve society in general by means of cultural, educational and festive activities that generate awareness and mystique about seeds and the roles of indigenous peoples and farming communities."*

The campaign is being coordinated by the Chilean Asociacion Nacional de Mujeres Rurales y Indigenas (ANAMURI), who can be contacted at anamuri@ia.cl and www.anamuri.cl; Tel: + 562 672 0019.

GRAIN supports the struggle against GM crops in Asia

Having been established in the Philippines since 1996 and India since 2001, GRAIN has found itself working more and more directly with different groups in the region. Many of these groups work with grassroots organisations on sustainable agriculture and local advocacy. One of the main and present dangers being faced in the region is the introduction, legally and illegally, of genetically modified (GM) crops.

Through the years, GRAIN has worked in partnership with different organisations on their campaigns, helping to come up with information and analysis and catalysing actions around GM-related issues. One of these, *The Long March for Biodiversity,* was instrumental in persuading the Thai government to ban open field trials of GM crops in April 2001. Organised by BIOTHAI, with the active support and participation from GRAIN, this week-long caravan covered six major provinces in Thailand, bringing information to and catalysing campaigns at the grassroots level. It brought in groups from other parts of Asia and was instrumental in furthering linkages in the region.

Press conference launching the hunger strike. Left to Right: Tony Claparols of Ecological Society of the Philippines, Luisita Esmao of PAKISAMA; Roberto Verzola of Philippine Greens and Mark Cervantes of SEARICE

In 2000, GRAIN embarked on a joint project looking at current trends in agricultural research and development in Asia with BIOTHAI (Thailand), KMP (Philippines), MASIPAG (Philippines), PAN Indonesia, the Philippine Greens, UBINIG (Bangladesh) and a number of university-based professionals. This project produced a number of publications on, amongst other things, *"golden rice"* (rice genetically engineered to produce vitamin A) and hybrid rice (see www.grain.org/publications). These groups and individuals continue to be active players in the fight against GM crops and intellectual property rights on biodiversity and associated knowledge.

In April this year in the Philippines, NGOs, activists and farmer-leaders belonging to the Network Opposed to Genetically Modified Organisms! (NO GMOs!) launched a hunger strike specifically demanding a halt on the commercial introduction of Monsanto's Bt corn. This act drew widespread support worldwide and has raised public awareness about GM crops in the country. After enduring for 30 days without food, Roberto Verzola of the Philippine Greens vowed to continue the fight and deepen the reach of the movement in the Philippines.

Hunger strike, day 24: Agriculture Secretary Cito Lorenzo meets with the hunger strikers for the 3rd time to tell them that he cannot issue a moratorium

In India recently, GRAIN has been working with the Andhra Pradesh Coalition in Defence of Diversity, a coalition of more than 140 civil society groups has been busy spreading the word about the failure of Bt cotton in Warangal, India (see p 13). GRAIN has been and continue to support these and other farmers groups and individuals, NGOs and activists fighting against the corporatisation of agriculture, which undermines the rights of farmers and farming communities' and control over their means of production. GRAIN's role has always been a supportive one - providing timely and relevant information and analysis, responding to requests and linking groups in the region. While the fight goes on, we look forward to establishing more linkages with farmers groups in the years to come.

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