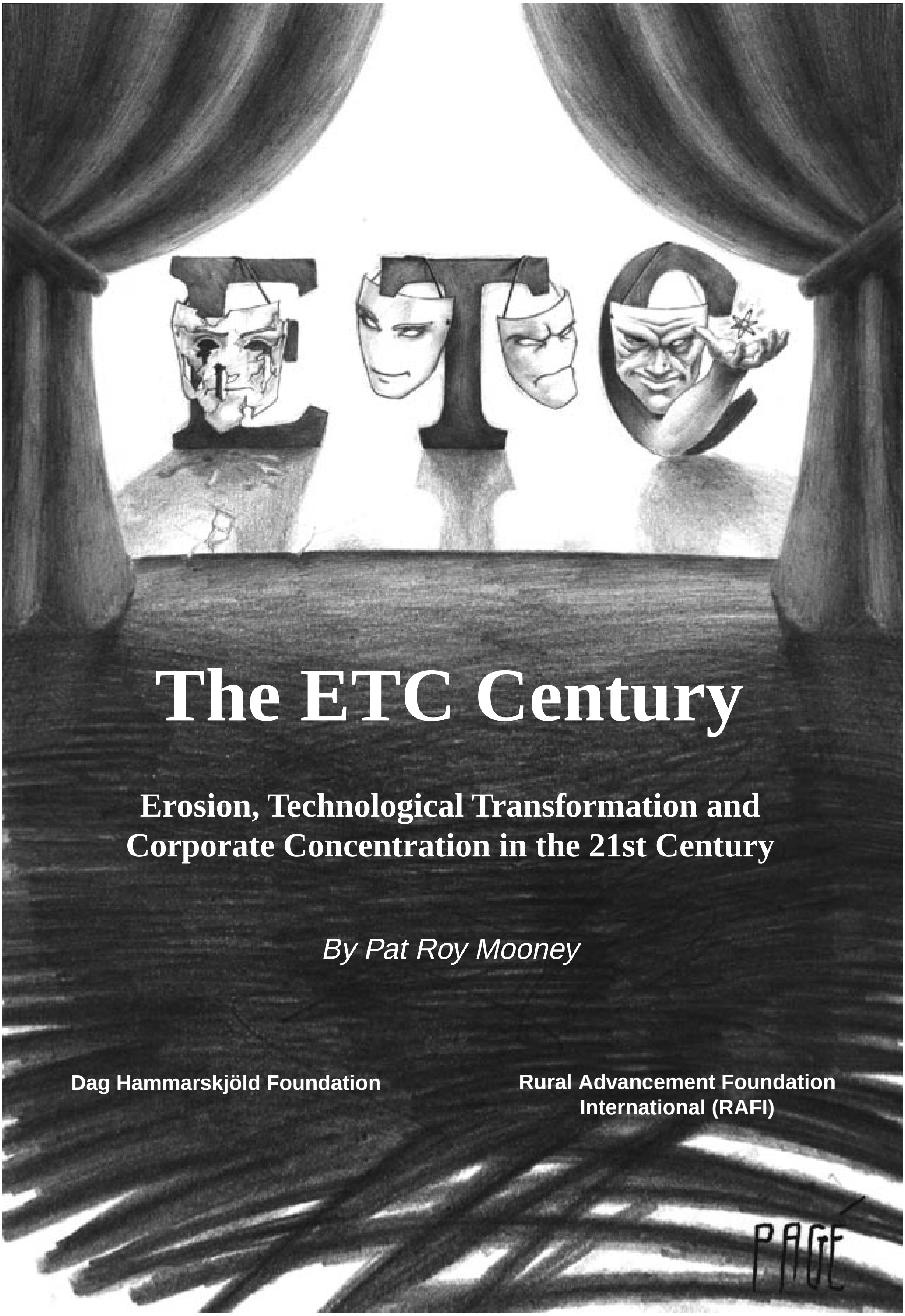

The ETC Century

Erosion, Technological Transformation and Corporate Concentration in the 21st Century

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Introduction to the ETC Century

More than ten years ago, the Dag Hammarskjöld Foundation published *The Laws of Life: Another Development and the New Biotechnologies*, in *Development Dialogue* (1988:1–2). The journal probably offered most of its readers their first glimpse of biotechnology and its implications for Third World societies. Written by four staff members of the Rural Advancement Foundation International (RAFI), *The Laws of Life* was also a report on the 1987 Bogève seminar on 'The Socioeconomic Impact of New Biotechnologies on Basic Health and Agriculture in the Third World'. That seminar, co-organised by the Dag Hammarskjöld Foundation and RAFI, brought together civil society organisations (CSOs) and academics from around the world for an intense political and philosophical debate on a number of socioeconomic issues associated with genetic engineering in health, agriculture, the environment and warfare.

This important meeting was 'billed' as being timed to define the coming debate over biotechnology. We were wrong. In order to have framed the debate and mustered the resources necessary to confront industry and its allies in the research community, CSOs should have been at work at least since 1980, or even earlier. This highly exploratory volume of *Development Dialogue* is an attempt to ensure that we are not too late to address the new set of technologies on the horizon today.

Also, in ongoing discussions between the Foundation and RAFI, it has been concluded that CSOs' strong focus on biodiversity and biotechnology tends to obscure their view of new, upcoming technologies. A more comprehensive approach might be to focus more on Erosion (environmental and cultural), Technology (as future technologies transform society), and Concentration (of corporate power and class dominance) – in short: ETC.

Erosion includes not only genetic erosion and the erosion of species, soils, and the atmosphere – but also the erosion of knowledge and the global erosion of equitable relations. We are losing both our biological resources and our eco-specific knowledge of those resources. Ecological destruction increases the commercial importance of dwindling genetic 'raw materials'. Paradoxically, this is occurring just when new technologies have the greatest need for (and capacity to utilise) the endangered biomaterials.

Technology means, in this volume, the Pandora's Box of new technologies such as biotechnology, nanotechnology, informatics, and neurosciences. (Technology can certainly be defined much more widely than in this document; there are social and cultural techniques that must also be considered, but this would need a much longer discussion.) While some of these technologies lean heavily on biological materials, they also lend themselves to a widening array of old and new monopoly mechanisms. Nanotechnology, in particular, vitiates the relevance of biomaterials (but only for those in power) on the assumption that the world's needs can be met through an infinite supply of manufactured molecules.

Concentration describes the re-organisation of economic power into the hands of high-tech global oligopolies. The interplay between vanishing bioresources, new life-controlling technologies, and the emergence of privatised technocracies may drive tomorrow's social and political changes. The ETC combination could lead to a world of 'Cyber-Cabbages and Nano-Kings', an entire world resembling – as the American writer O. Henry described Central America at the dawn of the 20th century – a banana republic. Were he with us on the cusp of the millennium, O. Henry might well call the coming world order the *Binano* republic.

In 1998, Jeremy Rifkin wrote *The Biotech Century,* arguing persuasively that the 21st century would be dominated by that powerful set of genetic tools known as 'biotechnology'. True enough, humanity has never contemplated a more potent science – one capable of restructuring life. Nevertheless, our myopic focus on gene therapies, mammalian cloning, genetically modified (GM) crops and 'Frankenfoods' have blinded us to the implications of other impending scientific tools. As we struggle to discern our decidedly '*un*Common Future' it is important to remember the lessons of history. Perhaps the most important lesson is that we have consistently failed to anticipate the future accurately.

It was not so long ago that the letters 'GM' appearing in a newspaper headline would have been assumed to stand for 'General Motors', still the world's biggest transnational. It was hardly a century ago, in 1893, that Karl Benz, in Germany, and Henry Ford, in the USA, introduced their 'horseless carriages'. Pundits predicted the coming of the 'Automobile Age', likening the advent of the car to the impact of the key technological discoveries of the Bronze Age or the Iron Age in earlier millennia. By the mid-1920s, however, the impact of the car had been equalled by that of the aeroplane, the radio, and even the lowly aspirin. Television and nuclear energy (the 'Atomic Age') loomed tantalisingly on the horizon. As powerful as the automobile's impact was on the economy and psyche of the world, there was hardly an Automobile Age. It was at best the Automobile Quarter-Century. Likewise, those who isolate and concentrate on biotechnology to the exclusion of other sciences will shortly find themselves part of the Biotech Quarter-Century. The 21st century will witness the coming-of-age of nanotechnology, robotics, neurosciences, space technologies and other patent technologies that will unite with genetic engineering to control 'life', not only in its physical sense but in its political sense as well. These new technologies are a central force in the coming ETC century.

Cue – If 'All the World's a Stage', who has the script?

In 1599, London's Globe Theatre opened its doors for the first time. Its inaugural performance was one of the millennium's most apocryphal plays, *Julius Caesar*, by William Shakespeare. The play poses the conflict between oligopoly and tyranny, disguised as a struggle between democracy and demagoguery. Four hundred years later, Shakespeare would still maintain that 'all the world's a stage' but he might also insist that our stage be filled with diversity – of actors, of plays, and even of playwrights. But, if our world is a stage, we have lost our roles and the script seems incomplete. The Terminator, Monsanto, life patenting, and GMOs (genetically modified organisms) are only a sampling of the villains cast for an epic drama still unresolved. Without the text the actors cannot perform their parts. We only perceive that the stage is much wider than biotechnology. The play itself seems to have three sub-plots: Erosion, Technology, and Concentration (ETC). As the biological foundations of life erode, the bio- and nanotechnological tools that manipulate matter become more potent. They also become more concentrated in the embrace of a corporate elite that is struggling for dominance over the rest of the earth. If we wish to be actors in this uncertain epic we must look to history for our cues.

Preludes 1977 to 2000: From seeds to ETC

From the Dag Hammarskjöld Foundation

The first time that the staff of RAFI and the staff of the Dag Hammarskjöld Foundation sat down together was over lunch in the temporary parliament buildings in Stockholm in 1981. But Pat Mooney reminds us that we almost met – should have met – in 1975 in New York at the Seventh Special Session of the United Nations General Assembly on Development and International Cooperation. The specific occasion was a news conference presenting *What Now: Another Development*, the 1975 Dag Hammarskjöld Report, which constituted the culmination of a major intellectual dialogue and exploration by the Foundation that has guided much of its work and the work of others ever since. Pat recalls that he was coming late into the briefing in the hope of meeting us just as we were dashing from the room to go on to other meetings.

We appeared to be travelling in different directions. The Dag Hammarskjöld Foundation was helping to shape and clarify the perspectives of a Third System – the Citizens perspective on society in contrast to those of the State and the Business Community – and to propose a global course of action on the whole panorama of development issues vital to the poor and powerless. At that time, before there was a RAFI, Pat was trying to focus down. He had resigned his post as founding Chair of the International Coalition for Development Action (ICDA) and was about to spend 14 months backpacking around the world. He was looking for roots and he came back with seeds.

By the time we sat down together in 1981, the gap between our wide and narrow perspectives seemed to have closed. At our invitation, Pat Mooney wrote *The Law of the Seed: Another Development and Plant Genetic Resources* (*Development Dialogue* 1983:1–2) and subsequently contributed to a 1985 edition of *Development Dialogue* with *The Law of the Lamb.* In 1987, the Dag Hammarskjöld Foundation and RAFI organised together the CSO consultation on biotechnology at Bogève, France, and in 1988, the results of the meeting were published in *Development Dialogue.*

About the same time, we began discussing the ETC (Erosion, Technology, Concentration) framework, first over dinners in North Carolina and then at the Dag Hammarskjöld Centre in Uppsala. Other events intervened, however, and Pat wrote a new edition of *Development Dialogue* for us in 1996–98, titled *The Parts of Life: Agricultural Biodiversity, Indigenous Knowledge, and the Role of the Third System,* completing an exciting trilogy that summarised RAFI's 'old' (but not discarded) agenda.

If there were ever any doubts about our common direction, *The ETC Century* should lay them aside. Over the years, RAFI may be perceived to have moved 'down', from seeds to genes to atoms. Yet, in *The ETC Century*, RAFI shows how control of the small can mean control of the world. Certainly the issues of biotechnology, nanotechnology, neurosciences and the '*Binano* republic' are global.

So, we have come full circle. Twenty-five years after *What Now* we are embarking on yet another intellectual exploration, which will culminate, we hope, in a new global vision to be entitled 'What Next?'. We are delighted to be able to offer *The ETC Century* as the first contribution towards the development of this new vision for the decades ahead. The meeting missed 25 years ago has led to a meeting of minds today.

From RAFI

This issue of *Development Dialogue* marks a transition. RAFI has always traced its birth to an international meeting of food activists, who were drawn together by RAFI staff members in Fort Qu'Appelle, Saskatchewan (Canada), in November 1977. Then, the issue was 'seeds', genetic erosion, corporate concentration in pesticides and seeds, and intellectual property monopolies over life forms. The transition to include biotechnology began, with great reluctance, in 1981 but is best identified with the meeting of activists at Bogève in 1987. Now, the move from 'seeds' to 'ETC' (and seeds are by no means abandoned) is made with similar reluctance. RAFI will soon change its name in order to encompass the widening scope of work.

In 1993, RAFI became the first CSO to document the collection of indigenous genetic material and the patenting of human cell lines around the world. This research took us to places we never planned to go. It never occurred to us that we could venture further still. Then, the work on the political economy of seeds and on the collection of human cell lines drove us to study the implications for biological warfare. This in turn led to the review of a very unusual set of military technologies. Hope Shand's 1997 report on 'BioSerfdom' in *RAFI Communiqué* directed us to 'precision farming', including satellites and sensors. These new technologies posed surprising questions regarding the control of the world economy and, most profoundly, the control of democracy and dissent.

RAFI feels it is important to bring out this somewhat futuristic contribution to the discussion for three reasons: first, because it addresses a vitally important set of new technologies and corporate strategies that although related to biotechnology do not receive the consideration their impact demands. Second, while these new areas are developing very quickly, action by CSOs could change their direction. Third, the implications for the poor – and for all of us – are just too fundamental to ignore.

Our concerns expressed here may be proven wrong – but we believe that RAFI's track record should give readers cause to consider this report seriously.

Backstage

Although it may seem otherwise, this volume has been in the making for more than one and a half years and has benefited from much advice. Nevertheless, responsibility for the outcome rests solely with Pat Mooney. Everyone in RAFI has tried to improve the document along the way and it is not their fault if the author sometimes failed to heed their advice or to understand their comments. As always, Hope Shand has tried her best to spot the scientific and political errors, while Jean Christie, Julie Delahanty and Silvia Ribeiro have filled in gaps and added clarity where it was sorely needed. Kevan Bowkett, a highly valued RAFI volunteer, did a wonderful job of identifying and summarising information and ideas on technology and society. Most especially, Beverly Cross has, on several occasions, rescued the

entire text and functioned as both style and science editor while managing RAFI. To this end, she even dragooned her family into the act in order to meet ever-moving deadlines. Any errors that remain are solely the fault of the writer who kept changing words and paragraphs right up to the final moment of printing.

Producers
This text was written while we were all doing other things during the course of 1999. It began over the Canadian Christmas Holidays of 1998–99 at RAFI's 'headquarters' in Winnipeg and it ended with the final edits in Sucre, Bolivia, in August 2000. During 1999, the work was moulded by four dialogues with CSO partners. The first took place in Cuernavaca, Mexico, at a meeting convened for the Global Forum on Agriculture by IATP (Institute for Agriculture and Trade Policy). The second meeting was held in Luleå, Sweden, co-organised by the Dag Hammarskjöld Foundation (DHF). Both these meetings were in early 1999. The third, in April, gave an opportunity to present a more extensive draft at the Dag Hammarskjöld Centre in Uppsala, Sweden. Finally, the almost finished text was shared with biotech activists at Blue Mountain in upstate New York in October. Both these meetings and much of the thinking behind these pages were propelled by Kristin Dawkins and Mark Ritchie of IATP; Olle Nordberg and Niclas Hällström of the DHF; Harriet Barlow of the HKH Foundation and Jon Cracknell and Chris Desser, who guided the Blue Mountain meeting along with Harriet. Wendy Davies and Gerd Ericson have edited and prepared for printing the manuscript with all its boxes, tables, charts and endnotes, a task which is not that simple but which they have solved in an excellent way. Jerry Mander, though he knows it not, forced us to re-think our ideas on technology and culture at several points during the last two years.

Upstaged
This work is dedicated to Sven Hamrell, RAFI's one and only (since our name will be changing) President. Sven first championed the ETC framework in 1988 and has been RAFI's eclectic inspiration ever since *What Now.* With his retirement from RAFI, the question for those of us throughout civil society who have relied upon his leadership in the Third System will be 'who next?'

Olle Nordberg *Pat Roy Mooney*

Erosion

Erosion in the Environment and in Culture Contributes to a Profound Erosion in Human Rights

The fact is that the world has been pretty well ransacked by this time.
William Bean, Curator, Kew Gardens, 1908[1]

A people become poor and enslaved when they are robbed of the tongue left them by their ancestors; they are lost forever.
Ignazio Buttira, Sicilian poet[2]

Cue – 'Curtains' for the stage?

Perhaps it is surprising to some that the disappearance of species and systems follows the same path as the loss of languages, cultures and knowledge. In truth, it would be more surprising were it otherwise. These erosions of environment and culture could never occur if they were not themselves preceded by an erosion in equity.

- *No fewer than 4,000 and possibly as many as 90,000 species are dying out annually.*
- *Tropical forests are disappearing at a rate of almost 1 per cent per annum.*
- *Crop genetic diversity is vanishing from the field at the rate of about 2 per cent each year.*
- *Endangered livestock breeds are becoming extinct at the rate of 5 per cent per year.*
- *Almost a quarter of our irrigated soils have been eroded.*
- *We are destroying soil at least 13 times faster than it can be created.*
- *37 per cent of the world's 1.5 billion hectares of crop land have been eroded since World War II and 5–12 million hectares are being severely eroded every year at a water/nutrient replacement cost of at least US$250 billion per annum.*
- *Fresh water consumption is almost twice that of its annual replenishment.*
- *52 per cent of coastal estuaries in the USA are so polluted from chemical run-off from farm land that marine production is being hampered.*
- *Twenty tonnes of earth are moved every year for every human being on the planet.*
- *Two per cent of the world's languages are becoming extinct every year.*
- *Four European languages comprise more than 80 per cent of all book translations.*
- *By the middle of the 21st century, almost all of the world's many ecosystems will be occupied by peoples who have no indigenous language capable of describing, using, or conserving the diversity that remains.*
- *The right to use and develop diversity is being eroded by intellectual property monopolies and corporate domination of government.*
- *There is a worldwide, unquantifiable erosion of cultural participation and innovation.*
- *Most tragically, along with the erosion of knowledge, is the erosion of social awareness and hope.*

Environmental erosion

Back in the mid-1970s, Garrison Wilkes wrote that the genetic wipe-out of farmers' varieties by corporate varieties was 'like building the roof with stones from the foundation'. As it is with crop genetic erosion so it is with all forms of biosphere destruction. If necessity is the mother of invention, then this threat to Mother Nature should be stirring considerable inventiveness. It is not. Most of our creative energy is continuing to erode the life-giving foundations most vital to the world's poorest in order to build or maintain the roof over the heads of the world's wealthiest.

RAFI has estimated that crop germplasm is eroding at 1–2 per cent per year in the field.[3] More than 34,000 species of plants (12.5 per cent of the world's flora) are facing extinction.[4] Every higher-order plant that disappears takes at least 30 other species (insects, fungi and bacteria) with it.[5] Livestock diversity may be eroding at the rate of 5 per cent per annum – or six breeds per month.[6] Possibly one-third of all domesticated animal breeds are endangered. Almost 900 million tonnes of sediment are flushed through the Amazon into the Atlantic every year. This erosion pales by comparison with the more than 1.1 billion tonnes of top soil swept away each year by the Huang Ho river in China or the 3 billion tonnes bled annually into the Bay of Bengal from the Ganges/Brahmaputra system.[7] Our mismanagement of irrigated soils – among our most important food lands – is especially disturbing. An estimated 24 per cent of the world's 250 million irrigated hectares are considered 'damaged'.[8]

There is a yet greater threat to the water we drink. Only one-half of one percent of all the world's water is not encased in ice or steeped in salt. Rainfall and melt provide 40–50,000 cubic kilometers of fresh water every year but our industrial and population demand for water is doubling every 20 years and according to the International Forum on Globalization, by 2025 need could outstrip annual supply by 56 per cent.[9] In 2000, governments developed a 'World Water Vision' (CSOs called it a 'Wet Dream') attempting to describe and manage the unmanageable conundrum ahead. By 2025, 1.8 billion people (almost a third of the world's population) – mostly living in the Middle East, North Africa, South Asia and China – will face absolute water shortages. Among other steps, they will have to divert water from irrigation and food production to household consumption, meaning that their food imports – and prices – will rise as the water table drops.[10]

Between 60 and 70 per cent of the world's coral reefs could be gone within a generation.[11] At least 70 per cent of the world's marine species are at risk.[12] Over the past century, 980 fish species have become threatened. Tropical forests are disappearing at about 0.9 per cent every year (29 hectares eve-

Historic cues: The erosion of public trust

There is growing evidence that smoking has pharmacological … effects that are of real benefit to smokers.

Joseph F. Cullman III, President of Philip Morris Inc., 1962

In 1953, the Ford Motor Company assured the driving public that 'waste vapours' from car exhausts did 'not present an air pollution problem'. In 1960, an executive of the William S. Merrell pharmaceutical company confirmed that thalidomide was absolutely safe. In 1974, the US Central Intelligence Agency warned of global 'cooling' and, in 1980, the newly elected President of the United States advised Americans that the annual waste from a nuclear power plant could be stored safely under his desk in the Oval Office (a tempting proposition). Not to be outdone, a year later, the Governor of New York offered to glug down a glass of PCBs, and claimed the toxin – now known to be one of the world's most dangerous – was safe, unless ingested in large quantities over a long period while pregnant. A year after that, the US Civil Defense Organization concluded that the ecological 'upside' of nuclear war would be the alleviation of population pressure and a sharp reduction in industrial pollution. What of tobacco's therapeutic benefits? When, in 1996, the US government tried to regulate cigarettes as a 'drug delivery system', tobacco companies argued that the 'pharmacological effects' of nicotine 'are not substantial'. Three years later, one of the companies announced its intention to develop nicotine-based drugs and, in late 1999, Philip Morris – the company that 37 years earlier had declared smoking beneficial – confessed that nicotine was a threat to human health!

ry minute).[13] During the decade of the 1980s, the world lost forests equal to the land area of Peru and Ecuador combined. Roughly half of the world's mature tropical forests (once totalling 15–16 million square kilometres) have been cut down or 'disappeared'.[14] Over half of Ethiopia's highland forests have disappeared in the past three decades, for example, and with that, half of the diversity of its most important agricultural export – *arabica* coffee trees.[15] Worst off is Asia and the Pacific where only 16 per cent of the original forests remain.[16]

Some analysts argue that humanity's disruption of the ecosystem now matches nature's own. Consumer demands force the 'movement' of 20 tonnes of material (minerals, fuels, soil, etc.) per person per year – an amount only equalled by the impact of volcanoes, earthquakes, river sedimentation and the movement of the earth's tectonic plates.[17]

Erosion and extinction are, of course, part of nature. Species come and go. By some calculations, only 5–10 per cent of all the species that have ever lived are with us today.[18] This is to make light neither of species extinction, nor to employ the hackneyed argument that because we are all going to die it is all right to kill. The rate of extinction is unnecessary and unacceptable. It is also without precedent since the advent of humans. To make matters worse, after some species disappear, some underlying causes of extinction, such as toxic chemicals, remain to terrorise the survivors. The US estimates that it will cost US$ 1.7 trillion to clean up its hazardous waste sites (the location of many past and future extinctions) over the next 30 years.[19]

As life-critical biological resources evaporate, industrial pollution, attacking from a different direction, is eroding atmospheric resources. The result – climate change and increased ultraviolet exposure – are posing unpredictable challenges to the surviving biosphere. The World Bank estimates, for example, that a 2–3 degrees centigrade rise in global mean temperature would reduce the mass of mountain glaciers by one-third to one-half, and endanger at least one-third of all species surviving in forests. Changes in glacier mass and forest area will profoundly impact agricultural productivity. Millet crop yields in Africa are expected to drop by between 6 and 8 per cent with global warming. A Senegalese study predicts that millet yields there will dip by between 11 and 38 per cent. In South Asia, yields for rice and wheat are expected to fluctuate wildly. The maize crop in South Asia and in Latin America is expected to shrink by between 10 and 65 per cent.[20] In general, agricultural productivity in the South will decline while crop production in the North – though erratic – could actually improve. Atmospheric erosion does not leave the North unscathed, however. Half or more of the forests of Germany, Switzerland, the Netherlands, and the UK are suffering from the effects of acid rain and the wider implications of this pollution remain unknown.[21] (People in Spain were amazed – and frightened – at the beginning of 2000 when blocks of ice, some weighing four kilos, tumbled out of the sky.)[22] Ironically, even the World Bank concurs that global warming is a phenomenon created by the North's so-called industrial revolution. The bills, however, will come due in the South. Capricious crop losses in the North threaten food surpluses and thwart export opportunities. Farmers in the North are, beyond doubt, an endangered species. But, while lives are damaged, it is usually their livelihoods that are at risk and not their lives. The same yield swings in the South threaten millions of human lives.

Is the human race destined just to be another tree that fell in the forest? 90–95 per cent of all the species that ever lived are extinct. The world carries on. The endangered species we need to worry about is ourselves. If we go, the world will muddle through but if we want to stay, we must protect diversity.

The South is also being asked to bear the risks of experimentation in some shocking new proposals to reverse the Greenhouse effect. Australian academics and Japanese companies, for example, are proposing that Chile turn its coastal waters into a carbon sink by lacing the ocean with heavy concentrations of nitrogen that would stimulate unnatural levels of biological activity. The most shocking aspect of this proposal is that the Chilean Government seems to be giving it serious consideration.[23]

Farmers can only be certain of uncertainty. Climate change means unexpected changes in pests and diseases. Tackling this requires the kind of scientific agility rarely manifested in corporate research.

The health threat to the human species (beyond our food supply) is also growing but unpredictable. There is some truth to the popular notion that diseases such as ebola are the revenge of the invaded rainforests. There will be new diseases.[24] The combined impact of global warming, coupled with extreme El Niño events and expanding aquaculture, are already seen as responsible for breaking down overstressed immune systems in marine species and causing old diseases to hop from one species to another. This is creating what *Business Week* magazine calls a giant ocean-scale *petri* (vessel used in laboratory experiments) dish.[25] In the summer of 1999, New York City was panicked by an outbreak of tropical encephalitis and some European cities were shocked by a sudden rise in malaria incidents where none had been experienced for centuries. New defences will be necessary to protect us from unknown pests and uncertain atmospheric pressures.

Obviously, our uncommon (and uncertain) future plays to the interests of high-tech companies who claim to have the patented tools we need to help us meet these new pressures. The very chemical complex that has been destroying our environment – that has turned diseases like asthma that were almost unheard of in 1900 into a menace that threatens more than 150 million in industrialised countries in 2000[26] – is now offering to save us with their latest gadgetry, which – once again – they insist is perfectly safe! The very folks who will cost the United States US$ 1.7 trillion in toxic clean-up expenses expect to be paid this sum to clear up their own mess.

Cultural erosion

Tragically, all this environmental erosion comes at a time of equally unprecedented erosion in knowledge. From an estimated 10,000 languages in 1900, the world has about 6,700 languages surviving today. Only 50 per cent of those surviving are being taught to children. This means that half the current languages will be effectively extinct within a single generation. Some studies argue that 90 per cent of the languages spoken in 1999 will be 'history' by 2099.[27] Half of today's languages are spoken by fewer than 10,000 people (and half of these are actually used by fewer than 1,000 people).[28]

Already, peoples who speak no indigenous tongue occupy one-third of the land area of South America.

The demise of most languages is paralleled by the ascent of a few languages. Three hundred languages are spoken by 95 per cent of the global population and the leading ten languages are the mother tongues of almost half the planet. Even this underestimates the extent of our cultural homogenisation. At the turn of the millennium, *The Economist* breezily announced that as much as 25 per cent of humanity can muddle through in English.

The reasons for this loss are many. One important cause is good old-fashioned genocide. There is also cultural genocide – much of it deliberate (and some of it due to the inexorable march of the invading culture of power). Even literacy campaigns destroy culture. Some literacy programmes that are highly sympathetic to local cultures still wipe out languages when their good intentions cannot be sustained due to budget decline or lack of qualified teachers and materials. Almost inevitably, the curricula are eroded by the dominant ethnic force.[29]

The decline of indigenous cultures is by no means confined to losses among remote forest populations – a group for whom dominant cultures have absurdly little empathy. In a 1998 UNESCO study of 65 languages for which data was available in both 1980 and 1994, 49 of the languages (75 per cent) had experienced a real decline in the number of works translated from these languages into other languages. Indeed, for these languages, there was a net decline in the total number of translations over the period. The proportion of English among total translations rose from a very substantial 43 per cent in 1980 to over 57 per cent in 1994. The share held by the top four translated languages (English, Spanish, French and German) rose from 65 per cent in 1980 to 81 per cent in 1994. French and German remained almost 'flat' while Spanish increased from just over 1 per cent of global translations to more than 3 per cent (see Chart 1).

A generation ago, a US president promised that his generation would be the first in history to extend the benefits of civilisation to all humankind. Rather, our generation is the first generation in the history of the world to lose more knowledge than it has gained.

The UNESCO data again underplays the true cultural surrender towards English. Between 1980 and 1994, the world's population rose by 26 per cent – with almost all of the gain in the non-English speaking world. The number of literate persons in that much larger population rose by about 10 per cent – making for a very substantial increase in potential readers over the period. Instead of benefiting by this, French and German translations have declined and only English and Spanish are gaining readership. Even here, let there be no delusions. Spanish is increasing because of the modestly growing afflu-

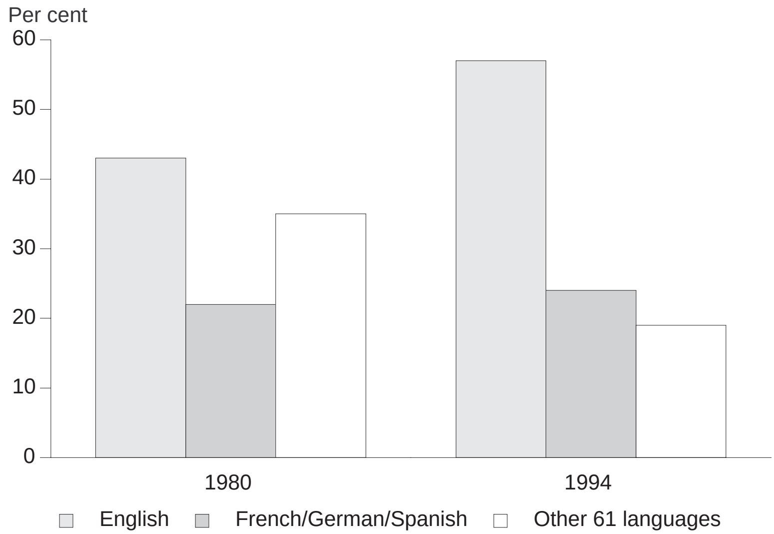

Chart 1 Translations from original language into English, French/German/Spanish, or other languages (relative proportions)

ence of Hispanics in the USA and population/literacy gains in Latin America – not because others in the world have been drawn to the language. Only English is taking over the turf of other tongues.

All this represents a threat to our collective knowledge. With the loss of every language we lose art and ideas. That is well understood. It is also of sadly little interest to the dominant cultures. What is not so well understood is that we are losing scientific information and innovative capacity. With the demise of every language, we are losing knowledge about medicinal plants and preparations that could cure today's (and tomorrow's) maladies. We are losing vital data about species, ecosystem management and climate. We are losing technological knowledge essential to world agriculture. If one-third of the total land mass of Latin America no longer holds peoples with indigenous languages, it means that we have lost the best possible scientific information for the management and development of one-third of South America.

In the 20th century, we had the potential to use technology to liberate creativity and extend cultural participation. Instead, we used these technologies to curtail participation and to control creativity.

Our alarm for what we are losing should be matched by our consternation over what we are left with. In the same study, UNESCO also offers empiri-

Table 1 The world's 10 most translated authors

Author	No. of languages
Agatha Christie	218
Danielle Steele	131
Victoria Holt	120
Patricia Vanderberg	112
Stephen King	110
Jules Verne	109
Barbara Cartland	98
Robert Louis Stevenson	96
Enid Blyton	95
Pope John Paul II	93

Source: Index Translationum, 3rd cumulative ed., UNESCO, Paris, 1996.

cal data on the number of language translations involving the world's 140 most published authors. Ninety of the 140 were English writers in 1994, compared to just 64 (of the 140) in 1980. The number of authors from France and Germany declined slightly. Russian/Former Soviet Union authors, for obvious reasons, dropped off the radar screen during the period.

The study also shows that cultural erosion is not confined to the collapse in translated languages. There is also a collapse in quality. The world's most translated authors could hardly be described as poised on the pinnacle of literary brilliance (see Table 1). The good news is that six of the world's top ten authors in 1994 were women. The bad news is that six of the ten were also writers of pulp fiction. The top three were Agatha Christie, Danielle Steele and Victoria Holt.

We have ended a century in which two key cultural indicators – books and music – became vastly more accessible than ever before in history. Yet, by and large, the books being written, read and translated are Harlequin romances, cook and diet books (!), and the degenerate offspring of 'Windows for Dummies'. The music being listened to is transient uni-generational and uni-theme romance. While more people can read than ever before, fewer people (as a share of the total population) create stories or compose music. We have moved from being *creators* to *consumers* at a time when technology could have amplified our creative capacities.

Once, culturally literate people – who could not read – sat together to repeat historical legends and to create new stories. They addressed the great human issues and they also described the marvellous minutiae of daily living. Now they can read the labels on canned food. Once everyone learned to sing or play an instrument and dance. Family members entertained one another by recreating the great classics of their culture and by inventing new songs and scores that described and clarified their lives. Now they mimic rock idols in Karaoke bars.

World music?

Industry, of course, denies this cultural erosion and even UNESCO points to the 80 *Gamelan* (Indonesian folk music) performing groups in the United States, and the rise in 'world music'.[30] However, UNESCO also acknowledges that the world music market is miniscule and that six transnational recording companies (all in the North) control 80 per cent of the global market for recorded music (worth US$40 billion per annum). Five multinationals – two controlling close to half of sales – dominate the world's music publishing (copyright) business.[31] In fact, mergers within the industry in the first days of the new millennium increased the concentration spectacularly. When the dust settles, four companies will determine the commercial music choices of the world.[32]

Do these 'musical multis' care about multicultural world music? A decade ago, 33–40 per cent of Germany's recorded music came from the UK – in English. Another third of the music Germans listen to came from the USA. Although both MTV and Sony have jumped into the continental Europe music scene, the decisions are made in London and New York and the artists are pushed into English.[33] Tone-deaf transnationals only want to hear what can be played around the world.

World web?

Industry also points to the communications democratisation offered by the Internet, yet more than 80 per cent of the information on the Internet is in English – even though only 8 per cent of us speak English as our first language. Hardly the great equaliser, the Internet caters for rich men – wherever they are in the world – and has further marginalised the poor, women and ethnic minorities.[34] In fact, the Worldwide Web is not very worldly when it comes to its own control. An estimated 85 per cent of Internet revenue and 95 per cent of Internet stock accrues to the United States.

Among others, linguists have begun to recognise the gravity of the homogenisation, especially for the poor. At least 70 per cent of the people in the South depend upon traditional healers for their medical care. Along with language, the poor are losing their knowledge of the medicinal preparations they customarily utilised in nature. Spanish is not just a poor, but an *impoverishing*, substitute for Quechua when the doctor, dentist, hospital and pharmacy do not accompany the teacher and the school. Even then, if there is no

Spanish equivalent to the Quechua word for the part of the plant (or even the plant itself) that is needed to soothe an ailment, the cure dies with the Quechua. Talking about a ‘crash in cultural and intellectual diversity similar to what biologists say is happening in animal and plant species’, linguists warn that only 5 per cent of the world’s remaining languages are not ‘endangered’.[35] The speakers of the language are also endangered.

One of the most often-told and most heart-warming stories about globalisation is the time Nelson Mandela encountered Inuit children in Arctic Canada when his plane was refuelling. He was amazed when they told him they had watched his release from prison on television. Mandela might also have been amazed to know that they were speaking to him in English because they could no longer speak their own language nor, therefore, understand the wisdom of their elders in protecting the fragile ecosystems of the high Arctic.

Is the world losing more knowledge than it is gaining? This is impossible to prove but it is almost certainly true. Even the knowledge that we are acquiring seems often shallow and unsustainable. Humanity has stored knowledge on parchment for more than 2200 years and that information remains accessible and usable today. For the past 20 years, however, the majority of the world’s new knowledge has been stored on diskettes whose life expectancy is only 30 years.[36] Indeed, even this is an exaggeration since most of the data stored electronically in the 1970s and 1980s used software that has long since been lost and forgotten. This can be more than just an irritation. Consider the case of software programmes written for nuclear missiles in the 1960s that cannot be deciphered now.

Equity erosion
E=TC^2

It does not require an Einstein to recognise the new equation of power. The exponential erosion of our biosphere – coupled with the erosion of our ability to understand the biosphere – coincides with a similarly exponential expansion of our technological ability to manipulate large living systems, safely or otherwise. What remains of diversity, and the technologies thrust upon diversity, are falling into the hands of corporate oligopolies.

Our rights are eroding. The same industrial mindset that turned the great opportunity of literacy and communications technologies into a loss of creativity and diversity now proposes to use its high-tech innovations to safeguard the biosphere and ensure our food and health security. Can we trust them with control over these powerful new sciences?

Are we winning or losing?

Half the world (at least of those who register in the data of the cash economy) was impoverished at the end of World War II. Now only a quarter of the (once again, cash-based) population is impoverished. Consumer food prices for cereals have declined by 150 per cent in the past two decades. These should be proof of progress. Yet, the overwhelming impression is that the world is becoming more inequitable – not less. In the North, the middle class is eroding as the upper class becomes wealthier. Health and education deteriorate along with the environment. Child poverty and disease are becoming epidemic in the United States and Canada. In the South, encouraging trends that dominated the third quarter of the past century seem to be reversing.[37]

Whereas, in 1960, the world's poorest countries (encompassing 20 per cent of the global population) accounted for 4 per cent of global exports, by 1990, their share had dipped to barely 1 per cent. The share of exports going to developing countries doubled from 13 per cent in the early 1970s to 26 per cent early in the 1990s.

Predictions that the 'poor might not always be with us' have not come true. In 1990, there were optimistic forecasts that the percentage of absolute poor in the world (those with incomes below US$1 a day) would drop to 18 per cent by 2000. By 1998, the figure was at 24 per cent and the trendline had turned upward.

Some of the gains so celebrated a couple of decades ago now seem illusory. Yields are declining for grains and high-protein pulses. What one recent study called the 'unexpected importance of micro-element deficiencies and toxicities' is now impacting on the most productive Green Revolution soils. The damage is the result of over-intensive agriculture and the heavy use of external chemical inputs. Chemical run-off – especially nitrogen – from farm fields is also now affecting the fresh water and marine harvest. Sixty per cent of the world's population obtain 40 per cent or more of their protein from aquatic sources. The legacy of the Green Revolution is now endangering that source.

The effect of high-input agriculture has not only been inequitable for the environment, it has given the farmers a rough ride as well. Between the 1950s and the 1980s, for example, US farmers experienced a 20 per cent decline in real income despite major increases in yield. During that period, the share of the food dollar assigned to farmers and their suppliers plummeted from 57 per cent to 22 per cent and the pattern has continued. One study comparing high- and low-input agriculture efficiencies in Colombia, China, Philippines, the USA and the UK showed that, on average, low-input farmers were five times more energy-efficient than their high-input cousins. Farmers in the Philippines found that in order to get a 116 per cent yield gain, they had to accept a 300 per cent jump in energy inputs.

The environmental inequities are paralleled by the health risks incurred by rural peoples exposed to heavy chemical inputs. In the United States, the annual cost in public health and natural resource destruction is thought to range between US$1.3 billion and US$8 billion. In Central America, estimates are that between 28.4 per cent and 57.8 per cent of agricultural workers associated with export crops become ill every year from toxic chemicals. In 2000, the World Health Organization (WHO) warned that life expectancy – calculated as years of living free of disabling illnesses – is declining in many South countries after decades of improvement.

The gap between the well-off and the poor – once thought to be narrowing – is widening again. Perhaps nothing demonstrates the shift better than the disgraceful degradation of the rights of the world's farmers through changes in the North's intellectual property laws. In the 1960s and 1970s, governments and seed companies concurred that farmers had the 'right' to save and even re-sell seed. By the 1980s, this 'right' had been transformed into the farmers' 'privilege' to save and exchange seed. In the 1990s, what had once been a 'right', and had then devolved into a 'privilege', was described as 'piracy' by some of the same corporations and governments.

Supposedly in return for the loss of their rights, farmers were to obtain powerful new technologies that would make them healthier and wealthier. In the 1960s and 1970s, these new technologies were the toxic chemicals we have already discussed. In the 1980s and the 1990s the new technologies were genetically engineered. Once more with feeling?

The erosion of confidence

Today, the biotech industry and many governments are assuring us all that genetically engineered organisms can be released into the environment without risk, and that transgenic foods can be consumed by livestock and people with impunity. They could be right. But their track record is abysmal. With the evidence of history, we have good reason to assume that they are wrong. That in fact, they don't know what they're talking about.

At the seminar at Bogève (see page 3), we concluded that it takes a full human generation for us to begin to comprehend the implications of a major new technology. We could add that, in the absence of a compelling human emergency, there is, therefore, no good reason to introduce new technologies until we have proof of their utility and safety.

The 'horseless carriage' of a century ago is a case in point. It is hard to imagine that, even with hindsight, society would have rejected the internal combustion engine. But, with reasonable planning and forethought, it could have been introduced within a context emphasising public transportation and de-emphasising (and taxing) private transportation. Many lives would have been spared. There is no denying that we might still have missed some critical factors such as the geo-politics of petroleum or the early diagnosis of air pollution, but the technology would have got underway in a socio-political milieu that permitted early detection and fast solutions. As much as it can be argued that rapid transportation brought us ambulances and fire engines, few would deny that the deaths caused by the car have outweighed the lives saved.

There are parallels between automobile engines and genetic engineering. Biotechnology is 'life in the fast lane'. More, it means 'life-changing lanes' as we move genes from species to species. Biotech proposes not merely to restructure our landscape but to restructure life. The precautionary principle is sacrosanct. Where are the 'Go Slow' or 'Danger Ahead' road signs?

This is not to oppose, philosophically or practically, the possibility of the eventual safe and reasoned introduction of biotechnology – nor to argue against all recently introduced technologies. It is an argument for comparing risk with benefit. The development of railroads, new mining techniques, the rapid rise of the petrochemical industry, all brought needless death and destruction. In every case, industry and government were sanguine about public safety – until the death toll became irrefutable. In every case, time proved them dead wrong.

In mid-1999, Europe was rocked by food safety scandals as toxins were found in poultry products in Belgium. A few days later, the Belgian government was forced to withdraw some Coca-Cola products. Belgian school children were sickened by twin attacks. Contaminated CO_2 in carbonated Coke joined forces with a fungus from shipping pallets. Somehow, the fungus was transmitted to the children. Within days, Coke was off the shelves in much of Western Europe. What are the chances of accidents like this happening? Pretty good. Were they alive, we could ask the only two drivers in Kansas City, Missouri, back in 1905. Although they had the roads to themselves, they managed one of the Automobile Quarter-Century's first-ever head-on collisions.[38] Across the state in St Louis, Monsanto (undergoing its own head-on merger with Pharmacia-Upjohn) should take note. Are governments and industry more careful today? Thus far, more than 70 people have died from 'mad cow disease' in the UK. As 1999 ended, EU reports warned that the disease might have spread to most of the continent. By mid-2000, governments could not rule out the disease's spread to North America and Australia as well.[39] Mad cow disease is a *bureaubacteria* – it would not have happened if business had not been greedy, scientists had not bungled, and bureaucrats had not lied. It is not the only current example. Hundreds – perhaps thousands – of people in France and Canada have had their lives shortened when bureaucrats and politicians decided to use tainted blood products. The informatics industry provided another example. US corporations spent US$150 billion – and the world's governments spent another US$500 billion – adjusting their computers to Y2K. It seems no one in corporate America was bright enough 20 years ago to realise that the century was coming to an end. And, just as we are paying the heirs of the chemical industry to clean up their dumps, we asked those who created Y2K to rescue us. In the opening days of the new millennium, the US government publicly acknowledged – after 40 years of denial and tens of millions of dollars in legal defence – that as many as 600,000 nuclear weapons workers in that country may have had their lives cut short due to radioactive contamination. A government 'fact-finding' panel also agreed that the reality of the risk had been known to authorities for decades.[40]

Corporations argue that the reality of environmental erosion can only be solved with the illusion of new biotechnological 'silver bullets'. There is nothing in history to suggest that silver bullets have ever hit their mark. So far, all that biotech companies have done is to shoot themselves in the foot!

In 1992, the year heads of state thronged to Rio for the Earth Summit to adopt protocols and conventions related to climate change, desertification, biodiversity and forestry, 5 million children died for lack of food or clean water or inexpensive vaccinations. This was the equivalent of one of those fine innovations of the Age of the Automobile, a school bus being driven off the top of the Aswan Dam every 60 seconds.[41]

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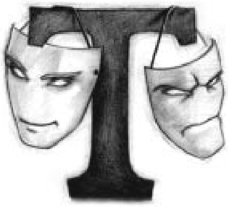

Technological Transformation

The Increase in Power and Complexity is Coming just as the 'Raw Materials' Are Eroding

Everything that can be invented has been invented.
Charles H. Duell,
Commissioner of US Office of Patents, 1899

Cue – The 'props' are taking over

If the planet's biological foundations are being corrupted, a host of new technologies are lining up to solve the problem. Who will control the new technologies? Whose interests do they serve? Are there technologies that are inherently 'good' – democratising, empowering and decentralising? Are powerful technologies automatically 'evil' – centralising, distancing, and destructive? Can poor people trust rich scientists (or their companies) to take care of them? If biotechnology is setting off alarm bells, what about nanotechnology? The only thing that is certain is that the pace of introduction for new technologies is accelerating.

- *Edison switched on the lights of Pearl Street in Manhattan in 1882 but it was another 30 years before electrical appliances became widely available in the USA.*
- *A quarter-century after the introduction of the automobile, there were fewer than 4 million cars being made in the USA.*
- *It took 38 years after the introduction of the first radio station before the new media was able to reach an audience of 50 million listeners.*
- *Television reached 50 million viewers 13 years after the first programmes were commercialised.*
- *It took 16 years after the introduction of personal computers before the technology could claim 50 million adherents.*
- *The early telegraph transmitted information at 0.2 bits per second. Today's fibreoptic cables transfer data at 10 billion bits per second.*
- *Just 4 years after its inception, the Worldwide Web had 50 million users.*
- *By 1996, the number of Internet hosts and e-mail messages were doubling every year and the number of Internet users now doubles every 4–5 months.*
- *The amount of genetic information being stored in the international gene banks is doubling every 14 months.*
- *It took 1,000 scientists 10 years to decode the first yeast genome.*
- *A quarter-century ago, it took a laboratory two months to sequence 150 nucleotides (the molecular letters that spell out a gene). Now, scientists can sequence 11 million letters in a matter of hours.*
- *The cost of DNA sequencing has dropped from about US$100 per base pair in 1980 to less than a dollar today and will be down to pennies by 2002.*

- *Standard gene sequencing technology once required at least two weeks and US$20,000 to screen a single patient for genetic variations in 100,000 SNPs (single nucleotide polymorphisms). Now, 100,000 SNPs can be screened in a few hours for a few hundred dollars.*
- *In 1991, the US Patent and Trademark Office had applications pending on 4,000 EST (expressed sequence tag) sequences. In 1996, there were 350,000. There were half a million in 1998. One year later, the leading three human genomics companies conceded that they had filed in excess of 3 million EST patent claims.*

The dawning of the Age of Lilliput?

We seem to have entered the 'Time of Small Things'. At the beginning of the 20th century, we remembered the laws of genetic inheritance[1] and much of this century has been consumed with understanding and manipulating genes. Not long after the rediscovery of Mendel's Laws, we were absorbed in the functions of the atom and of atomic energy. Now, at the beginning of the 21st century, we may be generating new technologies that merge our limited knowledge of the gene with our precarious understanding of the atom. When we have so consistently failed to do the big things right, are we capable of doing the little things well?

The inability of industry to comprehend its own technologies is not new. Thomas Alva Edison, one of the industrial age's most commercially useful inventors, not only missed the merits of his phonograph but then went on to trash the commercial viability of the telephone, radio, television and the aeroplane. Not long before Kitty Hawk, Wilbur Wright told Orville that heavier-than-air flying machines were a half-century away. (*Scientific American* apparently concurred. Three years after Kitty Hawk, the magazine was still openly doubting that the Wright brothers had actually flown.) The redoubtable Albert Einstein pooh-poohed nuclear energy 12 years before Hiroshima. Perhaps the greatest pharmaceutical blunder of the past 100 years was Bayer's initial rejection of the aspirin – the most profitable pill of the 20th century, and potentially of the 21st century as well!

Have the times changed? Have the 'experts' learned their lesson? Why are these new technologies poking their noses under the tent of the millennium? Here are some developments that bear scrutiny.

Biotechnology

If you buy the propaganda, biotechnologies provide the toolbox that industry can use to 'fix' the environment. According to the hype, genetic engi-

Historic cues: Strategic slip-ups in introducing new technologies

[Aspirin is] typical Berlin hot air. The product is worthless.
Heinrich Dreser,
Head of Bayer's pharmaceutical division, 1899

In 1845, the US postal service rejected Samuel Morse's offer to sell his patented telegraph for US$100,000 because it was purposeless. In 1877, Western Union, the company that finally took up Morse's telegraph, dismissed Alexander Graham Bell's telephone (also offered for US$100,000) for the same reason. In 1907, a major US telephone company turned down Leo DeForest's radio and, in 1926, DeForest himself concluded that television was commercially moribund. In the late 1970s, semi-conductor manufacturers laughed off personal computers and, in 1981, Bill Gates did not foresee that any PC would need more than 640k ram.

neering will make it possible for our food system to adapt to global warming and to feed the 'untold billions' who will imminently crowd our planet. Biotech may let us rebuild populations of endangered species. Some scientists argue that it will allow us to compensate for the loss of biodiversity *in the present*, by permitting the new and rapid creation of commercially useful biodiversity *over time* (i.e. there may be less diversity present at any given moment but the innovation process will generate a continuing flow of new and useful diversity as it is needed). Biotechnology is the magic bullet that has dominated the public imagination in the 1990s and today.

Five (not-so-easy) pieces

Those who pick up RAFI materials tend to be well acquainted with biotechnology. On this assumption, only some of the key developments critical to our sense of where the technology is heading are identified.

The cloning of 'Dolly' in February 1997 and the joint announcement by Dr Francis Collins of the Human Genome Project and Dr Craig Venter of Celera that they had completed the first crude map of the human genome in June 2000 are the pinnacle events that mark biotech's quarter-century. Both events were crowded with confusion. As cloning moved from sheep to cattle, scientists debated whether the process unnaturally aged the animals and the dispute seesawed from institute to institute and species to species around the world. In the enthusiasm for the first human genome map, the popular press largely ignored the tremendous implications of other genome maps underway or completed ranging from rice to tigers. People and politicians missed the main events.

Reverse DNA quiescence

Behind Dolly, however, was the more significant evidence that any living cell can, theoretically, be re-programmed to perform any function in the organism. The discovery of reverse DNA quiescence not only made the cloning of sheep, cows, and monkeys doable (and the cloning of a monkey made it scientifically hard to pretend that human beings could *not* be cloned), it meant that we can replicate tissue and organs from our own bodies for organ or bone marrow transplants. Dolly and her offspring grabbed the media attention, but it is the ability to regenerate body parts that could command the marketplace.

Chromosome transfers

In 1998, Japanese researchers taught us that whole chromosomes – several of them at a time – can be inserted into foreign species. The Japanese scientists inserted three entire human chromosomes (out of our species complement of 23) into a rodent. The potential to mix and match whole chromosomes that could be stuffed into everything from fungi to farmers may be limitless. In 1999, *Nature* magazine reported that scientists had isolated a 'memory gene', replicated it, and copied it into the DNA of rats to enhance their ability to remember.[2] The implications for the enhancement of human performance are both exciting and terrifying.

Jeremy Rifkin's brilliant challenge, forcing the US Patent Office to debate what it takes genetically to make a human being, will have reverberations for decades to come. How many human chromosomes can we put in a harp seal before Greenpeace sides with the cod? If you put three human chromosomes in a rat, can it run for office? If you replicate the human 'memory gene', will the rat remember its promises?

Epigenetics

Even as British and American scientists were congratulating themselves on mapping the human genome, a massive but far less publicised debate was breaking out over the laws of genetic inheritance and the uncertain role of so-called 'junk DNA' – that 97 per cent of the human genome that Venter and Collins deemed unworthy of mapping. New evidence is emerging that junk genes (material rendered irrelevent throughout the eons of evolution as we graduated from deep-sea thermal vents to the heights of mammalian accomplishment), actually continue to play an important role in our evolution and our immediate adaptability. Even the long-discounted environmental evolutionary theories of the appropriately despised Lysenko (Stalin's malicious and maniacal science czar) are being revisited. Many researchers were surprised to discover in mid-2000 that 'junk' DNA may be essential for silencing one of the X chromosomes in women. Hardly a minor matter.[3] Junk DNA may also play a role in other genetic variations that can grant longevity in some fruit flies but can also cause adverse effects for flies of the opposite sex or in other environment.[4] Just as we think we have the 'map' in hand, we are finding there are whole new hemispheres to explore.

Intragenic modification

In part connected to the re-evaluation of junk DNA, scientists are speculating that the time of transgenic or 'GM' manipulations may be at an end even while it has just begun. Until now, the movement of specific genes conveying useful traits from one species to another has been attractive for scientists because they can see, for example, the trait for cold tolerance or disease resistance obviously manifested in one species. They know, therefore, that they can theoretically isolate the trait and move it into another species deemed to be in need of the characteristic. For some time, however, researchers have also observed that the gene conferring resistance to a specific disease found in one species can be identical to the disease resistance gene found in a very different species. *Epigeneticists*, meanwhile, remind us that we share half the genes of a banana and that we are only a handful of genes away from a salamander. By sifting through our junk DNA and switching on or off various genes, scientists speculate that we will find most of the genetic diversity we need for plants, poultry or people *within* the species. No need for transgenics.

If this is correct – and RAFI bets that it is – it says nothing whatsoever about the safety of the environment or of food. There is no reason to think that intragenetic manipulation is any safer than transgenic manipulation. However, those who have staked their opposition to biotech on the premise that transgenics is unnatural, sacrilegious or immoral may have a problem. The final result may seem unnatural, but it could, in fact, produce organisms that nature might conjure up itself if left alone long enough with a bottle of bad scotch and a worse attitude.

Our basis for political action must not be built upon a static understanding of what is natural or supernatural. Each technology can and must be judged on its own merits. There are new technologies, for example, such as aspects of organic farming, which encourage democracy and decentralisation. Then there are other highly undemocratic and highly centralising technologies (such as nuclear power) that must be evaluated with vastly greater care.

Construction of living organisms

Dr J. Craig Venter and his colleagues have explained that we can now *create* life where no life existed before. True enough, the life he was forming – and decided to abandon for sound ethical reasons – was spliced together from a few microbial genes.[5] But the point is that humans may clamber onto centre stage with God in that exclusive club that can breathe life into clay.

The Terminator piece

It is tempting to add Terminator or Traitor Tech to the list of major scientific changes that are shaping the future of biotechnology. In truth, industry's Terminator strategy builds upon some of the discoveries listed above but gives these developments an ominous commercial application. Using Traitor Tech, they have found a highly lucrative way to sterilise a plant's seeds at harvest and then bring them back to life for the next planting. Lazarus-link seeds could soon be commonplace. More on this later.

At times it feels that we are nearing the end of science fiction. What we once considered absurd – or millennia away – is now at hand.

Biological warfare

Those of us who monitor biotechnology have paid too little attention to its military applications or its impact on democratic institutions. It was a rare occasion then, when on 11 May 1996, the *New Scientist* published a special report on 'bioterrorism'. In it, Robert Taylor warned that the weaponisation of bacteria and viruses was not only likely but almost inevitable. The report noted that biowarfare did not require sophisticated biotechnologies, but that the mushrooming of biotech would increase the effectiveness of bioweapons and that it would be next to impossible to monitor the institutions and scientists capable of developing such weapons. In 1996, there were more than 1,300 biotech 'boutiques' in the US alone and 500 more in Europe. The US biotech industry employed more than 60,000 scientists trained in biotechnology and close to 6,000 more were coming out of the universities every year. The report also noted the growing ability of the South to develop its own bioweapons.[6]

Because even a moderately-skilled poor 'enemy' could create weaponised viruses with the help of Java script on the Internet, every country has an excuse to develop a so-called 'defensive' biowarfare capacity. This is a weapon that will be used – especially for economic sabotage.

Future battlefields

The *New Scientist's* timing was impeccable. It was also in May of 1996 that the US army convened a two-day workshop on the future military implications of biotechnology, organised through a contract to Science Applications International Corporation (SAIC). 'Biotechnology 20/20' brought together key people from the Pentagon's Missions and Special Operations Directorate, the Army's Research Laboratory, the Future Battle Directorate, the Air War College, the Army War College, the Army Chem/Bio Defense Command, and a high mucky-muck from the Office of the Deputy Chief of Staff. The military strategists and scientists were joined by bioethicists and anthropologists from academia (e.g. the Center for Human Performance and Complex Systems, University of Wisconsin) and high-sci corporate gurus from companies such as Nanotronics Inc. Non-military government agencies such as the National Institutes of Health were also on hand.

RAFI learned of the workshop from the November 1996 issue of *Wired* magazine. Ever the intrepid investigators, we immediately filed for the workshop's background papers and reports with both SAIC and the army.

Table 2 BiowarBucks: A sampling of US-based biowarfare boutiques

Company name	Contract/grant (1998 and 1999)	Activity
Abgenix	US Army Medical Research Institute of Infectious Diseases	To develop antibodies that could protect US troops during biological warfare. The company's XenoMouse technology will be used to make fully human monoclonal antibodies against filoviruses such as Ebola and Marburg.
BioPort Corp.	US Dept of Defense	BioPort is the only company licensed to manufacture the anthrax vaccine in the US. The US government proposes to vaccinate all 2.4 million military troops.
Cepheid	US$750,000 from US Dept of Defense	To develop a portable, high-speed polymerase chain reaction instrument intended to alert military personnel to the existence of pathogenic agents in the field.
CombiMatrix (subsidiary of Acacia Research Corp.)	US Dept of Defense grant	To use the company's proprietary biochip technology to enable simultaneous detection of numerous chemical and biological warfare agents.
Genelabs Technologies	US$13.6 million from DARPA*	To create drugs designed to block pathogens at the level of DNA or viral RNA.
Hughes Institute	DARPA	To develop broad-ranging countermeasures for biological warfare defense.
Ibis Pharmaceuticals	US$6.6 million grant from DARPA (US govt)	To develop a new technology to identify molecular targets for drug discovery directly from genomic sequence data.
Meridian Medical Technologies Inc.	Contract with US Dept of Defense – expected to generate revenues of US$15 million	To supply auto-injector products for immediate self-administration of antidote for nerve agent poisoning.
Nanogen	US$8 million grant from DARPA and National Institute of Justice	To create a miniaturised lab for biological warfare defense applications.
Phylos Inc.	US$1.6 million DARPA grant	To develop an automated system for the rapid development and deployment of biological pathogen sensors.
SIGA Pharmaceuticals	US$800,000 DARPA grant	To develop vaccines and oral delivery systems for the continuous release of neutralising agents against biological warfare agents such as anthrax or plague.

* DARPA – the Defense Advanced Research Projects Agency – is the central research and development organisation for the US Department of Defense.

From January to June of 1997, various bytes and pieces of the US science-military and intelligence communities fought to deny our request (one also made by the government of Italy, the magazine *US News and World Report* and a private US military contractor). In mid-1997, despite the best efforts of the Biological Warfare Treaty Compliance Chief and the Director of the

Biological Arms Control Treaty Office, a technicality forced the Army Research Laboratory to surrender the documents. It took us another year to get around to studying the papers. It became our summer reading when some RAFI staffers gathered at the Seed-Savers' Exchange 'Heritage Farm' near Decorah, Iowa, in mid-July 1998. Heritage Farm is about as far away from biological warfare as you can get – and about as close to a real citizen's defence to biowarfare as can be imagined.

At Seed-Savers', one of the speakers reminded us of one of Krishnamurti's favourite sayings: 'It is not necessarily healthy to be well-adjusted to an insane society.' These words came back to us many times as we read through the briefing papers and strategic battlefield scenarios. Officers such as Colonel Gerald Jaax, made famous by the various 'Ebola' books that came out a few years ago, and now Director of the Biological Arms Control Treaty Office, opposed making the workshop data available to RAFI on the grounds that the workshop's highly futuristic and speculative 'free-thinking' style could be misinterpreted to be US government policy. This is a fair concern. You don't have to be a 'hawk' to accept society's need to defend itself against biowarfare. Indeed, had the US army *not* convened a think-tank session on biological warfare, American citizens could reasonably have risen up and court-martialled the whole lot for dereliction of duty. Once we accept that a responsible 'defence' establishment must contemplate the unthinkable, the parade of ever-more grotesque and horrific battlefield scenarios considered by the workshop all acquire the kind of well-adjusted normalcy that Krishnamurti warns us against.

To be clear (and fair), at no point in the documents sent to RAFI does the military contemplate a US violation of current treaty prohibitions to biowarfare. On the contrary, the SAIC analysis of the US 'military mind' suggests a natural abhorrence to this kind of warfare and a principled desire to honour treaty obligations. Yet even Gerald Jaax acknowledges that there are large grey areas in international law where treaty compliance and the definitions of biological warfare run into trouble. For this uncertainty alone, there is ample reason for public scrutiny and informed debate.

Hollywood's 1970s *Easy Rider* said it as well as Krishnamurti: 'Do not adjust your mind – there is a fault in reality.' The Biotechnology 20/20 Workshop surveyed the full panorama of new science fiction toys available in the ongoing 'RMA' (Revolution in Military Affairs). The point was that biotech cannot be understood except in the context of other unfolding technologies such as robotics, space technology, communications, computer sciences, nanotechnology and neural networks. In a sometimes witty but always dispassionate style, SAIC's theoreticians drew the workshop's attention to an all too credible array of deadly goodies that could be militarily viable by 2015–2020. Scientific advances are not only leading to the 'death of distance' (a recurring military theme), but the end of battlefields. There is no defence. Sanity suggests that the only course available to the general intent upon protecting national sovereignty is the hot pursuit of peace. The best defence lies in the removal of the socio-economic inequities and democratic shortfalls that have always been the overwhelming cause of war.

Even though the workshop documents recognise that many of the new technologies are being proliferated through the Internet and that biological warfare (in particular) is probably inexpensive, the 'peace' option is ignored and the focus of the workshop is military defence against each indefensible scenario.

The weapon that will be used

At Bogève, RAFI summarised our major concerns about biological warfare as follows:

- There are *no critical raw materials* whose mining, manufacture or transportation can be readily monitored. Biological weapons could be scraped off a rancid piece of meat or synthesised from backyard dirt.
- *It is cheap*. Most of the cost of modern weaponry is getting the explosive to its target. Bioweapons can ride economy class on a commercial airline, be sprayed on migrating butterflies, or sent in the mail.
- *It is easy.* New computer Java programmes are making it possible for scientists in poor countries to mimic research in cyber labs in order to design their own bioweapons relatively quickly and without expensive equipment.
- There is *limited stockpiling*. When needed, the toxin can be pulled out of the icebox and brewed in a few petri dishes or a beer vat. This makes monitoring next to impossible.
- *No one will know who did it*. The source of the 'attack' could be impossible to trace.
- *No one will know it was done*. If the weapon of choice is the mutant strain of a known disease, it may be impossible to prove that the 'attack' was intended. Even the victims could be convinced that it was an 'act of God'.
- Bioweapons can be used for *economic warfare* – targeting livestock or crops rather than people. Whether through late potato blight or coffee mosaic virus, biological weapons can destroy the economy or the food supply and topple an enemy government without anyone suspecting foul play.
- *It will be used.* Generals may prefer to sabre-rattle with nuclear weapons

but bioweapons are the poor man's/poor state's A-bomb. For all the reasons cited in this list, biowarfare will take place – and it may or may not be containable.

Ethno-bombs

All of these issues persist, but in 1993 RAFI added a new concern to the list: the global collection of human genetic material (usually cell lines) by medical researchers (including the Human Genome Diversity Project – HGDP) could make it feasible to develop ethnically targeted viruses. The HGDP and leading medical organisations – including some progressive genetic watchdogs – ridiculed this assertion. Not since we warned, at the beginning of the 1980s, that herbicide manufacturers were buying seed companies in order to develop plant varieties that liked their chemicals, has RAFI borne the brunt of so much abuse.

We were not so far ahead of our time as we thought, however. In 1996, the British government advised the Biological and Toxic Weapons Convention in Geneva that the information arising from the Human Genome Project '… could be considered for the design of weapons targeted against specific ethnic or racial groups…'.[7] The UK should know what it is speaking about. During World War 2, it planned – but did not carry out – what it termed 'reprisal' attacks intended for six major German cities. The attacks were to involve 2,000 Lincoln bombers carrying 500 cluster bombs containing each 106 anthrax bombs. The British military estimated that the bombs would kill 50 per cent of the cities' inhabitants and render the terrain uninhabitable for years to come.[8] By 1998, the British Medical Association championed a resolution adopted by the World Medical Association that 'ethno-bombs' are a real threat to human wellbeing and, in 1999, pointed out that the decade had witnessed concerted efforts at genocide against the Kurds in Iraq, the Tutsi in Rwanda, and the peoples of East Timor.[9] Both the US and UK governments have acknowledged that about a dozen countries are researching the use of ethno-bombs.

Weapons of genocide, of course, do not have to be ethnically designed so long as the target population is geographically concentrated. Anthrax will kill anybody. If it is dropped in a valley or on an island, it will not discriminate – and it is not likely to spread far beyond its intended territory.

In the ongoing debate around ethno-bombs, it is instructive to note that the horror that geneticists, gene mappers and gene hunters found inconceivable, their governments and defense ministries found feasible and even likely.

As already mentioned, early in 1999, Craig Venter announced that he was

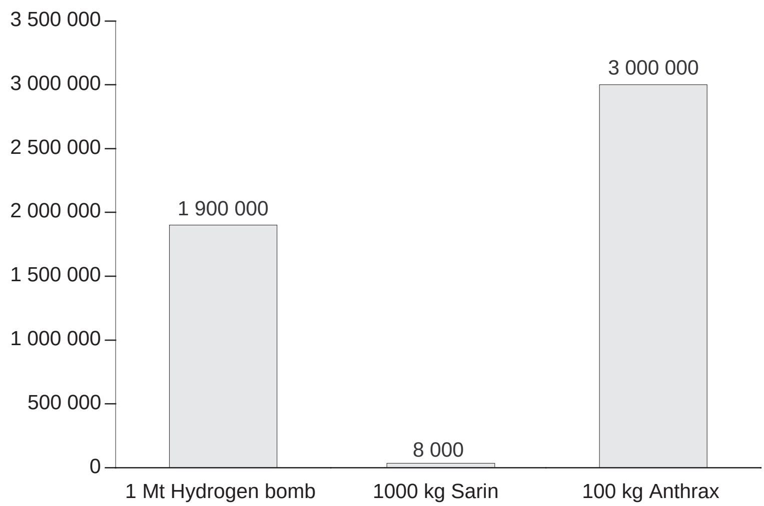

Chart 2 Comparison between different weapons of genocide (estimated number of people killed)

Source: Biotechnology Weapons and Humanity, British Medical Association, Harwood Academic Publications, 1999.

stopping the development of the first 'created life form' for ethical reasons. Venter told the press that not only does the creation of a living thing pose unanswered ethical issues for society, but that the simple bacterium he proposed to 'create' was so common and basic to life that it could slip in and out of any species and could become a deadly vehicle for biological warfare. The same concerns should be dogging the scientists who are trying to add more alphabet to the genetic code that governs most living things. In an effort to create 'artificial DNA' that can yield unique proteins for industry and medicine, California researchers could be going where Venter feared to tread.[10]

Terminator terrorism

Although RAFI first expressed concern over the likelihood of crop-targeted biological warfare at Bogève in 1987, our warnings elicited little interest until the Terminator patent was granted on 3 March 1998. Suddenly, the potential to switch a 'suicide sequence' in the seed on or off with a chemical promoter posed real concerns about economic sabotage – the real 'eco'-terrorism. Would it be possible to insert the Terminator into seed exports and 'bury' the trait for several generations of planting – or activate the trait through some remote command, chemical, or atmospheric condition? Such speculation seemed paranoid to many.

History shows that large-scale 'agro-terrorism' can only be orchestrated by governments – not the radical fringe. The threat is Terminator terrorism employed by agro-mercenaries on behalf of client states as economic (or eco) warfare.

However, the basis for concern was provided exactly one year to the day before the Terminator patent was allowed. On 3 March 1997, the South African government, having admitted that the former apartheid regime had undertaken biowarfare research on both crops and ethnic populations, tabled a list of 20 crop pathogens it had investigated for possible weaponisation. South Africa's study was presented in Geneva to the Ad Hoc Group of m countries considering ways to strengthen biological warfare treaties (see Table 3).

Sneak attack

Then, in June 1999, *Scientific American* published a stunning report by researchers at the University of Bradford in the UK that chronicled crop and livestock biowarfare research not only in South Africa but also the USA, the UK, Russia and Iraq. While some of the history dates back to World War II or the Vietnam War, the Iraqi work took place in this decade and included bioengineering of wheat pathogens that could have devastated food security in the Middle East.[11]

In fact, agro-terrorism tactics among the major powers is the rule not the exception. In World War 1, the French developed pathogens to destroy German cavalry horses and the Germans launched an elaborate strategy that wiped out livestock in Romania and stored grain and livestock (intended for export to the Allies in Europe) in Argentina and, possibly, other countries in South America. The German campaign also targeted draft and cavalry horse shipments in the eastern USA and all along the Western Front.[12] It is widely accepted that the USA tried to destroy the rice crop in North Vietnam in the 1960s and attempted to spread disease among Nicaragua's export crops in the late 1970s. There are also credible rumours that the United States – or dissidents it supports – have attacked crops and livestock in Cuba.

In a study of the US campaign to wipe out narcotic crops in the Andes, former RAFI staff member Edward Hammond (now with the Sunshine Project) discovered that both the US and the UK have channelled funds through the UN's anti-drug programme to access weaponised fungi developed by Uzbekistan (when that country was part of the Soviet Union). Both the fungi and the scientists are now contributing to the US research. Hammond points out that the US plan to aerial-spray genetically modified fungi has not yet been approved by the Colombian government.[13] In mid-2000, however, riders attached to aid funds earmarked for Colombia made approval of billions of dollars of financial assistance dependent upon Colombia's willingness to allow biowarfare experimentation against its narcotics crops. This is unacceptable pressure. Even the research and stockpiling of the fungi should be seen as a violation of the UN's Chemical and Biological Weapons Treaty.

Historic cues: Food and (other) political weapons

> *… modern biological agents permit even subtler targeting against agriculture and the human mind, against agronomic targets and psychological targets, with anti-crop and soil agents, for example, or insidious psycho-tropic or neuro-tropic agents …*
>
> Dr Robert Hickson, Professor of Philosophy, Strategy and Classical Humanities, United States Air Force Academy, 26 July 1999

At The Hague (armaments) Convention of 1899, the British Government 'strongly opposed any restrictions against its [Dum-Dum hollow bullets] among savage tribes'. In 1919, Winston Churchill berated his Colonial Office for being squeamish about using poison gas on Iraq's 'uncivilised tribes'. In 1939, the UK government began experimenting with anthrax but abandoned plans to release it over German cities due to unfavourable wind conditions. In the 1950s, Hubert Humphrey (later a US Vice-President) supported the use of food as a foreign policy weapon, and in 1974, Earl Butz, the US Agriculture Secretary, repeated his support for such a policy. In 1999, the British and American governments lobbied to protect the use of Terminator technology at the UN Biodiversity Convention. The two countries are cooperating on the development of weaponised fungi to destroy narcotics crops.

Between March and July 2000, I met with CSOs, agronomists and government officials at biotech workshops in La Paz, Sucre and Cochabamba in Bolivia. Although the country would be the primary target for bioweapons to destroy the large coca crop, not a single official or scientist had heard anything at all about the proposal to use their country as a guinea pig for weaponised fungi. Even senior staff in the Bolivian Ministry of the Environment dealing with biosafety issues claimed ignorance. Smack in the middle of a centre of crop megadiversity in the Andes, biowarfare could represent a major threat to not only Bolivia's – but the world's – food security.

While the US Congress was twisting the arms of Andean governments, the Centres for Disease Control (CDC), other US government agencies, and other governments were meeting in Atlanta, Georgia, to discuss bioterrorism. As always, the big concern was crackpots and dissidents holding governments to ransom by threatening to drop anthrax 'bombs' on Chicago. Yet, the only 'clear and present danger' from biowarfare came from the conference's hosts – and their British allies across the pond.

In November 2000, in a letter to Edward Hammond of the Sunshine Project, the UN categorically confirmed that it had abandoned all plans to use biological weapons in their drug war in South America. The decision to abandon the initiative may have come in July after the Colombian government

Table 3 Targets for agro-terrorism: South Africa's estimate of the most likely pathogens and crops

Crop(s)	Region(s)	Pathogen	Comment
		Basic food crops	
Bean Soybean Groundnut Sunflower Vegetables	World	*Sclerotinia sclerotiorum*	High weaponisation potential. Fungus causes rot or mould on many species except cereals and woody plants. Highly destructive as airborne and seed-borne disease.
Potato Tomato	World	*Phytophora infestans*	Low weaponisation potential; late blight, wind- and rain-borne, is extremely destructive.
Potato Tomato Tobacco Banana	World except South America	*Pseudomonus solanacearum*	High weaponisation potential; bacterial wilt/slime is highly destructive; transmitted by infected material and other means; no effective defence.
Maize Sugar cane Grasses	Africa, Asia, Australia, South & Central America	*Xanthomonus albilineans*	Medium weaponisation potential. Bacterium causes devastating leaf scald.
Sugar cane	Island Asia, South Pacific, Madagascar	Sugar cane Fiji Virus	Medium weaponisation potential. Virus spread by infected plants but is highly destructive.
Sugar cane	China, India	*Puccinia erianthi*	Low weaponisation potential. Leaf rust is wind-borne but requires narrow temperature range; resistant varieties are available.
Cereals (incl. 40 genera of grasses)	World except Australia, Southern Africa	*Puccinia striformis*	Medium weaponisation potential. Yellow, stripe, glume rust is very destructive and can be transported over long distances by wind.
Wheat	World	*Tilletia tritici*	Medium weaponisation potential. Fungus causes common bunt or stinking or cover smut with serious yield loss.
Wheat Triticale	India, Pakistan, Iraq, Afghanistan, Mexico, Brazil	*Tilletia indica*	Low weaponisation potential. Karnal bunt is moderately destructive and spread by infected soil and plants.
Wheat Barley	World	*Puccinia graminis*	Medium weaponisation potential; stem or black rust is highly destructive but resistant varieties are available. Wind-borne.
Rice	World	*Pyricularia oryzae*	Medium weaponisation potential; blast disease is highly destructive and spread by wind. Resistant varieties available.
Rice	All rice-growing regions	*Cochliobolus Miyabeanu*	Low weaponisation potential; brown spot fungus controlled by resistant varieties, fungicides.

Crop(s)	Region(s)	Pathogen	Comment
		Industrial (or non-staple food) crops	
Citrus (esp. grape-fruit)	Africa, Asia, Australia, South America	*Xanthomonus campestris pv. Citri*	Medium weaponisation potential due to bacterium (citrus canker) instability.
Citrus	Southern Africa Southeast Asia	*Citrus greening disease bacteria*	Low weaponisation potential. Insect vector and climatic conditions necessary.
Coffee	Central & Southern Africa	*Colletotrichum coffeanum Var virulans*	Medium weaponisation potential. Fungal rot; many vectors.
Pine tree	World	*Dothistroma pini*	Medium weaponisation potential; seed-borne (wind) blight can be highly destructive.
Apple Pear Quince etc.	North America, Central America, North Africa, Europe, China, Japan, New Zealand	*Erwinia amylovora*	Medium weaponisation potential; water and insect borne; highly destructive. Fire blight.
Rubber	Tropical South & Central America	*Microcyclus ulci*	Low weaponisation potential; highly destructive airborne blight but is unstable and requires specific temperature and humidity.

Source: Ad Hoc Group of the States Parties to the Convention on the Prohibition of the Development, Production, Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction, 'Plant Pathogens Important for the BWC', Working Paper by South Africa, Document BWC/AD HOC GROUP/WP. 124. Date: 3 March, 1997, Sixth Session, Geneva, 3–31 March 1997.

refused to bend to US pressure and joined Peru and Ecuador in opposing the dangerous plan. It appears that only Bolivia may have agreed to go along with the US/UN strategy.

Aside from the article in *Scientific American*, two other events in June 1999 served to accelerate public concern. First, Floyd Horn, the director of the US Department of Agriculture's Agricultural Research Service (ARS) was reported in the *Philadelphia Inquirer* to be seriously disturbed by the potential for 'agro-terrorism' to target genetically uniform crops in the United States.[14] Horn and his deputy have apparently been studying the issue for some time and have even attended NATO briefings on the threat.[15]

The news stories in *Scientific American* and the *Inquirer* appeared as the UN Convention on Biological Diversity was convening in Montreal to consider the report of a scientific panel led by Dr Richard Jefferson on the original Terminator patent. Paragraph 84 of the highly critical report drew our special attention:

> ... we anticipate within three to seven years there will be robust technologies to manipulate endogenous genes through molecular intervention (e.g. site-directed mutagenesis; homologous recombination), and that these must be considered proactively in anticipating trends with these Genetic Use Restriction Technologies (GURTs). *We envision these new molecular technologies for genetic manipulation to be more robust and penetrant, but at the same time much harder to detect and police, due to the subtle and potentially non-transgenic nature of the changes made.* [Emphasis added]

As this report was tabled, RAFI discovered yet another Terminator-type patent (the 31st) granted to Purdue University with funding from USDA. The patent, following the paranoid path RAFI has feared, claimed that the suicide trait could be suppressed for several generations before being activated by a remote chemical inducer. The Purdue claims posed a perverse scenario in which the suicide sequence would remain inactive only for as long as a specific chemical (for example, a herbicide) was sprayed on the crop, perhaps requiring several sprayings every growing season. If the chemical was not applied, or malevolently denied, the harvested crop would bear sterile seeds. In fact, the trait activated or de-activated by the inducer chemical could conceivably code to immediately impact on the current crop – drop the protein content in rice, up the natural cyanide level in cassava, or launch premature sprouting in wheat, for example. This is Traitor technology. It is also offensive biological warfare research in contradiction of the 1972 Chemical and Biological Warfare Treaty first proposed and adopted by the United States.

Would this ever happen? In Montreal, 108 governments debated between adopting a Norwegian resolution, calling for a moratorium on Terminator research and field trials, or a UK proposal that amounted to almost the same thing without the politically charged word ‘moratorium’. During the debate, the US delegation bluntly threatened countries with economic retaliation and possible WTO reprisals if they prevented the commercialisation of Terminator in their sovereign territories. Would the United States use Terminator technology to enforce its own interpretation of its infamous ‘level playing field’? Why not? After all, the US has, in very recent times, imposed economic embargoes on Cuba and even mined harbours in Nicaragua. Floyd Horn, the ARS director at USDA who is so concerned about agro-terrorism, not only has supported Terminator but his shop is leading the work on weaponised fungi in Colombia.[16]

Agro-terrorism is an acceptable topic so long as the conversation sticks with the possible threat from crackpots and the radical fringe. It is not an acceptable topic when the threat is seen as governments or corporations. The topic is completely unacceptable if it involves biotechnology – such as Uzbekistan's genetically engineered fungi. In mid-August 1999, Julie Delahanty of RAFI raised these unacceptable issues at the joint annual meeting of the Canadian and American Phytopathology Societies in Montreal.

It had seemed like the perfect place for a serious discussion. The phytopathologists (plant disease specialists) had set aside a half-day session to contemplate agro-terrorism. An expert panel had been brought together including representatives from the FBI, the US military, USDA, and biotech companies. However, the session began with the Chair's admonition that biotechnology should not be discussed since it would only give aid and comfort to the industry's critics. From there on, the talk focused on the obscure acts of frustrated suitors and students attempting to poison one another with toxic plant compounds. Why this was a concern to the US Air Force and the FBI (both on the platform) remained something of a mystery. Delahanty's concern – that the only large-scale agricultural terrorism had been and was being conducted by governments and that biotech research, such as that undertaken for Terminator, should be the issue – was greeted with ridicule and anger.

In a world in which a handful of transnational enterprises dominate agricultural biotechnology, in a world where the Terminator is the platform technology upon which all new biotech breeding is undertaken, it is not difficult to believe that corporations or governments would use the technology to impose their will. A textiles trade dispute with South Asia, for example, could lead to the US denial of an export permit for a modified herbicide needed to ensure the rejuvenation of cotton seeds carrying the Terminator sequence. A vegetable oils dispute with France could lead to the same threat to the French BT maize crop. Brazil's soybean harvest – a major export competitor with US processors, would be rendered defenseless if the US soybean breeder – or the USA – withheld the critical chemical 'protector'. Eco-terrorism could prove to be far cheaper and much faster as a means of resolving trade disputes than WTO arbitration processes that are both lengthy and uncertain. In the 1970s, a US Secretary of Agriculture appointed by the same US president who unilaterally dismantled biowarfare stockpiles nevertheless felt entitled to acknowledge that food is a political weapon, echoing sentiments expressed by a US Vice-President when he was a Senator in the 1950s. The policy continues.

Enthused by the level of governmental interest in their discussions, the phytopathologists put together a special report in mid-September for their website. The report seemed heavy on the world's need for more phytopathologists, with more funding and more respect, and a whole battery of monitoring and emergency procedures that would make it easier for phytopathologists to save the world from crackpot phytopathologists. There was no talk of biotechnology and nothing about the Terminator or Traitor technology. This is astonishing.

As Richard Jefferson and his colleagues recognised in their report to the Biodiversity Convention, the Terminator shows that it is possible to switch plant traits on or off. While the most commercially obvious trait is the plant's ability or inability to develop fertile offspring, remote control of this trait is not particularly attractive militarily. Since the crop in the field can be harvested and consumed, no one will go without food until the next growing season. This is slow punishment, and it gives adversaries several months within which to secure another seed (or food) source.

However, if the trait control can be turned to govern the value of the current crop, then the military use of Terminator could be enormous. If, for example, external chemicals (applied or not) could govern protein levels and carbohydrate production, cause sprouting or lodging, or redirect the plant's energy into leaf rather than seed development, the current crop could be devastated.

This is the real threat. It is far more serious than someone lobbing anthrax into a feedlot. But it is a threat that can only be carried out by governments or corporations with the help of phytopathologists.

During the World Food Summit of 1996, the United States argued that the Right to Food should not become part of the final declaration. They eventually lost. However, the USA won its argument that sovereign states need not strive to be food *self-sufficient* as long as they were food *self-reliant* – that they could afford to buy the difference between national need and national production. Now, with Terminator technology, food deficit countries are faced with the possibility that their national production will be wholly dependent upon foreign exports of critical chemical inducers.

Terminator and genocide

Terminator technology threatens the lives and livelihoods of the 1.4 billion people who depend on farm-saved seed for their food security. The export of Terminator seed should be challenged under the Biological and Toxin Weapons Convention and, also, under Article 2 of the Genocide Convention. The Genocide Convention broadly encompasses any deliberate acts to do harm to national or other definable groups. Poor farmers and the rural poor could be considered as fitting within the terms of the Convention.

Nanotechnology

Four hundred years ago, even as Shakespeare's *Julius Caesar* met his fate in London's Globe Theatre, the ex-Dominican philosopher Giordano Bruno was being burnt at the stake in Rome. His crime? Theorising that our globe circled the sun and that the heavens were filled with billions of sun-like stars. Less known to the populace (but equally heretical to the prelates?) was Bruno's speculation that all matter, including the living kind, was composed of infinitesimally tiny particles – atoms. Although his hypothesis found no favour among the Romans, his ideas actually came much closer to current theories than the better-advertised postulates of Copernicus and Galileo.[17] Nanotechnology hasn't improved much in popularity since 1600.

This is about to change. The absence of public interest in nanotech has been, perhaps, not surprising. Biomaterials, after all, have a clear human constituency. Nanotech, erroneously perceived as 'rock', does not. While we have all been staring dumbstruck at the latest toys in biotechnology, some scientists have been talking confidently about the Post-Biotech Era, when our reliance upon carbon-based resources will come to an end. Jerry Mander sounded an early alarm about some of this back in 1991 in his book, *In the Absence of the Sacred*.[18] Mander points out that new technologies propelled by computer and informatics research are changing almost everything. Many of the changes involve biomaterials but some could not be further removed. The following is a brief discussion of some developments in other scientific sectors and how they might affect society, governance and security. At the centre of these other technologies lies nanotechnology.

Nanotech is another variation on the 'peaceful use of the atom' – the 'Atomic Age' ready for a re-match. This time, it could work – or it could serve to impose peace by ending dissent and surrendering the tools of production to monopoly control.

What is Nanotech?

Nanotechnology is to inanimate matter what biotech is to animate matter. As the practitioners of biotechnology work to gain control over that 40 per cent of the world economy based on biomaterials, the proponents of nanotechnology are seeking new ways to control the rest of the earth – not only the other 60 per cent that is not living, but all carbon-based resources as well. Biotechnologies are carbon-based, but although nanotech research is focusing on carbon atoms, its potential encompasses the entire Table of Elements. Life is carbon-based. The atoms that make the molecules that structure DNA are carbon.

Connections can, and will, be made to bring biotech and nanotech together.

Nanotech development is now about where biotech was a quarter-century ago. This does not mean it will take another 25 years before nanotech attracts the kind of capital investment enjoyed by genetic engineering. Advances in other scientific fields, especially informatics, mean that progress in nanotechnology will be rapid.

In the end, only a society that is fundamentally just can be trusted with nanotech. However, if a society is fundamentally just it may not need to take the risks involved in nanotech in order to end poverty and safeguard the environment. The first goal remains – as it has throughout all of human history – to achieve a socially just society. The rest will take care of itself.

Excepting Bruno and some scarily prophetic Muslim and Greek antecedents, the most famous advocates of the theory of nanotechnology were physicist Richard Feynman and Eric Drexler of MIT. They first postulated their theories in scientific journals and the popular press in 1959. Although no one was burnt at the stake this time, the two scientists were ridiculed and vilified. The first nanotech scientific conference, in 1992, drew a nervous handful of slightly embarrassed academics. The 1997 meeting brought together more than 350 well-established scientists. Industry surveys (prone to the same hyperbole we have come to know and love to ridicule in biotech) estimate that the commercial market for nanotech in 1997 was US$5 billion and that it was more than doubling every year.[19]

What is nanotech? Simply put, a nano (or nanometer) is one-billionth of a meter, an atom-sized bit of flotsam that can snuggle inside almost anything. In commercial terms, nanotech is the manufacture and (most important and difficult) the *replication* of machinery and end products that have been constructed, from the atom up.

What can nanotech do?

Until recently, the pinnacle of nanotech research accomplishment amounted to little more than parlour tricks like stacking the letters 'IBM' atom by atom. This is changing. On the eve of a 1999 global nanotech conference in London, delegates were applauding the latest breakthroughs – nanotech-aided inkjet printers and nanotech-grade airbags. The advances in medicine are more spectacular: nanotechnologists boast new handheld sensors that allow almost instantaneous analysis of blood samples, micropumps that enable the administration of measured doses of therapeutic drugs to highly defined sites, and, in cancer treatment, coated nanoparticles that target drugs to specific organs.[20] Most recently, Israeli researchers have used nanotechnology to forge new pathways in the human nervous system to replace damaged nerves. The new 'nerves' are a *bionic* combination of living and nanotech (carbon) materials.

When researchers at the University of Toronto and Michigan State University joined forces to design a 'nanopump' that could be used to make micro-machinery atom by atom, the scientific press sat up and took note.[21] The medical scientists are trying to find a way to sneak past the body's immune system to deliver drugs to specific cells. 'Mechanical' delivery systems could have the advantage of fooling the immune response process where gene therapy and other biological agents encounter stiff resistance. Another research team, this time at Cornell University, has made this idea a lot more feasible when they were able to construct a biomotor fuelled by photosynthesis – the world's first solar-powered nanomachine.[22] From obscurity and downright ridicule two years ago, nanotechnology now makes regular appearances in the mainstream scientific media and is being showcased in business journals and advertisements. Its time is coming.

Scientifically, nanotech includes chemistry and biochemistry, molecular biology and physics. It also involves electrical and protein engineering, fabrication, microscopy and proximal probes, atomic imaging and positioning, quantum and molecular electronics, materials science and computational chemistry. If nanotech achieves the goals articulated by its proponents, this complex of new technologies will change the world more than any other technological advance – including biotechnology.

Biotechnology has shown us that DNA can theoretically be moved between any and all living material. Microbe and mammal genes or whole chromosomes can be inserted into plant DNA (and *vice versa*) and an amazing array of human DNA has been stuffed into rodents. Human genetic material is being increasingly seen as resembling Lego blocks that can be mixed and matched at will. Non-living matter can also be Lego-built, atom by atom and molecule by molecule. Depending on how the Lego is put together, the end product could be a diamond, a daffodil or a dinner for two. In theory, nanotech can pull its atomic raw materials from garbage dumps or thin air to manufacture houses and hair-dryers that are stronger and more durable than any products available in the marketplace today.

The atom-by-atom construction of a hair-dryer could become a little tedious – or the end product a little small (50,000 nanotubes laid side by side are the width of a human hair) unless something is done that will speed up and scale up the process. The key to commercial nanotechnology is the ability to design millions of intelligent nanobots (nano-scale robots) that can be programmed to build specific products. In order to do this, the nanobots have to be able to build themselves as well. If scientists can manufacture self-replicating nanobots, then the rest is (or could become) a piece of cake.

Where it was once scientifically imprudent to speculate about what could be invented, it is now scientifically unwise to imply that something cannot be invented.

There is virtually no area of social activity or economic production that will not be affected by nanotechnology – from nanobots to attack cancer cells in medicine to micro-rockets to explore other solar systems. In a *bionic* world where nanotech and biotech merge, we will see nano-scale biocomputers and biosensors able to monitor everything from plant regulators to political rallies.[23]

Nanotech – the mini miracle worker?
According to its proponents, nanotech offers:

- 'an end to disease as we know it' (as nanobots attack pathogens within our bodies and we build nanotech cells);
- the elimination or even reversal of the ageing process (as nanosurgeons reconstruct the human body and its organs);
- the eradication of air and water pollution (since nano-products can be created from waste products);
- the end of hunger (and agriculture) through nano-food production;
- the cessation of reliance on fossil fuels (since nano-construction can rely on solar power);
- the provision of new and theoretically limitless consumer products;
- 'the creation of heretofore unknown wealth, sufficient to bring radical change to the political and economic power matrices of the world.'

All this sounds like the early days and dreams of nuclear energy when those advocating the 'peaceful use of the atom' predicted a limitless source of clean energy that would transform the world. Nanotechnology also proposes the peaceful use of the atom as the building block for construction. Some analysts are projecting somewhat similar negative complications: '… the core capability, self-replication, requires unmatched diligence to avoid hazards equal to or exceeding those associated with atomic energy. As uplifting as nanotechnology might be for humankind, if not controlled, it could be more devastating than a hundred Hiroshima bombs or a thousand Chernobyl meltdowns.'[24]

If this seems extreme, remember the story of the *Sorcerer's Apprentice*. Self-replicating nanobots capable of geometrically accelerating production of incredibly durable (and invisible) machinery could cause immense damage. What if the nanobots cannot be stopped? What of the implications for military purposes and terrorism – especially state terrorism? The same nano-medicine that can fight a virus can also become a virus. Trying to defend against nanotech machines could be, as Ray Kurzweil suggests, harder than finding a trillion invisible needles in a trillion haystacks. Indeed, the very power of nanotechnology to accomplish all things physical – visible and invisible – inexpensively and inexhaustibly, is also its threat. Nanotech may lend credence to the claim of governments that they must control society in order to safeguard the application of the technology.

For our own safety?

Given the incredible scenarios proposed for nanotech, close governmental supervision would seem to be an understatement. Some would employ nanotech to re-upholster the ozone layer, counter greenhouse gases, create fresh water, or desalinate ocean water. If you can re-engineer atomic structures, nothing is impossible. Since the risk factor in all of this is as mind-boggling as the ideas, governments in our privatised world will act to secure monopolies for the enterprises undertaking these ventures. So-called democratic societies will surrender much of their freedom in return for the 'safe' use of nanotech for these colossal projects.

Myth or monster?

Will nanotech work?

Or is it just another urban legend like Cold Fusion? Common sense actually argues that nanotech will work. Biotech propositions that all living things can be boiled down to replicable DNA sequences (mammalian cloning, etc.); and that we can manufacture new life from non-living material (as Craig Venter warns). We may not succeed in doing these things safely or perfectly. We might even do them disastrously. But we will do them. In 1995, *Wired* magazine surveyed five leading scientists for their views on nanotech and the likely timetable for its commercial introduction. Table 4 summarises their five-year old estimates. Among them, Storrs Hall of Rutgers and Richard Smalley of Rice University (who won the Nobel Prize for Chemistry and helped found the University's nanotech centre) were the most optimistic – but all predicted major developments between 2010 and 2020. In setting the commercialisation bar at 2010–2020, scientists point to three trendlines. If current trends continue, they suggest, then the number of atoms required to store one bit of data will reach 'one' by 2010–2020. Similarly, by this point in time, the number of dopant atoms needed in a transistor will reach 'one'. And finally, somewhere during the same ten years, the energy dissipated by a single logic operation will approximate to the energy of a single air molecule at room temperature.[25] If this seems a little abstract to anyone but a nanonerd it can be translated as meaning that nanotechnology becomes scientifically and economically feasible at that point.

There are, perhaps, three reliable methods of measuring whether or not nanotech is serious stuff. First, is there a critical mass of scientific interest? Second, is there sufficient investment in basic research related to the field? Normally, the public sector carries the burden of basic research. Finally, are

Table 4 Nanotechnology timetable according to five leading scientists

Step	Hall	Smalley	Birge	Drexler	Brenner
Nano laws	1995	2000	1998	2015	2036
Commercialisation	2005	2000	2002	2015	2000
Molecular assembler	2010	2000	2005	2015	2025
Cell repair	2050	2010	2030	2018	2035
Nanocomputer	2010	2100	2040	2017	2040

Source: *Wired* magazine 1995.

we seeing the kind of corporate interest that could indicate that basic research will be followed by commercialisation? If these three elements are visible, a new technology is almost inevitably en route to the marketplace.

Scientific interest

One good indicator of scientific interest and commitment is the number of references to nanotechnology in the scientific literature. No references, no interest. For the year 1988 there were hardly 250 title notations involving nanotech in the venerable *ISI Science Citation Index*. Ten years later, according to Michael Cross, the author of *Travels to the Nanoworld*, the number of citations in the first eight months of 1998 came close to 4000 and were already far ahead of the total nano citations for 1997.[26] There is every reason to assume that the rate of interest has accelerated since Cross's study.

Investment in basic research

Are governments putting their financial weight behind nanotech? Without their support, there would be little work on basic research. Most observers agree that Japan and the European Union are – uncharacteristically – at least each matching US government spending on nanotech research. Britain has established a Nanotechnology Link Programme and the French and Germans have created 'Nano-valley' in the Upper Rhine. Japan maybe still further advanced.[27]

Not that the USA is a laggard. In June 1999, the White House leaked budget rumours that it wanted to double or even triple nanotech spending in the next couple of years. Al Gore, as a US Senator in 1992, conducted the first Congressional hearings on nanotech and he has been a cheerleader ever since. In 1997, the Pentagon identified nanotech as a major area for strategic research and in 1999, the National Science Foundation highlighted nanotechnology as the most important new technology coming downstream.[28] In mid-1999, an additional round of Congressional hearings extolling the importance of

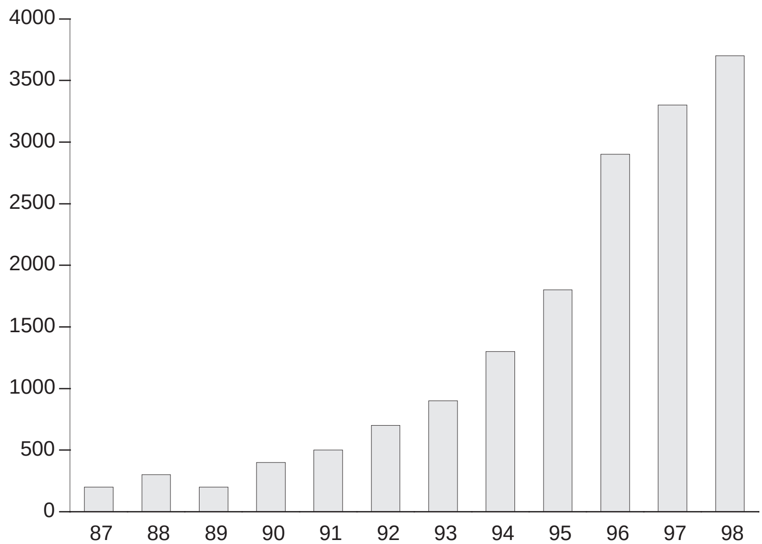

Chart 3 Nano-science citations

Source: *ISI Science Citation Index* and Cross, Michael, *Travels to the Nanoworld.*

nanotech prompted *Business Week* to announce that 'matter is software' and to predict that consumers would, by 2020 or so, have nanoboxes into which sheets of plastic and special nanotech cartridges would be inserted. Operating from home computers, customers will, according to the magazine, be able to download recipes for almost any manufacturable goodie off the Internet and then cook up the product in their own household nanobox.[29]

US government research expenditures on nanotechnology have soared from US$116 million in 1998 to US$220 million in 2000 and more than US$460 million the following year (see Chart 4).[30] Major US institutions, from the National Science Foundation and the National Institutes of Health to the Departments of Energy and Defense, all think nanotech is worth investigation. Leading the pack is the US navy which bears a well-founded reputation for highly innovative and successful research. Nobel laureates and leading universities in the USA – Harvard, Cornell, MIT, Stanford, Rice, and Berkeley (University of California) are all prominent in nanotech investigation.

Commercial backers

But nanotech is not the sole preserve of governments and academia. In contrast to the early days of biotech, some very big companies are also investing in the technology. Given that the key to nanotech's success depends on its

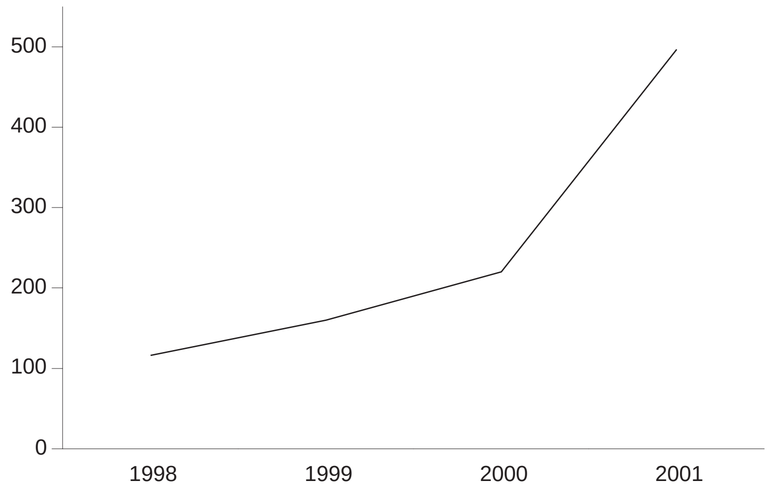

Chart 4 US government expenditures on nanotechnology (in US$ millions)

Source: Crawford, Marc, *New Technology Week*, 6/11/99.

capacity for self-replication, it should not be surprising that one of the research leaders is Xerox – the company that led the global photocopying industry. At its Palo Alto labs, Xerox is having some success developing self-assembling modular robots.[31] Another old-timer in the office machinery business, IBM, is also looking at ways nano-machines could create themselves – and design new computers. IBM scientists think they may be able to develop machines vastly more powerful than today's supercomputers. These computers could be woven into clothing and powered by body heat. IBM theorises that super-intelligent nano-computers could be injected into the blood stream, operated on miniscule batteries that would outlive the patient, and provide instant diagnostic evaluations of the health of the client.[32] The company's groundbreaking research, quite uncharacteristically, made the front cover of *Nature* magazine – a sure sign that conventional science is taking nanotechnology seriously. Aside from predictable firms such as Xerox and IBM, industry analysts suggest that major aerospace companies such as Boeing, energy enterprises such as Exxon, electronics majors such as Toshiba and industrial manufacturers such as 3M are actively engaged in nanotech. It is remarkable that the Fortune 500 transnationals have been so quick to embrace nanotech. The range of enthusiasts is also a testament to the potential of the technology. No field of economic activity is beyond tiny Nano's reach.

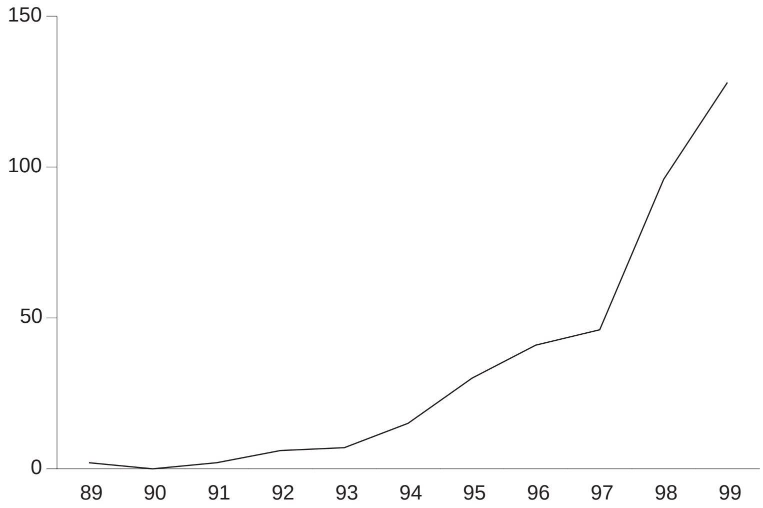

Chart 5 US nano-related patents 1989–1999 (numbers per annum)

As with biotech, nanotech has already inspired its own corporate 'boutiques'. Where genetic engineers had their Genentech and Biogen, Nanotechies boast Nanogen in the USA, Nanoway Oy in Finland and NanoFrance in France.

One of the best ways to measure the commercial enthusiasm for nanotech is to monitor the number of patents issued that include references in their abstracts to nano. Chart 5 indicates the explosion in nano-related patents in the USA since the end of the 1980s. Since each patent involves a significant financial investment in legal and application fees, where there is smoke there is likely to be fire.

In sum: this is a technology with momentum. It will go forward – for good or ill.

The New Revolution

According to a UNESCO-sponsored study in 1996, 'Nanotechnology will provide the foundation of all technologies in the new century'. Predicting that nanotech could exceed the impact of the Industrial Revolution 'by 2010 or 2020', the study enthusiastically states that 'Nanotechnology is the logical consequence and ultimate destination of our quest for the control and manipulation of matter'.[33]

No-no tech?

Just as with biotech, we are not suggesting that this field of research should be abandoned. But now – before the commercial hype and corporate pressures are too great – society should establish the benchmarks and ground rules for its investigation. Extreme care should be taken that, unlike with biotech, society does not lose control of this technology.

On 1 January 2000, the *Wall Street Journal* began the new millennium by introducing its readers to the 'lure of the Lilliputian'. In a feature article that summarised the social and commercial potential of nanotechnology, the journal concluded by wondering aloud, 'And finally, there's the question of whether it's desirable'.[34] On 21 January 2000, Bill Clinton answered the question when he flew to Palo Alto, California, to announce his National Nanotechnology Initiative with funds, in FY2001, of US$497 million. As a testament to the scope of the new technology, Clinton's Initiative will be spread among six Federal departments and programmes: the National Science Foundation, NASA, Energy, Health, Defense and Commerce.[35]

Other technologies

Most of the technologies briefly summarised here have connections with nanotechnology and with biotechnology. Although each is important in itself, the 'core' technologies of the coming century are those that govern the minutiae of living and non-living matter.

Computers

Society is more aware of technological change in computer sciences than in biotechnology. The transformation of the past 20 years has been staggering. Ray Kurzweil, an informatics guru (already cited with respect to nanotech) consulted by the White House, predicts that within ten years, a 1000-dollar computer will be able to perform more than one trillion calculations a second, that well within the first quarter of the next century, a similarly priced computer will match the human brain, and a few years later, a thousand dollars will buy rich kids the computational capacity of one thousand human brains.[36]

It is already true that the human brain – or at least, some of our DNA – can be part and parcel of the computer. A cubic millimeter of DNA 'wired' to a computer can house the data that today would fill one trillion CDs. Neural networks with AI (Artificial Intelligence) and AL (Artificial Life) are being constructed that could monitor and manage take-offs and landings at every airport in North America – or all telecommunications activity on the continent, or all neighbourhood conversations. By seeking out complex word or voice patterns, biocomputers can manage '911' emergencies or signal so-called 'subversive' activities. These are technologies that are well on their

Table 5 Comparing biotech in 1987 and nanotech in 2001

Biotechnology *Bogève I* (1987)	Nanotechnology *Bogève II* (2001)
Science fiction: ***It won't work outside the lab. Such engineering defies natural law.***	
In the 1980s, conventional scientists in both agriculture and medicine often warned that genetic engineering would run foul of the infinite complexity of nature; that what works in the lab would fail in real life. Maybe they were right … but today 55 million hectares are sown to GMOs, and biodrugs and gene therapy experiments are proliferating.	Some scientists believe that manipulating the Table of Elements will run foul of theories of energy and still unknown natural laws. But atoms are the next logical 'declension' from genes. Nanotech may not be safe, it may not work well, but it will be commercialised.
Ponderous progress: ***It's generations away. We're just beginning.***	
In the 1980s, most scientists thought biotech products were a long way off. They completely misjudged progress in computer and gene-sequencing technologies that have both slashed costs and massively accelerated R&D.	Engineering machines or food atom by atom seems slow now but molecular assemblers are on their way and continuing advances in informatics will bring nanotech to market much faster than biotech.
Hype: ***It's Wall Street propaganda. Desperate companies are trying to convince would-be investors that new products are just around the corner and will solve all the world's problems.***	
In the 1980s, Biotech 'boutiques' were struggling to survive and promising 'pie in the sky'. Many died out and the rest are being bought out by the gene giants. After a slow start, new products (good or bad) are coming on stream fast. The world, however, appears no closer to Nirvana.	Nano 'nichers' are springing up now as bio-boutiques did before. There is the same 'silver bullet' hype. However, unlike with biotech, the biggest corporations are getting in on the ground floor.
Niche market: ***It may work well in special cases but it will not have a wide impact on how we produce things.***	
One gene giant argued in the 1980s that herbicide tolerance would only be viable to combat Johnson's Grass in Texas. Today, three-quarters of the global transgenic area are in herbicide-tolerant varieties. 'Niche' market human genomics companies are mapping crop genomes. One of the most profound characteristics of Biotech is its broad application in agriculture, pharmaceuticals, personal care products, and industrial manufacture.	Some argue that nanotech is a novelty; that it will only be used for highly specific purposes because of its cost and complexity. In fact, Nanotech's reach is greater – by far – than biotech. As the range of companies involved makes clear, nanotech will dominate every aspect of the global economy.
Nanobucks: ***They are tiny and fragile. They don't have the clout needed for the science or the market.***	
In the 1980s, biotech 'boutiques' were small, scarce and starving. The big agrochemical and pharmaceutical giants appeared uninterested and many predicted that the little upstarts would go bankrupt.	The nano 'nichers' of today are also small, weak and struggling. The difference is that the Fortune 500 – the 'nano nabobs' – are in hot pursuit of the new technology.
Patents & regs: ***The governments don't provide the requisite patents or regulatory flexibility.***	
They got it. By the late 1980s, the US Patent Office announced it would allow patents on plants and animals as well as microorganisms. The USDA, NIH and FDA regulations were being manipulated to meet industry needs.	They will get it. Nanotech has fewer patent barriers. Biotech has already set legal precedents for sweeping claims. Regulatory constraints for 'atomic power' will be manipulated into ineffectiveness.

way to operational reality by 2015 or 2020. *Scientific American* has reported that students used DNA no more than a sugar cube in size as a computer to crack the US Federal Data Encryption Service code. The bio-computer can handle as much data as 10 petabytes (10 million billion bytes) of data. In mid-1999, scientists at the Weizmann Institute in Israel designed a bio-computer 25 billionths of a meter across.[37] When the White House announced its nanotech initiative, the press office predicted the potential to store the entire Library of Congress in a device the size of a sugar cube.[38] (The potential to store Congressmen was not discussed.) Beyond surveillance, military uses include spectacle- or helmet-based computers that could give infantry almost unlimited access to maps, language translations and other data as they move through battlefields. The same technology could be used to assist farmers to adjust input decisions even as they pass over their fields – or to help policy-makers reach informed decisions on the run.

In the first half of 1999 a severely disabled American was given a 'chip' implant in his brain that allows him to direct his computer cursor without touch, voice or movement. Almost simultaneously, German scientists developed the same capacity on the European continent and Scottish researchers formed a research team to extend this new opportunity for the disabled to other machines and purposes. In mid-1999, researchers showed how computers could direct brain activity when electrodes were hooked to rodents and pulses were sent that mimicked patterns that prompted drinking. The tests showed that computers could copy a normal brain wave and then send the message to the brain externally.[39] Most recently, scientists have developed a potential means of vastly speeding up the internet by transmitting data at 100 gigabytes per second through light pulses. At this rate, your home computer could download a two hour DVD movie in a fifth of a second.[40] About the same time, other US researchers designed a new internet server dubbed 'Principia Cybernetica Web' that builds and deletes web links as user needs evolve. The strategy carefully mimics the way the brain functions.[41] And, if you don't trust your instincts, a badge-like computer that can be attached to your lapel is under development and that will allow like-minded (or programmed) individuals to find one another in crowded conferences or singles' bars.[42]

With the Death of Dissent, the 'Right to Know' and 'Freedom of Information' will be interpreted as the Corporate State's right to have access to private information; the 'Right to Privacy' will be interpreted as a sub-set of Trade Secrecy.

In sum, the most thrilling and threatening work in computer technology involves DNA chips (efforts to emulate the human brain) and work in quantum physics that proposes to collapse the past and present (and future?) into an instantaneous capacity to compute everything at once. Table 6 in this section identifies the major research fields and the lead institutions.[43]

Table 6 Leading enterprises in new computing technologies

Institute	Bio	DNA	Molecular nanotech	Quantum physics
Bell Labs		•		
Boston Univ.	•			
Caltech Univ.				•
Delft Univ.			•	
Duke Univ.		•		
Harvard Univ.			•	•
Hewlett-Packard			•	
IBM			•	•
Lawrence Berkeley	•			
Los Alamos			•	
MIT	•			•
New York Univ.		•		
NIST				•
Oxford Univ.				•
Princeton Univ.		•		
Rice Univ.			•	
Rockefeller Univ.	•			
Stanford Univ.				•
UC Berkeley				•
UCLA				
Univ. Colorado			•	
Univ. Wisconsin		•		
Univ. Southern Cal.		•		•
Yale			•	

Source: *Technology Review*, May/June 2000.

Computers sometimes play the role of the Great Equaliser. The much-touted Java script – and still newer incarnations – hold the possibility of vastly superior technical training at vastly reduced costs. Not only can students have access to the most recent and most authoritative information and training, but they can also perform highly sophisticated experiments on screen rather than in a lab requiring unaffordable state-of-the-art equipment. Although this is good news, it obviously worries SAIC and their military colleagues. The US army is distressed lest poor countries and rabid terrorists clamber onto the Internet, crank up Java, and design their own ethno-bombs. All the experimentation might be conducted in front of the screen; only the final product will require manufacture.

Sensors

Some of the most powerful new technology complexes are associated with sensors capable of detecting and transmitting sight, sound, smell, chemical composition and pressure-changes. In agriculture, biosensors might be 'sprinkled' in fields, and their information gathered by low-orbit satellites or conveyed to farm machinery passing over them. This could enable corporate farms to manage large tracts of land, with robot machines adjusting seeding and chemical rates to every variable metre of soil. Proponents claim that biosensors, in league with robotics and other technologies, could soon outperform farm families in cost and land expertise.

In industry, biosensors could also be used to monitor petrochemical and other manufacturing processes. Within the military, biosensors are seen defensively to monitor the periphery of camps and to allow platoons to detect the position and number of enemy soldiers ahead. Olfactory sensors are said to be on the drawing board that can search out testosterone concentrations – indicating nearby soldiers. To date, however, the sensors can be confused by the application of other chemicals such as mosquito repellents or perfume.[44] The US army is thinking of biosensors mounted on nano-robots that would come with biocomputers and an ability to adjust to remote orders and mission changes. The robotic sensors could slip behind enemy lines virtually into the war rooms and mess halls of the enemy and transmit back real-time information. Even if nanotechnology is further off, micro-robotic sensors could prove to be almost as difficult to identify. One recent example of the interplay between biotech and related technologies is a poison gas detection device developed at the Applied Physics Laboratory of Johns Hopkins Hospital. Using fibre-optic cables, lasers and the rare metal, *europium*, the device can be used in subways and airports to warn of terrorist attacks.[45]

Scientists have been social somnambulists pleading that their pursuit of science excuses them from social responsibility. They have no right to this delusion.

Sometimes the biosensors can be living microbes or insects. Researchers at Savannah River Technology Center in South Carolina have developed bacteria that have been genetically altered to glow when they feed on the *trinitrotoluene* (TNT) chemicals that leech out of about 90 per cent of the world's land mines. The scientists have inserted a luminescence gene beside the gene that controls digestion so that when the bacteria graze on TNT, they glow, signalling that there is a mine nearby.

Not to be outdone, a biology professor at the University of Montana is looking at using bees as land mine detectors. TNT in the soil is taken up into plants whose pollen is captured by bees. Researchers are trying to train the bees to associate the odour of TNT with food and lead soldiers to land mines.[46]

Remarkable technological developments are already on their way to the market. In his book, *The Transparent Society*, David Bain reports that researchers at Tokyo and Tsukuba universities are inserting microprocessors and microcameras into live cockroaches with the objective of seeking out earthquake survivors. Sandia Labs, according to Bain, has engineered a mechanical cockroach-size robot capable of checking out nuclear power stations.[47] One of the problems with sensors is maintenance. Keeping thousands of remote devices powered is at least a major nuisance – but one the US Navy may have licked by attaching their sensors to microorganisms found on the ocean floor that appear capable of providing perpetual power.[48]

'Sensors' are already in common use for security purposes. There are more than 300,000 closed circuit TV cameras monitoring the highways and byways of the UK and their use is becoming almost as widespread in countries such as Japan, the USA, Singapore and Thailand. If not yet at the nanoscale, full-function micro-units can be smaller than a sugar cube and New York stores sell concealed units in everything from radio/alarm clocks to toasters and pens.[49] Not all sensors need be spies. A Japanese firm has developed a sensor that can be worn on the finger as a ring. The sensor automatically adjusts the room thermostat to accommodate the body temperature of the wearer.[50]

Robotics

Since at least the 1950s, industry has been predicting that robots will take over most manufacturing tasks from the labour force. Though delayed, that time may now be coming. Linked to neural networks and biosensors, robots could function with cognitive intelligence. Thus, one can imagine a farm robot capable of performing all the major tasks from seeding to harvesting with minute attention to soil, pest and weather conditions. Intelligent micro- (or nano-)robots, according to SAIC, are a chilling likelihood before 2020. The micro-robot that can slip unnoticed behind enemy lines need not only send back reports on troop movements and munitions. It could also blow up the munitions. Not only could it report on the conversations of Generals in the mess hall or the war room, it could kill the Generals. The US military is currently developing 'army ants' – large numbers of identical intelligent robots capable of acting cooperatively (or independently) to take on what is described as a wide range of military chores. SAIC and IS Robotics (a private US company) have separately designed robots capable of clearing land and surf-zone mines via remote control.

Some of the military technology has already been transferred to the health care system in the form of *Robodoc*, a robotic surgeon now being tested in

Sacramento, Boston and Pittsburgh, USA. It appears capable of working with human surgeons to perform minute operations beyond the dexterity of mere mortals.[51]

There are also applications in industry and transport. For example, two robot airplanes have flown from Newfoundland to Scotland without incident, and before that, a robot car navigated safely from Pennsylvania on the Atlantic seaboard to California on the Pacific seaboard through thousands of kilometres of interstate turnpikes and urban traffic jams. There were no accidents (although the car did pull to a halt in Sacramento with its hubcaps missing). During the first half of 2000, every issue of *New Scientist* carried new reports of robots like 'Flipper', the short-order cook that can flip 500 burgers an hour, whip up fries and crack eggs[52] or robot 'nurses' that can fluff pillows, pour tea, record patient's health status and go for help when needed.[53] The police and military are developing robots to go where no one else wants to go to defuse bombs, detect toxins, or clean up nuclear waste dumps and NASA has 'Nomad', an intelligent robot destined to comb the Eastern Antarctic for meteorites.[54] Most amazing of all is a robot computer designed like a snake that can 'S' its way into inaccessible locations (for safekeeping), wiggle up and down stairs and slither into your lap when you are ready to compute.[55] Most disturbing is work at the University of Genoa coupled with two US universities that has created a 'cyborg' – a mechanical robot whose movements are controlled by the brain of a fish.[56] Properly schooled, the researchers believe that they will be able to eventually teach human beings to manipulate robots the same way … or vice-versa? As with everything else electrical and digital, the costs for robots is dropping like a landslide.

Biomimetics

Shape is cheaper than materials. This is the essential *raison d'être* of biomimetics. Our understanding of biology and our growing capacity in miniaturisation are creating this new scientific field. Researchers are trying to replicate the shell of a beetle that can withstand the force of a car driven at more than 100 km an hour. Other scientists are examining the shell of a nautilus capable of surviving the crushing depths of the ocean floor. In each case, the idea is to mimic the living shell structure molecule by molecule with non-living materials.[57] A fly that became extinct 45 million years ago is now being used as a model that could improve the efficiency of solar panels by as much as ten per cent over the course of a day. The fly, found entombed in amber and on display in a Warsaw museum, has a compound eye with nano-ridges gridding the compound segments in such a way as to capture more light while apparently reducing glare.[58] Recently, US Navy scientists have managed to transfer the silk-making gene from spider webs into bacteria.[59] They predict that it may be possible to develop bulletproof clothing and helmets with a fiber that can absorb 100 times the amount of energy as steel, is much lighter than cotton and can stretch 40 per cent of its own length.[60] Other investigators are exploring the chameleon quality of some lichens and moths as a possible route to the creation of camouflage uniforms that change colour depending on sunlight and other atmospheric conditions.[61] (Rumour has it that such camouflage outfits have been designed but that it takes three days for the cloth to adapt from, say an urban environment to a forest setting, meaning that rather than safeguarding soldiers it will just make it harder for medics to find their bodies.)

Microelectromechanical Systems (MEMs)

This sub-set of nanotechnology miniaturises and merges electrical and mechanical systems to micron-size (the width of a human hair). To this end, science has already invented microscopic gears, valves, and motors.[62] *MEMbrain* smart skins can theoretically be used to improve helicopter stability and aircraft speed. *Piezoelectric* materials are being developed that can expand and contract with electricity or pressure. Scientists envision suspension bridges and skyscrapers able to adjust to high winds and earthquakes. Beyond construction, the technology could also be used in developing highly sophisticated sensors.[63]

Multimedia technologies

Optoelectronics and photoelectronics, along with computers and satellites are all contributing to a new media environment. Consumers in industrialised countries are familiar with multimedia technology products such as lasers used in CD players and medicine as well as laptop computer screens and high-resolution digital television. The commercial use of optoelectronics alone is leaping from about US$50 billion per annum worldwide in the mid-nineties to a projected US$200 billion by early in the new millennium. The Japanese government says that multimedia technologies (including optoelectronics) will account for 6 per cent of its GNP (about US$1.2 trillion) next year – a figure three times that of the vast Japanese automobile industry.[64]

Three decades ago, Marshall MacLuhen announced that ‘the medium is the message’. The basis for a good debate then, few would now dispute the overwhelming import of multimedia communications. Collectively, the gaggle of technologies offers a vast opportunity to facilitate effective communications and to improve everything from engineering to medical research. The same technologies also offer to blur the distinctions between illusion and reality – to pacify dull and direct social thought. Much has been said of this in the popular media and there is little more to add here.

Aerospace Technologies

Advances in space exploration will also influence socio-economic realities here at home. General Electric has been developing extremely precise GP (Global Positioning) technologies that permit civilians pinpoint accuracy in determining someone's exact location.[65] Simultaneously, Motorola has filed patents that describe exactly how anyone with the technology (or license from Motorola) can listen in on satellite communications[66] and the US Defense Department has developed ways to use some of these same technologies to create a new generation of missiles that can select their own targets based on pre-set conditions.[67] In May 2000, too, the United States took the blinkers off civilian spy satellites so that they can identify earth objects down to a metre in size. It is now possible to monitor a specific car in traffic from space. Within a very short time, it will be possible to monitor an individual, visually, from a satellite.

Recently, MIT announced the development of micro-rockets – dime-size engines with 20 times the per-unit thrust of the space shuttle's main engines. A hundred of these tiny engines can fit in the palm of your hand, but linked together, can throw a fifty-pound satellite into earth orbit.[68] Combine this discovery with other advances in remote sensing and laser technology and we have the potential to launch clouds of mini-surveillance and attack satellites to monitor/control everything from crop production to dissent. By cutting the deadweight in space exploration launches, mini spacecraft might also take us to other planets and solar systems at greatly reduced expense.

Hollywood movies have recently brought popular attention to the potential for orbiting satellites to monitor the movements of single persons. Though grossly exaggerated in the cinema, the potential to visually or biologically track an individual is credible within the next couple of decades.

At the beginning of 1999, *The Economist* magazine reported on the work of three nanotech-style research institutes to develop micro air vehicles (MAVs) as attack and/or surveillance aircraft. One prototype, known as the Black Widow, under development at Aerovironment, a US company, has actually managed to get airborne. It is 15 cm (6 inches) in diameter, can fly through apartment windows at about 45 km/h, stay aloft for 16 minutes, and carry back recorded images. Other mini-craft is being developed at MIT and at the Georgia Tech Research Institute. When mass-produced, the US Defense Advanced Research Projects Agency (DARPA) – which is funding much of this research – expects the cost will be below US$1,000 apiece. Each micro-plane will be able to stay aloft at least one hour and transmit sight, sound, and other biosensory data back to individual soldiers (or security agents?) in real time.[69] Not all the research is taking place in the United States: in Mainz, Germany, the Institute for Microtech has developed a micro-helicopter only one inch long and weighing less than one hundredth of an ounce.[70]

This potential to monitor ourselves causes unease in most quarters. *The Economist* raised some of the key issues on its front cover on 1 May 1999 postulating 'The end of privacy' with its lead story, 'The surveillance society'.[71]

Neurosciences

Research in the neurosciences bridges biology and informatics. The focus is on the nervous system at the molecular and cellular level. Commercial and military enthusiasm is highest for the potential for 'pattern recognition' in the development of neural networks. The attraction of pattern recognition is the potential to automate the monitoring and management of complex systems. In the popular media, this may translate as 'smart computers' but it implies cognitive reasoning in machines and its applications could include running major chemical plants, farming huge areas of land, or something as mundane but useful as 'listening' for – and eradicating – mould build-up in stored grain.[72] Neural networks could also marshal New York's traffic system, or eavesdrop on (and understand) all the telephone conversations of an entire country.[73] Canada, together with the UK, USA, New Zealand and Australia, has established the *Echelon* satellite communications monitoring system that already allows their intelligence agencies to simultaneously monitor hundreds of thousands of international phone conversations and select out those using specific words and phrases.[74]

Human Performance Enhancement

Although Human Performance Enhancement (HPE) is properly a subset of neurosciences, this field comes with a unique moral burden including slavery and eugenics. Discoveries in neurosciences, according to SAIC's analysts, 'are projected to be significant in the next 10–15 years'. Two breakthroughs in brain imaging, *functional magnetic resonance imaging* and *position emission tomography* make it possible to determine what part of the brain does what – and lends credibility to the possibility that science will be able to monitor and manipulate brain functions. SAIC calls this a 'quantum leap' in our ability to manage humans and notes that 'once this door is opened' science will be able to manipulate and enhance human functions. Researchers project that HPE studies could lead to a smooth interface between people and machines allowing individuals the possibility of hands-free remote management of tanks or tractors or surveillance equipment.[75]

Table 7 The new technologies: A partial summary of some of the new technologies and their implications

Technology	Industry	Comment
Biotech	Agriculture	If transgenic (GMO) crops survive the mounting opposition and spread as rapidly as industry originally predicted, then Terminator/Traitor Technologies will be on-stream by 2004. And cover 80 per cent or more of the world's commercial croplands shortly thereafter.
	Health	Diagnostic kits, drugs, and artificial skin are already in the marketplace; gene therapy is coming quickly; map of the human genome will be completed by the end of 2000.
	Warfare	New 'weaponised' viruses and bacteria may already be operational; 'ethno-bombs' can be expected by 2005–10.
	Industry	Up-scale fermentation applications are increasing; uses in mining, environmental management are coming on-stream and will be widespread by 2005.
Nanotech	Health	Initial applications in repairing nervous system and drug delivery are progressing speedily. Major uses in organ replacement and in operations by 2005–10.
	Warfare	Uses in conjunction with other new technologies to monitor 'enemy' (or dissent) by 2005-10; covert offensive uses shortly thereafter.
	Industry	Commercial uses in printing and process monitoring already underway, widespread consumer production uses not until second quarter of 21st century.
	Agriculture	While crop monitoring uses will come on-stream by 2010 or somewhat sooner, capacity to replace farm production is not expected before 2040 (if then).
Computer	Warfare	Advanced Internet tracking technologies to be commercialised in 2000 but major 'control' initiatives should be in use by 2005 and will only improve thereafter.
	Industry	Economists are now attributing sudden recent burst in productivity efficiency to integration of computer into manufacturing and service systems. Functions will expand massively in conjunction with other technologies such as robotics and sensors.
Multimedia	Warfare	Use in battlefield simulation already developing.
	Health	Multimedia imaging devices will allow remote diagnosis and surgery allowing isolated communities access to specialist medical care.
	Industry	'Single screen' entertainment information systems are on our doorstep; virtual reality entertainment in infancy but will have high commercial use by 2010.
Sensors	Warfare	Monitoring capacity increasing daily; use in public transport areas expected in a year or two; greater offensive and defensive uses to come in near future.
	Agriculture	Some uses now but real change on field and livestock monitoring by 2010 or sooner.
	Industry	Some uses already underway but sophisticated full-production control is still years away.
Robotics	Industry	Robots can be found in virtually every large manufacturing process but the real boom is yet to come – 2005 or shortly thereafter. First viable 'home' robots in 2000.
	Health	Already taking blood samples, robots – linked to miniaturisation – will eventually play a major role from scrubbing down arteries to major surgery and nursing tasks.
	Agriculture	Use in food processing is already significant but use on the farm will have to compete with cheap migrant or family labour – 2015–20.
	Warfare	'Army ants' are already removing land mines and their future use – linked to miniaturisation and computers – is only a few years away.

Technology	Industry	Comment
Biomimetics	Warfare	Wide-ranging work is well-developed in areas such as camouflage and armour but active use is still some years off.
	Industry	Timetables for use on commercial aircraft, bridge spans, skyscraper construction, etc. are coming up fast.
Microelectro-mechanics	Industry	Applications related to transport, because of the high safety concerns, may come more slowly than other building uses may.
Aerospace	Warfare	Surveillance technologies are improving quickly and miniature air (not space) vehicles could be operational by 2005 or sooner.
	Industry	The industrialisation of space for the purpose of manufacture has already begun but the conventional use of space for this purpose is some distance off.
Neuro-sciences	Warfare	Although some uses might be operational in a year or two (memory enhancement), social acceptance (even within the military) could delay widespread applications.
	Industry	Conventional use by employers will slowly follow military applications.
	Agriculture	Experimental use of neural networks in detecting plant health and soil conditions is already underway. Wider applications will await changes in farm labour/ownership structure.
	Health	Some aspects of this technology.

But the potential to manipulate human emotions, senses, and capabilities lies at the heart of HPE research. Among the most interesting applications according to SAIC, is the possibility of reducing 'fear' in soldiers – or enhancing fear in the enemy's combatants. 'In other words, it is possible that in the near future we will be able to chemically-enhance vigilance and attention-spans, increase stress tolerance, increase sleep deprivation tolerance, and enhance memory.'[76] As with biological warfare, of course, research into 'enhancement' as contrasted with research into 'debilitation' is in the neurons of the researcher.

Progress in this field is break-neck. The Sahlgrenska University Hospital in Sweden and the Salk Institute in the USA have proven that humans can grow new brain cells – thus increasing the potential to remedy diseases and brain damage – and to manipulate brain structure.[77] Meanwhile, a British biotech start-up, Genostic Pharma, has come up with a device that can detect variants in over 2,500 genes including genes that affect behaviour and intelligence.[78] What kind of behaviour? Emory University (USA) have experimented with oxytocin to stimulate and mute the development of familiarity between individuals. They have created socially inept rodents (aren't they all?) genetically engineered to lack oxytocin. Such rodents seem unable to recognise other rodents with whom they have just been intimate. This same hormone behaves the same way in humans meaning that gene therapy here could be a logical sequel to the 'morning-after' pill – the 'plausible denial' pill.[79]

In short, neuroscientists are developing strategies that could manipulate the interests and skills of workers (including soldiers), and that could also reduce the need for workers if the so-called 'man/machine' interface with cognitive neural networks makes management of complex industrial and agricultural systems realistic.

If you can do this, you can also win elections – or do away with 'democracy' altogether.

Of 'Luddites' and 'Eli-ites'

Why is there a word for those seen to be opposing technological change but not for those forcing untested technologies upon us? Are those of us questioning biotechnology 'Life-ites'?

Some technologies, by their nature, pollute, imperil or otherwise threaten our environment, health and security. More often, however, new technologies – used in the appropriate context in an aware, socially responsive environment – have the potential (theoretically, at least) to be beneficial. It usually boils down to ownership and control. Society needs to debate each new technology. We also need a debate about science and technology *across the board.* There is no doubt that some technologies are inherently democratising and decentralising while others are tyrannical. However, we should not be over-confident of our ability to decide which is which. As always, history offers us lessons.…

Our experience with the Industrial Revolution is not unique. Without doubt, the most profound technological change in human history occurred about 12,000 years ago when ancient societies abandoned hunting and gathering for agriculture – the world's first Agricultural Revolution. Popular theory has it that this revolution literally created 'civilisation' by permitting people to be sedentary, to develop architecture and art. Theory has it that the increased food supply allowed for a population explosion and generally contributed to social well-being. Yet the study of skeletal remains in the periods immediately before and during the local formation of agriculture – particularly in the Mediterranean basin and North America, but as far afield as India – suggests that the advent of farming stunted the growth of children and reduced the stature of male adults (by almost 10 centimetres in regions such as Greece). The recovered bones of farm children aged between two and five show that after weaning their bone development lagged and that there was an increase in bone-related diseases in comparison to children from hunter-gatherer times.[89] In other words, the immediate introduction of agriculture – a technology universally assumed to benefit all of humanity – may have damaged the lives of at least the first generations that adopted farming.

Historic Cues: Revisiting the Industrial Revolution

> *The smaller machines are in the hands of the poor and the larger patent machines are in the hands of the rich … the work is better manufactured by small than by larger ones.*
>
> UK textile rioters protest, 1779

> *It may be in the twentieth century that the peasant of Dorsetshire may think himself miserably paid with 15 shillings a week; that the laboring men may be as little used to dine without meat as they now are to eat rye bread; that sanitary police and medical discoveries may have added several more years to the average length of human life.*
>
> Cited in *Scientific American*, July 1849

For a century and a half, the artisans and craftspeople of Europe – itself an innovative continent of tinkerers, defended their livelihoods against the destructive character of the sometimes illusory 'Industrial Revolution'. We choose to remember only the brief and violent struggle in the British Midlands around 1811–15. Then, threatened textile workers axed mills and machinery. Lord Byron's maiden speech in the House of Lords was an impassioned plea for their cause. Although the plight of the workers caught in the technological tumult won some sympathy, by 1815 the rebellion, epitomised by one Ned Ludd, ended at the gallows. Today, Ludd's rebellion is almost universally interpreted as a tragic example of society's failure to comprehend the march of scientific progress. Anyone opposing new technologies is dismissed as a 'Luddite'.

But if the Industrial Revolution – as exemplified in new textile machinery – devastated working families in the Midlands, it brought mass starvation in India where cotton-growers and cloth-weavers lost everything. Cotton-growing shifted to the southern US where production costs were massively subsidised through the African slave trade. The new machinery, symbolised by Eli Whitney's famous cotton gin, spun finished cotton cloth – and usurped the place of Indian weavers working Indian hand-looms. By 1834, the Governor of the British East India Company wrote, 'The misery hardly finds a parallel in the history of commerce. The bones of the cotton-weavers are bleaching the plains of India.'[80]

Yet not all the devastation was due to the supposedly inexorable pressure of 'a good idea whose time had come'. A significant factor in the push to large textile machinery in the UK was the clothiers' perceived need to control their workers and safeguard their profits. Labour unrest in the textile industry was a major concern throughout the 18th and 19th centuries and the owners saw the cumbersome new machines as a way to bring discipline into the workforce and also reduce the number of workers. Even Adam Smith conceded that the factory system created by the clothiers represented a form of 'mental mutilation' of the workforce.[81] Years before the observations of the British governor – and to the dismay of British mill-owners and the chagrin of US slave-owners – India had continued to be competitive in the face of new technologies. Indian cloth was of finer quality and its price threatened the purse and premise of the new industrialists. To safeguard the march of progress, British agents set impossible production quotas and then seized the goods of defaulting Indian weavers. At times, in desperate protest, cloth-winders cut off their own thumbs.[82] In 1814, even as the Luddites swung at the gallows, Britain imposed harsh restrictions on the export of India's finished cloth. Soldiers actually used their muskets to smash the fingers of rebellious weavers.[83]

The image has poetic irony. Eli Whitney's patented cotton gin (1793) was not the only weapon used against British and Indian Luddites.[84] In 1798, Eli Whitney also patented the first musket with interchangeable parts. It was this musket that British soldiers used to smash the hands of Indian weavers and winders.[85] The ideological heirs to Eli Whitney's musket and machinery must, 200 years later, be considered the 'Eli-ites' of technology today.

Whatever their methods, were the 'Eli-ites' correct? In Britain, the Industrial Revolution led to unprecedented wealth and increased life expectancy. Within the textile industry, cloth and clothing prices fell to levels even the poor were said to be able to afford.[86] (That they had previously made their own clothing at still less cost is a fact generally ignored by economists.)

Yet even if there was an 'upside' in the UK, no such benefits accrued to England's overseas empire in India. Even in England, as *The Economist* recently conceded, by the mid-19th century, 'the initial enriching impact of the industrial revolution had given way to the Dickensian miseries of urban life'. Even British insurance companies noted that agricultural workers in the countryside fared better than their factory-working counterparts in the cities. Urban children especially suffered. One well-documented indicator, the stature of British and US soldiers, shows that the steady rise in the height of new recruits witnessed from the mid-18th century to the beginning of the 19th century (the time of the Luddites) turned downwards until the 1850s or later and did not return to the levels of 1800 until after 1900.[87] Although, in general, the stature of people in industrialising Europe did increase significantly beyond that of their non-industrial neighbours during the 19th century, many countries, including Britain, Sweden and Hungary, experienced several erratic decades within which average stature notably declined.[88] Luddites would argue that social well-being could have been better served.

This should not come as the surprise it does. After all, hunter-gatherers were able to follow food and water wherever seasons and climates took them. Settled farmers were more at the mercy of irascible climate and weather. Hunter-gatherers could select from a vast cornucopia of plant and animal food sources – farmers were left to depend on a handful of cultivated crops and domesticated livestock. The formation of agriculture created the opportunity to control land and water. Hunter-gatherers had need of greater cooperation at the hunting end and the opportunity for greater independence at the gathering end. The combination encouraged, perhaps, a stronger sense of communal justice than among sedentary societies where the inputs of agriculture could be controlled by some against the needs of others.

As it was with the first Agricultural Revolution, was it also with the Green

Revolution of the 1960s and 1970s? Popular theory bestows upon the Green Revolution the same unquestioning obedience as demanded by the Industrial Revolution and the birth of agriculture. Since the baseline studies were absent and we have yet to delve through the skeletal remains of poor urbanites and displaced rural workers from these decades, no one can speak with absolute certainty. But, as we have seen, history does have a way of repeating itself.

Neither silver bullet nor poison dart

Without ignoring any of the concerns already expressed about the new technologies, we must still warn against techno-fatalism. All is far from lost. Much can still be gained from *some* new technologies.

We do not have the empirical data we need to compare pre-colonial or pre-industrial societies with today. Are the health and nutrition gains of today nothing more than a *recovery* from the downturn experienced with colonialism and Eli-tism? Hardly. But the hype around the benefits of the Industrial Revolution is absurd. The real declines in infant mortality and of death from diseases came from clean water, sanitation improvements and immunisation programmes. These gains can be attributed to improvements in public health, which, in turn, were supported by increased literacy made possible by an expanding economy. These initiatives were connected, but there is no direct connection to any single silver bullet technology. In fact, there has been an observable *disconnection* between industrialisation and development in this century in the South. Since the mid-1940s, world population has tripled. Basic biology teaches us that the numbers of a species do not grow in the absence of a reasonable food supply. Although there are still close to 840 million chronically hungry people on this planet, the proportion of us that is hungry seems to have declined. Since the 1960s, life expectancy in the South has climbed from 46 to 63 years. The rise among Least Developed Countries (experiencing little or no industrial development) was less dramatic but still significant – from 39 to 50 years. Countries such as Sri Lanka and Costa Rica now have life expectancy figures that match those in many industrialised countries. If you are 65 in Tanzania today, you are likely to outlive most of your OECD friends. This is not because of super-hardiness but because you have a healthier lifestyle and you have managed to dodge the bullets of infant mortality and common infectious diseases.

Since the 1970s, adult literacy in the South has jumped even more dramatically than life expectancy – from 46 per cent to 69 per cent. Even the poorest countries have seen a literacy increase from 29 per cent to 46 per cent.[90] Despite our concern for the knowledge-destruction caused by literacy cam-

Table 8 Seven sins/virtues of commission/omission

As Eli-ites see it	The Luddites' response
1. Conception (good/bad old days)	
Look how much better things are now. Give us credit for making major – if uneven – improvements.	The issue is usually not that there has been no improvement – but that there could have been greater improvement, with fewer complications – if the science had been conducted in a more socially beneficial context.
2. Connection (tandem technologies)	
We are the experts in our science and we say it will move slower/faster than Luddites think and, therefore, will not have the implications they suggest.	Scientists in one field are often unaware of tandem technological developments elsewhere (the impact of microelectronics on microbiology, of oil drilling on the auto industry, of rocketry on materials, etc.) that can effect the pace of change.
3. Context (optimist/pessimist)	
This technology could do wonders. Luddites don't see its labour-saving / energy-saving/ food-securing /health-benefiting /pollution-abating /wealth-creating merits.	It takes at least a generation to comprehend the implications of any new technology (internal combustion engine, synthetic chemicals, nuclear power, electricity or new biotechnologies). This is not an indictment of science but an argument for humility and caution.
4. Control (ownership and osmosis)	
Government and Industry know their voters/customers and will protect their interests. After all, there are anti-trust and consumer protection laws.	Commercial technologies are quickly appropriated & contribute to new concentrations of economic power (railways, petroleum, media and biotechnology). There is an osmosis effect as the irresistible force of profit pressures the highly-movable object of government legislation/regulation to bend to its needs (i.e. Commons Enclosures, seed certification, life patents).
5. Consequence (safe or suicidal?)	
Luddites are alarmists. The world will not come to an end. We know how to control this technology.	Tell it to the railway workers of the 1800's, the miners and chemical workers in the first half of this century, or the nuclear workers today. It takes a generation to understand the consequences (positive & negative).
6. Contribution (taking up and trickling down)	
If not directly beneficial to all of society, at least there will be a trickle-down effect from the creation of new wealth that will benefit the poor eventually.	Any new technology introduced into a society that is not itself a 'just' society will exacerbate the gap between the rich and the poor. Whether it ultimately benefits the poor depends upon many social factors. (Agricultural Revolution on enclosures, Industrial Revolution on health, Green Revolution on the rural poor, etc.).
7. Conflict (pugilists and polemicists)	
Luddites paint everything in intractable black and white making sweeping simplifications, trumpeting doom to the media, and refusing to compromise. Why can't they be more realistic and reasonable?	Eli-ites are in charge. Luddites get 'one kick at the can' when new technologies first appear. Those in opposition fight an uphill battle with an uncritical, mesmerised media. The political forum is such that every compromise is just an interim step toward total control. The message has to be clear and compromise is to be distrusted.

paigns among indigenous and rural communities, there is some justification for using literacy as an indicator of potential progress, at least in urbanised societies.

To whom – or what – do we attribute these improvements? For those of us who lived through these decades, sound governance is not a credible answer. At least for food and life expectancy, the change has come through mostly inexpensive community-based and public health-based practices supported by modest technologies. Industry's contribution, in terms of food and health security, has been marginal or even detrimental. The gains claimed by industrial technology are either non-existent or achieved only at a tremendous cost to the environment and at the risk of economic 'meltdown'. They are not likely to be sustainable.

How is it that the very industries that have retarded human progress are now claiming credit for what little gains there have been? Looking back over the phenomenal advances in science over the past century, the shock is not that technology has done so much but that it has accomplished so little. So much sound and fury – so little of social value!

Unfortunately, the *proof* of unsustainability can only be confirmed posthumously. Every new technology that has been introduced in this century has come with proclamations that it is either a silver bullet or a poison dart. So far, the predictions of both sides have been premature. History offers us no reason for complacency or for despair.

The bottom line is not that we have thus far evaded disaster – but that decades of scientific and technological discovery have failed to do what they could so easily have done – eradicate hunger and poverty and safeguard the environment. There is no excuse for so much to have accomplished so little. There is also no Law of Nature that guarantees that each new technological introduction will be able to safely walk the tight rope above disaster. Every time, the technology becomes more powerful and the potential for ruin becomes that much greater. Technology is nothing more than the manifestation of accumulated human genius – nasty or noble. So, as always, it is not technology we need fear or trust – it is ourselves.

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Concentration in Corporate Power

On the Coming *Binano* Republic

'We share half our genes with the banana.'
Robert May, UK Chief Scientist, discussing the Human Genome Project, June 2000.

Cue – The 'roles' are converging

Exactly 100 years before Will Shakespeare presented his epic play on the corruptive nature of political power, another drama demonstrated the corruptive comraderie of politics and science. In 1499 Leonardo Da Vinci left Milan to rendezvous with Niccolo Machiavelli. Together these two geniuses of art, science and politics schemed to dam and divert rivers, monopolise agriculture and dominate the natural economic resources of central Italy. Has this relationship between technology and politics changed in the intervening 500 years?[1]

As our survival base erodes and uncertain new technologies muscle their way into our social infrastructure, extraordinarily powerful new corporate configurations are replacing governments and engineering new systems of control over almost everything.

- *One-third of the US Fortune 500 companies listed 20 years ago were bought out by 1990 and another 40 per cent were merged by 1995. In the past five years the pace of corporate extinctions has surpassed the loss of livestock breeds.*
- *In 1980, the UN Centre for Transnational Corporations (UNCTC) published a study of the world food and beverage industries identifying 180 companies that dominated highly segmented markets at that time. Today, one-third of these companies occupy roughly the same market power – and UNCTC is extinct.*
- *Twenty years ago, not one of the world's 7,000 major sources of planting seed held an identifiable share of the commercial seed market. Today, the top ten seed companies have a third of the world's market.*
- *Twenty years ago, the top 20 pharmaceutical companies held about 5 per cent of the world prescription drug trade. Today, the top ten companies control well over 40 per cent of the market.*
- *Twenty years ago, 65 agricultural chemical companies were competitors in the world market. Today, nine companies have approximately 90 per cent of global pesticide sales.*
- *Twenty years ago, RAFI was not monitoring the world veterinary medicine market. Today, however, ten companies have more than two-thirds of world sales.*

- *Twenty-five years ago, the total value of mergers in the US, in a single year, soared to US$11.4 billion. In 1999, the total value of US mergers was more than US$1.7 trillion.*
- *In 1999, the total value of global mergers and acquisitions approximated to 10 per cent of the combined GDP of the entire world, more than US$3.4 trillion.*
- *Twenty years ago, intellectual property was largely a rich man's sport confined to non-living material. Today, intellectual property monopolies play a role in more than half of all goods and services (living and non-living) traded across national borders.*
- *At least 70 per cent of all international patent royalty payments are made between parent and subsidiary companies.*
- *The number of annual patents applied for in Europe has risen from barely 3,000 per year in the early 1970s to over 76,000 in 1999.*
- *Ninety per cent of new technologies and product patents are controlled by global corporations.*
- *As the new millennium begins, the world's top 200 corporations account for 28 per cent of global economic activity; the top 500 account for 70 per cent of world trade and the top 1000 companies control more than 80 per cent of the world's industrial output.*[2]

Bold fusion?

If biotech and nanotech merge, the two great sources of productive power – minerals and microbes – also come together. In 1987 at the Bogève seminar on biotechnology, we argued that any new technology introduced into a society that is not a fundamentally *just* society will, at least initially, exacerbate the gap between rich and poor. The coming together of nano- and biotechnologies does not merely, as the US military suggests, spell the 'death of distance'; it foretells the *death of dissent.* By the mid-century mark (if not much sooner), our children may be in a world controlled by a handful of corporate oligopolies.

Global corporations now control one-third of the world's productive assets and three-quarters of all world trade.[3] In their New World order, governments will function to maintain the myth of democracy, to sustain a minimal social safety net (for which they must have the power to collect taxes) and to enforce contract law. The new hegemony is facilitated by three related strategies.

The levers of power: mergers

The pace and scope of multinational mergers exploded from a record US$0.9 trillion worldwide in 1996 to a breathtaking US$3.4 trillion in 1999.[4] Most of us find such figures incomprehensible. The total of world

Historic cues: The politics of unpredictability

Between 1480 and 1700 more than twice as many books were written in France about the perils of the Turkish Empire than about the Americas. In the final decades of the 20th century, many times more books were written about the 'Evil (Russian) Empire' than about the perils of corporate copulation. The real threat still comes from the Americas. In 1849, *Scientific American* opined that a proposal to extend telegraph lines from St Louis, Missouri, across the Bering Strait to the capitals of Europe would fail because the 'language of freedom' that would travel the wires would not be welcome overseas. In 1899, the Telegraphone, a magnetic taping machine was invented in response to Alexander Graham Bell's telephone and the need to record important conversations. Seven days before the stock market crash of 1929, a leading Yale economist concluded that stocks had reached 'a permanently high plateau'. And, at the end of the day of the great crash, 35 Wall Street firms issued a joint statement announcing 'The worst has passed'. In 1936, leading British scholars predicted that, within 50 years, food, shelter, clothing and energy would be so accessible and cheap that unemployment would either be universal or non-existent. In 1959, the managing director of the International Monetary Fund announced the demise of inflation. In 1940, Gandhi thought Hitler wasn't so bad. Gandhi was just a little behind his times. And, in 1932, Winston Churchill predicted that 50 years from then the world would abandon the 'absurdity' of growing whole chickens but would simply grow chicken breasts and wings 'under a suitable medium'. Just a little ahead of his time?

mergers in 1999 amounts to a sum roughly equivalent to 10 per cent of total world output (the combined GDP of every country).[5] Global mergers in the last two years of the bygone decade exceeded the total of the previous eight years.

We are talking about sudden and enormous concentrations of power. It is a sign of the pace of change that the securities and investment industries have only lately begun to monitor worldwide mergers. However, RAFI staff have monitored US mergers and acquisitions since 1974 and, therefore, our historic data for US corporations gives a fuller view. In 1974, the annual value of US acquisitions stood at less than US$12 billion. In 1988, the tally soared to US$330 billion, before dipping slightly in the recession years that immediately followed. In 1999, the US merger figure was well above US$1.7 trillion.[6]

By no means has all this activity been fuelled solely (or even primarily) by the carbon passions of the biotech and nanotech industries. Petroleum and automobile industry mergers, as well as financial and informatics (telecoms and media) industry mergers, have led the field. At the mid-point of 2000, cross-border mergers were up 26 per cent over the previous record-shatter-

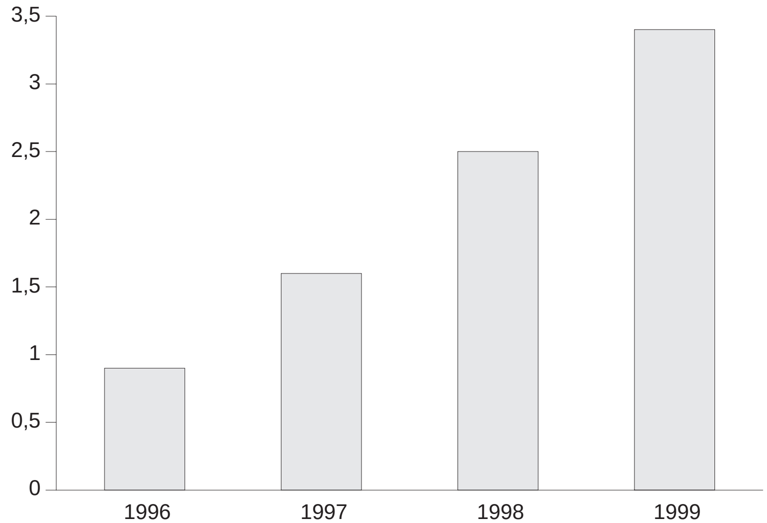

Chart 6 Estimated value of global mergers of corporations 1996–99 (US$ trillions)

Source: *Financial Times* and RAFI material.

ing year with a tally in excess of US$1.9 trillion. Half a trillion dollars' worth of these mergers were in the informatics sector.[7]

But the Life Industry (including food and health as well as other bio-based products) has not been a bystander. According to a UNDP study, mergers in the global biotech industry (excluding pharmaceuticals, for example) rose from just US$9.3 billion when RAFI wrote *The Laws of Life* ten yeas ago to more than US$172 billion in 1998.[8] Roughly estimated, 'marriages' in the pharmaceutical sub-sector, that reached US$80 billion during the period 1994–97, have probably exceeded US$400 billion (in betrothals and consummations) today. In the first six months of 2000, drug company mergers added up to just under US$100 billion.[9] As one millennium called it quits and another began, Glaxo Wellcome and Smithkline Beecham (two UK drug firms) agreed to what was fleetingly the world's largest drug industry merger (US$76 billion). Days later, Pfizer snapped up Warner-Lambert (two US drug majors) in a still bigger deal valued at US$90 billion.[10] Only Merck among the world's top ten drug companies is not thought to be a potential buyer or seller, yet. Mergers in the agribusiness industry (including food processors and retailers as well as agricultural input companies) leapt dramatically in 1999 when DuPont bought the world's largest seed company, Pioneer Hi-Bred, for US$7.7 billion. Monsanto, however, led the field in agbiotech with its purchases of almost US$8.5 billion in seed company stocks since the mid-decade point. Now Monsanto itself is being acquired by Pharmacia & Upjohn (now to be called Pharmacia) in a deal valued at US$37 billion. Yet, in the first half of 2000, the astonishing pace of mergers in the food sector exploded beyond all expectations with almost US$150 billion in acquisitions.[11]

The levers of power: alliances

Corporate marriage (mergers) are only one way companies are taking over more territory and technology. Marriage or not – there is always a place for corporate promiscuity. In order to avoid anti-combines laws or nationalist policies, companies increasingly form alliances to share patents, know-how and turf in less-regulated ways. Between 1996 and 1998, the world's largest transnationals established more than 20,000 such alliances. The top 20 pharmaceutical houses, for example, had 375 alliances with biotech boutiques in 1998 compared to only 152 a decade earlier. Almost all of them were 'cross-border' arrangements. Since the early 1990s, corporate revenues drawn from these alliances have doubled and now account for about 20 per cent of company income in Europe and 21 per cent for the US *Fortune 500*.[12]

Because of the subterfuge provided by alliances, the extent of global monopoly in pharmaceuticals or in agribusiness appears modest according to the conventionally applied monopoly rules monitored by most countries. But what are the implications, and what was the deal, when Monsanto agreed to market its smashingly successful arthritis drug with Pfizer? The new arthritis treatment is actually outselling Pfizer's famous Viagra. To argue that the top ten drug houses have 43 per cent of the global market does not impress a monopoly commission that is focused narrowly on asthma or cardiovascular sub-markets. Neither are anti-combines cops interested in monitoring the whole seed or pesticides industry when they perceive the competition to be waged between maize breeders or broad-leaf herbicide manufacturers rather than across technologies. Governments have shown little interest in – or capacity for – cross-sectoral technology analysis. The monopoly now arising is within a Life Industry that governments do not even understand to exist. It is beyond their comprehension that a common biotechnology could link human genomics with human pharmaceuticals with veterinary medicines with crop chemicals with seeds with cosmetics with household cleaning products. The biotech industry has massively outflanked the corporate police. The nanotech industry will do the same. Civil society organisations – as a matter of highest priority – must work to increase the ability of governments to perceive, monitor and resist technological monopolies.

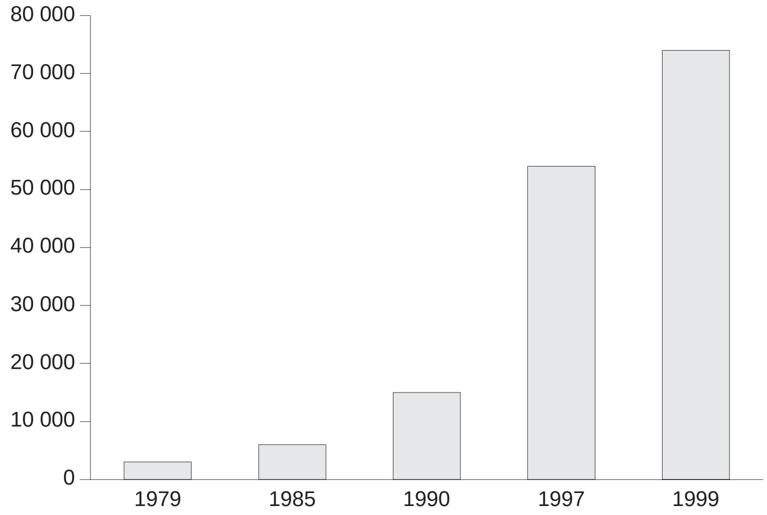

Chart 7 Patent applications per annum under the Patent Cooperation Treaty (PCT)

Source: *Human Development Report 1999*, UNDP, and WIPO statistics.

The levers of power: old and new enclosures

The direct monopolisation of knowledge remains the 'vehicle of choice' for most transnationals. Intellectual property (patents and plant variety 'protection') is a growing (but temporary?) force. Between 1980 and 1994 – a period that began with the US Supreme Court's decision to allow 'life patenting' and ended with the GATT Uruguay Round – the share of global trade involving high-tech (patented) production rose from 12 to 24 per cent and now accounts for more than half of the GDP of OECD countries.[13] This does not take into account that the overwhelming majority of agricultural commodities produced and traded by OECD countries are also 'protected' by patents and/or Plant Breeders' Rights (plant variety protection). Perhaps the most telling development is that the number of annual patent applications made via the Patent Cooperation Treaty has skyrocketed from barely 3,000 in the mid-1970s to over 76,000 in 1999 (see Chart 7). Half of all royalties and licensing fees paid to inventors in the mid-1990s went to corporations in the USA. Nothing better illustrates that patent monopolies are a strategy to deny others access to markets than the estimate by WIPO (World Intellectual Property Organization) that 90 per cent of all cross-border licensing payments – and 70 per cent of all licensing fees – are made between subsidiaries of the same parent transnationals.[14] In its *Human Development Report 2000*, the UNDP estimates that 90 per cent of the patents related to high technologies are held by global enterprises.[15]

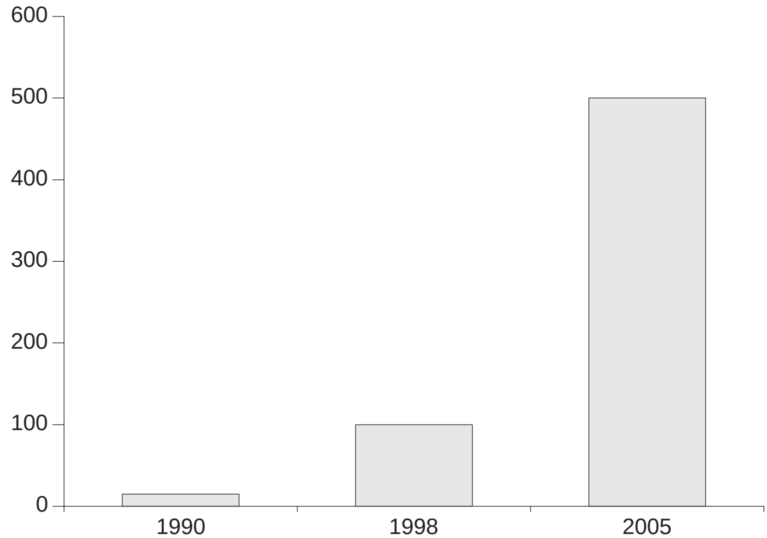

Chart 8 US patent licence revenues (US$ billions)

Source: Rivette, Kevin G., and Kline, David, *Rembrandts in the Attic*, Boston, 2000.

The 'No patents on life' battlefield

The quarter-century long industry campaign for intellectual property monopoly over life forms faces its most important battle in 2000–01. An industry victory can only be denied through organised popular opposition. The battle theatre will shift between the European Court, the next WTO trade round (and possible TRIPs review), Southern governments and United Nations agencies such as FAO, WIPO and the Biodiversity Convention. Despite the uphill struggle, this battle has to be our urgent primary goal. If we are successful even in defining the terms of engagement, a loss in 2000 could still position CSOs for the longer-term struggle. Then, too, there is the possibility that we will win.

If we lose the TRIPs battle over plant varieties, what future battle is there for us to 'position' ourselves for? The answer is the battle to deny industry monopoly patents over the *substances* of nature. Although many CSOs have taken determined and effective positions against the patenting of life, they have not addressed the wider inequities of the entire patent system – living or not. New patents on nanotechnology – 'atomic patents' – suggest that we could win the battle over life patenting but still surrender monopoly control of agriculture and health to the nanotech industry. The industry is looking for sweeping patent claims that will dominate this technology. In some cases, the claims will not involve life. In many cases, the claims will relate to bionic matter. There is an urgent need to re-think the framework of the intellectual property debate in order to challenge the new technologies now.

Intellectual piracy

At the end of 1992, RAFI joined with a number of individuals in government, industry and science in a non-consensus dialogue process. What became known as the Crucible Group was galvanised by the approval of two 'species' patents – on soybeans and cotton – that appeared to grant exclusive monopoly control of the biotech development of the crops to Monsanto. The Group was also spurred into consultations by the seemingly uncontrolled acceptance of patents on genes and on indigenous knowledge. In urging the holding of a dialogue, RAFI warned that intellectual property regimes had become rudderless and ruthless and that there were no longer any 'rules of the game'. We argued that patents were no longer incentives to innovation but bargaining chips big firms used to trade turf among themselves and to exclude smaller enterprises. Patent litigation costs – then estimated at about US$225,000 per combatant – had turned intellectual property into a non-tariff barrier to market entry for smaller innovators. We speculated that if trends continued, we would see patents become stock market negotiable assets – possibly even develop their own 'trading floor' – and that the sacred embargoes against patents on pure science, methods of doing business, and mathematics would all erode. Industry-oriented participants in the Crucible Group thought our concerns fanciful.

No longer. In 1998, US courts confirmed that methods of doing business – specifically trading practices and investment strategies – were patentable. In effect, it is now possible to patent Wall Street. In 1999, a San Francisco-based investment bank announced plans to create a patent futures market by 'securitising' corporate patent portfolios and selling notes to investors. At the same time, a virtual trading floor in patent licences was created by yet2.com so that companies such as 3M, Allied Signal, Boeing, Dow, DuPont, Ford, Honeywell, Polaroid, and Rockwell could 'exchange' patented technologies. Breaking the tradition that all inventors are created equal before the patent office, the Japanese government has announced plans to grant venture capitalists and major IP (intellectual property) investors 'various preferential treatments'.[16]

While the media have been mesmerised by the antics of 'dot com' entrepreneurs like Amazon in trying to patent chunks of the Internet and its functions, the most worrisome and amazing intellectual property claims have continued to come from the Life Industry. In December 1999, the US Patent

Office granted its 6 millionth claim since its establishment more than 200 years before. But even as the ink was drying on that award, three human genomics companies together admitted that they had applications pending on about 3 million claims against bits and pieces of human DNA and gene fragments. Patents have already been granted on human genes and SNPs (Single Nucleotide Polymorphisms), the utility of which is totally unknown. By the time Bill Clinton and Tony Blair announced the completion of the Human Genome map, not a single scrap of our 'humanity' remained unclaimed by the Life Industry.

This is piracy and it is also 'driftnet' patenting. Not only in our own DNA, but also in the rainforests, the fields, and the beaches of the South, biotech companies are scavenging for unique (unpatented) diversity and placing claims on it without the slightest notion of how it might be useful – or how others have used it for thousands of years. At the end of the 1990s, Heritage Seed Curators of Australia and RAFI joined forces to identify 147 cases where patent or Plant Breeders' Rights claims had been made on plant material without apparent justification. Almost all the possible abuses identified were based on a search of the Australian records and amounted to at least 6 per cent of all plant variety applications in that country since legislation first made such claims possible. Similar studies of plant claims in other countries – perhaps especially in New Zealand, Israel, South Africa, and the European side of the Mediterranean – would be likely to yield similar scandals.

Is the Periodic Table of Elements patentable? As it was once seen to be impossible – and is now woefully possible – to patent genes, species, SNPs and processes of life, the nanotech industry will use this biological precedent to patent the permutations and processes associated with basic elements. Nano-boutiques, and then their masters, will surround the known elements with patented variations and gain de facto monopoly over the fundamental building blocks of matter.

Some would like to think that the patent system is like a balloon that is about to pop; that it has expanded so rapidly and irrationally that it will go to pieces. This is not impossible. Certainly its size and power will draw more and more public scrutiny and – hopefully – opposition. In 1990, total revenues from patent licences amounted to US$15 billion. By 1998, licencing fees garnered US$100 billion, and some experts justifiably predict revenues of half a trillion dollars per annum by 2005. Meanwhile the average cost of litigation has ballooned to about half a million dollars per litigant. If patents were once an obscure and dusty corner of the legal system, they are no longer. They are at the centre of the New World Order.

Then, too, patents could be in trouble simply because patent offices will make more and more mistakes as the demands of claim examiners become impossible. While patent offices are scrambling to hire and train more examiners, both the number of patent applications and the complexity of technologies are rendering their job unbearable. As a result, an ever more obvious tide of 'stupid' patents is being granted. Since 1995 in the USA, the number of intellectual property lawsuits reaching federal courts has risen ten times faster than other legal actions. There were 8,200 cases in 1999 alone.[17] The resulting public ridicule and private litigation does create uncertainty for the whole system.

New Enclosures

In the midst of the fray over life patenting, it is essential that we do not lose sight of industry's primary purpose – within which intellectual property is a weapon, not a goal. Industry has two objectives: first, to secure societal acquiescence to a virtually limitless global proprietary culture; second, to entrench intellectual property as a non-tariff barrier to market entry for all but the most privileged members of the corporate clique. Mega-mergers – often driven by patent and technology fears or opportunities[18] – are already transforming the once-diverse Life Industry into a handful of homogeneous Gene Giants. The giants trade patent licences and industrial and geographical turf among themselves and exclude public and lesser private enterprises. Independent public research is becoming extinct. Entrepreneurial science is being priced out of the patent poker game.

Because patents on more technologies are unreliable and because litigation is both expensive and uncertain, transnationals would be more than happy to find more reliable systems of monopoly control. New Enclosure mechanisms are being developed. Among them, *negative* technologies (Trait*or* Tech) are attractive because of their built-in exclusivity and long-range controls. The first (and arguably the worst) of the Trait*or* Tech generation are agriculture's Terminator patents. Peculiarly, these technologies offer a case wherein banning the patents means banning the technology. The US government argues, with some logic, that nations cannot ban the patent on the grounds that it is against public morality and then use the technology anyway – not without being challenged at the World Trade Organization (WTO) in Geneva. The fight against the Terminator, although only one element of the negative technology initiative, focuses the whole life-patenting debate while raising the alarm over the Trait*or* Tech strategy that Terminator portends.

Beyond biological strategies there are still other New Enclosures. On 1 May 2000, the US government dropped its edict that prevented commercial satellite companies from viewing the earth at resolutions down to one metre. Prior to the policy change, the military prevented civilian satellites from having effective photo accuracy below 10 metres. The difference is considerable. At one metre, you can make out the make of a car. At ten meters, you can just barely discern the highway. Predicted advances in satellite monitoring will make it possible to monitor individuals – and the genetic make-up of a field crop. In fact, an experiment is already underway in Tasmania where satellites are eyeing every square meter of farmland to monitor plant growth, pests and soil conditions. With a handful of companies running the food system, agribusiness will not need patents to keep farmers in line – just traditional contract law (far cheaper and easier to enforce around the world) and their 'eye in the sky'.

Yet another New Enclosure strategy comes in the form of government-enforced public safety requirements. Biosafety and Nanosafety protocols can be used to impose monopoly under the pretext that the necessity to feed the world or safeguard the environment warrants the risk in the high-tech solutions – and for the same reasons the high-tech solutions can only be entrusted to single enterprises. This would, by no means, be the first time that the state would guarantee private gain in the name of the public good.

Where is this taking us? What follows is a brief projection of the direction we are being forced along in four broad industrial sectors and an overview of the new *Binano Republic* that awaits us if we fail to act now.

Future food – the biomaterials industry

From 'input' to 'output' trait controls

Generation X meets Generation Three

Will the world ultimately reject the corporate approach to agbiotechnology? Although an impressive counter-revolution is underway from Rio Grande do Sol to Tamil Nadu to Seattle, industry scenarios continue to anticipate that GM products will take over no less than 80 per cent of the world's commercial seed market within ten years. Given the mounting hostility around the world it is easy to dismiss the company claims as nothing more than desperate bravado. Yet, the Biosafety Protocol adopted on 29 January 2000 (so astutely endorsed by Novartis and so absurdly embraced by Greenpeace) could well lull the world into believing that all is settled on the transgenic foods front. If so, virtually all non-subsistence farming (and a tragically large share of subsistence farmers as well) will be 'conned' or coerced into the bio-industrial mould. Farmers will lose control of their agricultural inputs as all breeding advances are joisted into the Terminator platform. At the other end of the production line – at harvest – the Trait*or* Tech strategy (the control of other production and quality traits in the plant), still tied to proprietary herbicides and insecticides, will make sure that the farmer can sell to only one processor. Novartis has patents that describe exactly this kind of Terminator/herbicide connection. The same applies to new patents including invertebrates, livestock and, of course, humans. BASF, University of Texas, and UC Berkeley claims leave open these possibilities. We too can be 'Terminated'.

The combination of Terminator Tech with Trait*or* Tech places farmers in a vice they cannot escape. However, if consumers continue to recoil from biotech's Generation One products (agricultural inputs such as seeds and pesticides), we could see an ungainly scramble in the corporate world to disassociate itself from a 'loser' strategy. Indeed, prior to the Biosafety deal, the financial press were projecting a 20 per cent or greater decline in the crop area sown to Generation One GMOs in the United States alone. On the other hand, if the Protocol survives the ratification process, industry's low-profiling tactic will be replaced by a renewed media and market push. In this case, there will be another wave of mega-mergers linking agbiotech with food processors and traders. This second wave will herald Generation Two – biotech products with *output* traits that could reduce processors' costs by, for example, increasing the dry matter content of agricultural raw materials, extending product shelf life, reducing transportation costs, or utilising waste materials for food or other purposes. Since none of these output traits will offer real benefits to either farmers or consumers, they are likely to be met with the same resistance. Some time before the end of the millennium's first decade, however, biotech will roll out Generation Three – the so-called *nutriceuticals* or *farmaceuticals* that will at least pretend to benefit affluent consumers. At this point, the food retailers – the giant enterprises that have borne the brunt of consumer distaste for Generation One and are likely to carry the bruises for Generation Two as well – will step in.

But, make no mistake. Generation Three bears a potential for good and for ill. It will require more careful thought and more stringent analysis than has been typical among CSOs following biotechnology.

'Life' Industry 'dead'?

There is a theory that the Life Industry never existed – or that it died prematurely. Exponents of the theory point to the move by Novartis and AstraZeneca to join their agricultural divisions into a new enterprise to be known as Syngenta that can be kept at arm's length. If the stink from agbiotech's Generation One threatens the well-being of the two parent companies' main healthcare divisions, Syngenta can be quietly divested. A second example cited is the surprising union of Pharmacia & Upjohn with Monsanto. Skeptics point out that the combined enterprise is to be known as Pharmacia and that the united agricultural divisions will actually be cut back but kept under the Monsanto banner. This too could be 'protection' or 'insurance' for the pharmaceutical side of the merged businesses. Is the Life Industry – so recently unified – on its way to being 're-segmented'?

Would that it were true! Rather, it is a short-term tactical move to allow the

Biotech's Generation One – *Tales of a Misspent Youth*

The RAFI revue of the scientific, political and media disasters that struck the Agbiotech industry since the BioSafety Protocol was adopted in January 2000.

January 2000

Soiled reputation: As delegations readied for the Montreal biosafety meeting, US and Venezuelan researchers confirmed that the Bt toxin in transgenic maize could (contrary to industry expectations) escape into the soil killing larvae up to 25 days after the break-out.[19]

February 2000

Hard to resist: Canadian scientists acknowledged that Monsanto's *Roundup*, Cyanamid's *Pursuit*, and Aventis's *Liberty* herbicides lost their effectiveness against weeds only 2 to 3 years after an Alberta farmer planted the companies' GM canola seeds.[20]

March 2000

Wowel language: A long-suppressed US Government memo dating to 1993 revealed an experiment in which 4 of 20 female rodents fed the *FlavrSavr* (a GM tomato now owned by Monsanto) suffered gross stomach lesions.[21]

'Play possum' penis plot: New Zealand scientists proposed to develop GM carrots engineered to sterilise possums when eaten. Possums are threatening the country's crops.[22] Scientists pooh-poohed concern that the carrots might have the same effect on people, and insisted the carrots could be kept separate from the human food chain if necessary.

The* '*Which Blair Project': Tony Blair reversed his position of a year earlier ('the Prime Minister is very strongly minded that these [GM] products are safe') and told readers of *The Independent* that 'there is no doubt that there is potential for harm from GM food'.[23] Further flip-flops are widely predicted.

April 2000

***Weevil wars*:** It was found that GM cotton that 'volunteered' in GM soybean fields may be bringing the dreaded cotton boll weevil back into the USA as a major pest.[24]

***A-maize-ing pace*:** American maize growers were shunning GM seeds because their 1998/99 exports to Europe had dropped to 137,000 tonnes from 2 million tonnes one year earlier.[25] The announcement came on the heels of media reports that major potato processors and fast-food chains were warning growers to avoid GM potatoes.

May 2000

'Safe' … wherever they are: GM seeds were routinely – though accidentally – shipped to Europe by US and Canadian seed companies who could not seem to keep their conventional seeds separate from their GM lines.[26] In the following days, the sloppy inventory management problem spread throughout Western Europe as country after country found their fields contaminated with illegal and unwanted GM crops. (New Zealanders were assured that such stock management problems could never occur with carrots.)

'Safe' … whoever they are: Monsanto advised US officials that it had detected an unidentified strand of DNA making 'mystery guest' appearances in its GM soybeans. Monsanto assured officials that the unknown DNA was perfectly safe (and was not a virus playing 'possum').

German Bee Bellies: A researcher in Saxony found that a gene had transferred from genetically engineered rapeseed to bacteria and fungi discovered in the gut of honeybees. Industry had previously claimed such a transfer was highly unlikely or impossible.

June 2000

Spider Man: A 'jumping gene' being used in genetic engineering has crossed the species barrier at least seven times, including one jump between flies and humans. If organisms modified using this footloose gene are released, there is risk of further unexpected jumps.[27] (New Zealanders were assured the gene would not be used in developing transgenic carrots.)

'Safe' … whatever they are: The New Zealand Government admitted that there were at least 100 illicit GM crop experiments underway in the country.[28] After checking on half the experiments, the Government announced that (as with Monsanto) everything was okay (and that none of the experiments could possibly involve either possums or carrots).

July 2000

No safe refuge: Non-GM maize 'refuges' planted by farmers near their GM maize fields in order to slow resistance to the bacterial toxin in the GM fields just do not work. The vulnerable insects in the refuge plots refuse to breed with the resistant insects from the larger GM fields. (Possums, however, are understood to find the corporate designed plots to be ideal breeding grounds.)

Wander-lust? A large-scale study of the UK's oilseed rape crop and indigenous weedy relatives proved that crosses can occur and that traits such as GM herbicide-tolerance could leap to weeds.[29]

Still mad: UK authorities reported a new case of Mad Cow disease in one cow born after stringent new controls were established in 1996.[30] Public distrust of government and scientists over GM crops in Europe began with their failures in handling mad cows.

August 2000

… and madder still: Human deaths from Mad Cow disease in the UK were reported to have increased markedly in the first half of 2000 compared to 1999. There were 15 deaths to August 2000 compared to only 18 in all of 1999.[31]

The real Golden Rice: A US university study of 'sticky' rice varieties in China and the Philippines showed that planting a number of diverse varieties increased yields by 89% while reducing disease by 98%. Their conclusion: diversity outperforms genetically uniform GM varieties.[32]

Better flee butterfly! Researchers in Iowa (USA) confirmed a controversial Cornell study proving that GM maize is a threat to Monarch butterflies. Industry had disputed the earlier Cornell findings.[33]

Possum labels? Bowing to public pressure, both New Zealand and Australia announced they would require labelling for almost all GM foods. This brought the two countries close to Europe and further isolated Canada and the USA who still oppose labelling.[34]

September 2000

Taco bulls: A GM maize variety ('StarLink') banned in the USA for human consumption (because of fears of rare allergic reactions) but permitted as a livestock feed, showed up in taco shells served at Taco Bell restaurants. The Aventis variety raised new concerns about industry's and government's capacity to manage GM products.

Golden fleeced: The May surrender of the public sector's Golden Rice technology to AstraZeneca due to fears that the Vitamin A enhanced GM cereal contravened up to 105 intellectual property arrangements was shown to be false. At most 11 patents could be implicated and all would likely be surrendered upon request.

'Safe' … whatever part it is? US researchers warned of a loophole in biosafety regulations for GM crops such as tomatoes and potatoes where the rule of 'substantial equivalence' applies only to the edible portion of the plant and neglects changes that might occur in roots or leaves. Failure to test for significant genetic alteration of the inedible parts could risk the environment they warned.[35]

October 2000

Power Ranger epi-needles: The Taco Bell scandal spread to Kellogg's corn flakes as the giant cereal company closed down one plant for fear that the illicit GM StarLink maize had infected breakfast cereals. (StarLink was approved for animal feed but not for human consumption.) In a panic, the White House sent emissaries to Japan and Europe to try to calm concerns that Aventis's 'StarLink' had illegally entered their countries. Consumers joked that breakfast cereal makers would have to give away epi-needles or epi-pens (injections to threat anaphylactic shock) in cereal boxes instead of Power Rangers or Star Wars toys for fear of allergic reactions in children.[36]

Super sugarweeds: German researchers reported that a GM sugarbeet designed to resist one herbicide accidentally acquired resistance to a second herbicide. EU biosafety rules do not permit double-resistance because of the increased possibility of gene diffusion into weeds and the creation of superweeds.[37]

Slow learners: Mad Cow disease = the food crisis that sparked distrust of scientific judgement and government regulatory competence, appeared to be taking hold in France with new reports of diseased animals.[38]

Possum patent policy: A policy change that would have allowed the world's largest agricultural research network devoted to Third World food security to patent genes and gene sequences was turned down when the Consultative Group on International Agricultural Research (CGIAR) met in Washington. The move would also have encouraged a shift toward GM crops.[39]

November 2000

Unethical monopolies: The first meeting of the UN Food and Agriculture Organization's Ethics Panel (a group of world-reknowned agronomists and ethicists) concluded that GM crops are risky, Terminator technology is immoral; and that patenting genes and other genetic material leads to crop genetic erosion and unacceptable monopoly.[40]

Biotech's billion dollar mistake: With the Aventis's 'StarLink' scandal spreading to hundreds of food products and companies, the company estimated that its clean-up costs would be less than US$1billion. Then the GM maize turned up in Japan and Korea …[41]

December 2000

Montpellier's Monsanto rescue: The world's 'biocrats' gathered in France to debate biosafety rules and rescue Monsanto. Never before have so many gathered to debate biosafety for so few! In essence, the US$2.5 billion GM seed market involves 4 major industrial crops (soybean, maize, cotton and canola) grown in 3 countries (the US, Argentina and Canada accounted for 98 per cent of the total GM area in 2000). In 1999, Monsanto's GM seed traits accounted for over four-fifths of the total world area devoted to GM crops.[42] Demand for GM seeds almost flattened in 2000 with an increase of only 8 per cent after years of doubling and redoubling. Analysts predicted that, at least until 2003, demand would remain flat or decline. In other words, the purpose of Montpellier was to rescue Monsanto, the USA, Canada and Argentina from their GM blunder!

Genealogy of Agbiotechnology

Generation One refers to *input trait* control systems most profitable for the seed/agrochemical industry. These are crops genetically engineered to tolerate chemical weedkillers or to express insecticidal genes. The goal is to modify the use of chemical inputs applied to crops, and to expand or prolong the herbicide and insecticide businesses of the enterprises.

Generation Two refers to the modification of *output trait* control systems oriented to the interests of food processors. This involves the manipulation of crops in order to reduce processing energy, storage and transport costs. A classic example is Calgene's slow-rotting tomato engineered for longer shelf life. Generation Two is just now entering the marketplace but is already suspected of suffering from the same credibility afflictions to which Generation One succumbed.

Generation Three refers to the next generation of ag biotech products, designed for the food/pharma retail sector, which will offer perceived benefits for consumers, ranging from edible vaccines, anti-cancer vegetables, cholesterol reducing grains, crops fortified with micronutrients, and blue carnations. The fate of agbiotechnology rides on consumer acceptance of Generation Three.

industry 'plausible denial' if Generation One continues to self-destruct. Other, less publicised, developments in the US market point in a very different direction. Around the time of the adoption of the Biosafety Protocol – perhaps sensing victory – ADM (Archer Daniels Midland) quietly abandoned its plans to require segregated (GM and non-GM) grain management at its elevators and processing plants. At the same time, DuPont formed a pact with General Mills (one of biggest food processors in the USA) to develop 'functional foods'. Functional foods is the latest industry euphemism for transgenic crops that are supposed to offer Generation Three nutriceuticals. Days later, DuPont made another deal with Affymax, a Glaxo subsidiary, to help it discover new pesticide compounds. These, short days after the Protocol, showed renewed faith in Generation One. Also post-Protocol, Novartis announced a major deal with Quaker Oats, another major food processor, to create a joint venture in North America (including Mexico) called Altus. Altus, too, will develop 'functional foods'. In recording the deal on its website, Inverizon International Inc. commented, 'This marks another step towards the merging of sustenance and health aspects of future foods.'[43]

Who is on top of the food chain?

Which companies will dominate? There are at least four – and possibly five – contending groups. While processors and retailers (two of the groups) enjoy much larger revenues, the Life Industry has much higher profits and is much more skilled in the management of new technologies. There is also the distinct possibility that the food processors will make the mistake of the *input* trait enterprises by welcoming Generation Two. Any attempt to foist on the market GM products that reduce production costs rather than offer value-added nutriceuticals to consumers could easily fail and cause severe damage to the stock (political and financial) of the companies involved. If the input companies fall victim to Generation One, and the *output*-fixated processors bite the dust over Generation Two, there is every possibility that food retailers, using their private brand-label advantage and their intimate connection with consumers, will lay claim to the entire food chain and champion Generation Three.

Food retailers, of course, are also consolidating. The giant Dutch conglomerate Ahold, for example, is reported to be interested in buying up as many as ten grocery store chains with combined sales of more than US$35 billion. Three of the chains are in North America, three in Latin America, and four in Europe.[44] As the enterprises closest to the consumers, retailers could merge food and drug marketing and claim the agriculture and health systems for themselves.

It remains to be shown that the processors, traders or retailers have the intelligence or the cash to outflank the Life Industry with its deep pockets and technological dominance. The world's leading food processors have profits only equal to about 3.6 per cent of revenues. The top global food retailers weigh in with profits of less than 2 per cent of sales. Nevertheless, the first half of 2000 witnessed an unprecedented eruption in traditional food industry mergers reminiscent of the takeovers that took place on the *input* side of the food supply a quarter-century ago. In a period of six months, there was an excess of US$150 billion in corporate combinations – a figure only surpassed by the high-tech telecom industry and film studios.[45] Among the biggest deals, Unilever gobbled up Bestfoods, Ben and Jerry's and Slimfoods for a total of almost US$24 billion and Philip Morris took over Nabisco and a fast food burger company for over US$15 billion. In July 2000, General Mills and Pillsbiry (then a subsidiary of Diageo in the UK) began discussing a US$11 billion arrangement that would unite the two processors.[46] No one believes the buying spree is over, and rumours abound that Cadbury-Schweppes, Hersheu's and other confectionary companies may also be takeover targets.

Global market power

Although the current rate of consolidations along the food chain is without precedent, the process of concentration is hardly new. In 1980, the ill-fated UN Centre on Transnational Corporations (UNCTC) published a unique analysis of the world's 180 most important food and beverage companies. The study identified surprisingly high levels of market concentration in specific segments such as dairy, meat, tropical fruits, grain and tropical beverages. Twenty years later, RAFI's Hope Shand is attempting to replicate the original study. At the time of writing, her work is not complete, but initial surveys suggest that barely a third of the original 180 enterprises are still among the living today. Almost all of the 'disappeared' have been absorbed into the surviving third. Today, the top five grain trading enterprises control more than 75 per cent of the world market for cereals[47] and similar levels of concentration exist for most internationally traded commodities. According to one recent study, a handful of transnationals control about 90 per cent of the global trade in wheat, maize, coffee, cocoa and pineapple; about 80 per cent of the tea trade; 70 per cent of the global banana and rice markets; and more than 60 per cent of the world trade in sugar.[48] One Mexican-based transnational commands 40 per cent of the US vegetable seed market and 25 per cent of the commercial vegetable seed business worldwide. Remarkable levels of concentration are also developing at the retail end of the food chain in both OECD and Southern countries. Half of the national vegetable business in Costa Rica is dominated by one enterprise. One company controls 40 per cent of the same market in Honduras. Five retailers control 50 per cent or more of all food purchases in France, Germany and the UK.[49]

Whoever wins, the implications for farmers and consumers remain the same. The medium-term trendline will witness a movement from biotech's tactically stupid emphasis on *input* traits to add *output* traits. The phenomenal pace of mergers within seed and agrochemical/pharmaceutical companies, as we have already noted, will be followed by a similar spree linking Gene Giants to food processing, trading and (possibly) retailing transnationals (Nestlé, Unilever, Philip Morris, Cargill and Safeway or J. Sainsbury). Farmers will enter an era of *bioserfdom* wherein they will rent germplasm from the gene subsidiaries of food processors. These processors will also be the sole buyers of the transgenic commodity (containing the designer traits demanded by the processor). Companies such as DuPont and Archer-Daniels-Midland are already moving in this direction.[50] This scenario does not necessarily place the processors at the top of the food chain, however. At this point, the possibility of 'organic' or 'sustainable' or 'agro-ecological' food production devolves to the mythic world of bygone days and legends.

If, as the song goes, 'the buyers and the sellers are just the same fellers', then the food 'won't be what it ought to be'.

Life Industry insurance?

Within the realm of *traditional* Life Industries there is an almost perfect interweave between agricultural and pharmaceutical interests and technologies. There will be a struggle between food and beverage enterprises (brewers have the scale-up capacity for bio-fermentation or factory farming) on the one hand, and pharmaceutical enterprises on the other. But there is also the possibility that the Life Industries of genomic management have already been patented.[51]

'Dysfunctional foods'?

The longer-term industry scenario (2010–20) will witness the commercialisation of nanotechnology and its convergence with biotechnology. The marriage of microforms of biological and material sciences will offer new dimensions to 'precision farming' and food production. While this is often described as transferred military technology ('beating swords into ploughshares'), it is more likely to beat farmers into landlessness. The wider dimensions of the union of biotech and nanotech (*binanos*?)[52] would eliminate farmers and farming as we know them. Nanotech theorists suggest that some time before mid-century, we will be building our food atom by atom in a household contraption not unlike today's kitchen microwave. Atom-by-atom cooking may not seem exactly like 'fast food' but, as already discussed, self-replication could put a Big Mac and fries in front of you in a nanosecond.

Table 9 presented here on agricultural-related industry sectors is derived from the Fortune Global 500 list published by *Fortune Magazine* in mid-2000. The table considers the major biological/agricultural industries including beverages, food, food and drug stores, forest and paper products, and tobacco. The table indicates the number of global companies in each segment that form part of the Fortune Global 500 and offers basic data for the segment for revenue, profits and employment. Below the 'total' for each segment is the company with the highest revenue. Often, this company also has the highest profit. If not, a second enterprise, that with the highest profits, is listed. The purpose of the table is to offer some sense of the size and power of the major contenders in the fight for that portion of the economy directly dependent on agriculture and forest resources.

Twenty years ago, Wes Jackson of the Land Institute in Nebraska joked that serfs in Europe donned tunics bearing the heraldic crests of their feudal masters. Today, farmers don baseball caps bearing the trademarks of their corporate masters. Not much has changed.

It is somehow fitting that aspirin was commercialised 100 years ago. Novartis, perhaps the world's most powerful Life Industry in 1999, uses the control of a close relative of aspirin to govern traits in its version of Termi-

Table 9 Future food – the biomaterial industry in 2000

Segment and rank	Company	Revenue US$billions	Profit US$billions	Profit as % revenue	Workers	Number of companies
Beverages		*82,591*	*7,489*	*9.1*	*314,090*	*5*
203	Pepsico	20,367	2,050	10.1	118,000	
215	Coca-Cola	19,805	2,431	12.3	37,400	
Food		*215,579*	*8,801*	*4.1*	*915,518*	*10*
41	Nestlé	49,694	3,144	6.0	230,929	
Food & drug retail		*552,460*	*10,666*	*1.9*	*3,162,786*	*25*
46	Metro	46,664	295	0.6	171,440	
111	Tesco	30,352	1,088	3.6	134,896	
Food services		*23,295*	*2,095*	*9.0*	*569,973*	*2*
368	McDonald's	13,259	1,948	14.7	300.000	
Forest & paper		*89,809*	*3,947*	*4.4*	*319,648*	*6*
162	International Paper	24,573	183	0.8	99,000	
379	Kimberly-Clark	13,007	1,668	12.8	54,800	
Tobacco		*111,960*	*11,374*	*10.2*	*253,892*	*4*
29	Philip Morris	61,751	7,675	12.4	137,000	
Total		1,293,414	57,180		6,630,417	52

Source: Fortune Global 500, *Fortune Magazine*, August 2000.

nator technology today. The Novartis approach actually weakens the natural resistance abilities of the plant and makes the crop dependent upon external chemical support. If you find all this a trifle sickening, take two you-know-whats and call your government in the morning!

Future health – the biochemicals industry
From 'sick' to 'well' drugs

The pharmaceutical industry is one of the most profitable and fastest-growing sectors of the world economy. Short decades ago, the top 20 drug houses controlled barely 5 per cent of the world patented drugs market. Today, the leading ten firms have 35 per cent of the market – and that market is expected to double over the next two to three years over its current sales volume of US$297 billion.[53] As already noted, since the mid-1990s, the industry has experienced close to US$400 billion in mergers – among them some of the largest in history. As was done for the previous discussion on food, Table 10 summarises the various industry segments that comprise the health sector. The table is confined to the Fortune Global 500 – the 500 leading world enterprises. The segments included in the industry grouping are pharmaceuticals, health care, soaps and cosmetics, and chemicals. Again, if only one company is noted under the segment's total, it is both the highest revenue and highest profit enterprise in this field in the world. Again, if a second company is listed, then the first has the highest revenues and the second has the highest profits. The intention is to provide readers with a sense of the size and power of the corporations involved.

Within the framework of human health care, the industry is moving on several fronts. First, it is integrating vertically into 'managed care' companies

Table 10 Future health – the biochemical industry in 2000

Segment and rank	Company	Revenue US$billions	Profit US$billions	Profit as % revenue	Workers	Number of companies
Chemical		*197,566*	*14,470*	*7.8*	*642,012*	*11*
108	BASF	31,438	1,319	4.2	104,628	
123	DuPont	27,892	7,690	27.6	94,000	
Healthcare		*114,298*	*3,861*	*3.4*	*427,737*	*7*
136	Aetna	26,453	717	2.7	55,900	
201	Signa	20,644	1,774	8.6	41,900	
Pharmaceuticals		*245,411*	*36,088*	*14.7*	*866,935*	*14*
100	Merck	32,714	5,891	18.0	62,300	
Rubber/plastics		*46,361*	*1,186*	*2.6*	*340,484*	*3*
240	Bridgestone	18,343	780	4.3	101,489	
Personal care		*49,576*	*4,602*	*9.3*	*152,164*	*2*
75	Procter & Gamble	38,125	3,763	9.9	110,000	
Total		810,697	78,377		2,889,549	37

Source: Fortune Global 500, *Fortune Magazine*, August 2000.

and other services. Secondly, it is expanding its research into ‘well people’s drugs’. Thirdly, it is moving its market scope along the lifeline from the embryo to the grave in an attempt to dominate every stage of human activity.

Generic manipulations

The move into managed care companies should provoke public alarm. Merck, for example, acquired Medco, the largest US prescription drugs provider. Within a year, the number of Medco clients had soared by 14 per cent and the number of Medco’s written prescriptions leapt by 30 per cent. How much of this increase turned into Merck sales is open to speculation.

Pharmaceutical companies are also moving into certain kinds of clinical services associated with their leading patented drugs and technologies. For example, in 1997, Zeneca (now AstraZeneca after its merger with Sweden’s Astra), the world’s second largest manufacturer of cancer drugs, took over the management of 11 cancer treatment centres in the US.[54] Other major drug companies are reported to be following their lead.

Meanwhile, US drug companies and managed care companies have been milking senior citizens in the United States for all they are worth. The prices for the top 50 drugs purchased by the elderly went up an average of 3.9 per cent in 1999 whereas inflation was only at 2.2 per cent.[55] US consumers have seen their annual bill for prescription drugs double since 1995 from an average of less than US$250 per person per year to almost US$500 in 2000 and projections for 2002 of almost US$700.[56] Meanwhile, health management companies, in an effort to cut costs, jettisoned millions of poor pensioners from their programmes in a political move to force the White House to pay them more for the care of senior citizens.

Lifestyle drugs

The second move – into medicines for people who do not need them, who are essentially 'well' – was foretold by the chief executive of Hoffman-La Roche back in the mid-1970s, when he noted that because well people keep working and do not die (easily), they are a more secure market for drug researchers. From this starting point, pharmaceutical firms inevitably directed their attention to *lifestyle* (mood-altering or stress-reducing) drugs; drugs working on diet sometimes linked with diabetes, a much more serious concern; performance-enhancement drugs (making it either easier – or harder – to sleep, for example), including the famous Viagra; and drugs for the demographically mushrooming and financially affluent geriatric population in industrialised countries.

It is not difficult to describe this focus on well people as socially beneficial. Creative marketing turns these products into 'preventative medicine' and makes it possible for drug companies to churn out data predicting major health cost savings down the road. After all, well people remain breadwinners. Keeping them moving means protecting the weaker and (younger or older) family members. Where the research turns to 'nutriceuticals' or 'agriceuticals', such as no-fat cakes or vegi-snacks, it is hard to level criticism. For the first time in 1999, a few farmers grew maize and soybean crops with output traits that could, in theory, enhance the quality of consumer foods. The market for nutriceuticals is almost limitless and medium-term estimates are modestly set at US$29 billion – 10 per cent of today's global pharmaceutical market.

The darker side of drugs for well people hearkens back to the interests in biological warfare and the use of neuroscience to promote HPEs (Human Performance Enhancement). Back to Krishnamurti – those of us marching to drums that are out of beat with a crazy world are stressed and often depressed. The solution is not to drug the person but to change the society. People faced with monotonous or otherwise unhealthy jobs should find relief through improved job conditions – not through mind-numbing (or altering) drugs. In the future, while workers will pay the bills, the real 'customers' for pharmaceutical houses will be their employers – corporations looking for (and insisting upon) drugs that reduce boredom and stress on the one hand and increase memory, vigilance and dexterity on the other. Drugs that keep workers alert and content, that improve their sight or hearing or smell sensitivity (or reduce them), that improve short-term memory are all commercially useful to manufacturers. In some areas, HPEs could be an alternative to expensive on-the-job training. Workers who want to get ahead will feel pressured into taking a regime of medications in order to pass unnaturally high job qualification tests. This approach could allow employers to sidestep the controversies involved with genetic screening since prospective employees will not only volunteer to take – and pay for – HPE medications but offer personal data to company doctors as well.

From cuddle to cadaver

The third area of industry expansion is, in fact, more directly linked to genetic screening and eugenics. In 1999, it was already possible to discern a trail of human genomic patents beginning pre-conception (patents related to human sperm and eggs) through the umbilical cord and T-cell patents to disease-gene patents, DNA diagnostic kits, and gene therapy. A number of companies are already offering expectant parents the 'opportunity' to have T-cells from their unborn foetus cryogenically stored for the life of the offspring. Pharmaceutical firms are preparing to offer parents the possibility that they will assay the major disease and genetic propensities of the soon-to-be-born and offer the family a printout at birth of the child's possible genetic destiny. Based on this, the company will also offer the family the potential for 'designer drugs' to be derived from modifications to the child's stored cell line to be manufactured in yeast, insect bellies, wheat stalks or cow's milk as needed. Further, the company will offer individually tailored nutriceuticals and other 'well people' drugs to support HPEs and help the child 'maximise her or his potential'. This 'cuddle to cadaver' contract will require initial cell line harvest fees, annual storage fees (for the cell line), health maintenance fees (renewable at regular intervals) and special financial arrangements (including 'finder's fees') for designer drugs of both the disease and HPE kind. Beyond these fees and special charges, companies will reserve the right to use the human cell lines in their charge for other research purposes and will obtain the right to patent any discoveries they make. They may also want to retain the cadaver at least for autopsy purposes if not for organs and tissues. And, of course, if parents don't have full confidence that all this will bring their offspring longevity, love and employment, they can always take out an insurance policy with the pharmaceutical subsidiary's parent.

If your doctor is also your insurance agent, the fight for genetic privacy is going to seem a little silly.

Such developments may prove closer at hand than many predict. The Mount Sinai Hospital in Toronto has successfully harvested human eggs from the back muscles of rodents. By 2001, the scientists predict they will be able to offer this egg-storing service to women who risk damaging their ovaries during medical treatment.[57] At the other end of life, an undertaker in Nagoyo, Japan, is offering bereaved stay-behinds a memorial tablet containing the DNA of the departed. For under $300, family members can have tablets that could, the company acknowledges, also be used to clone the deceased or as evidence in court to prove or disprove post-mortem paternity.[58] Advanced Cell Technology, a US biotech concern, working from the recent discovery that adult cells can be made to 'change their occupation' and grow replacement organs, is proposing to insert human DNA in bovine eggs. The human cells will then be harvested from the eggs and directed to grow body parts. In this way, individuals can be given organ transplants that are their own 'clones' and wholly compatible with their immune system.[59] In April of 1999, ten major pharmaceutical companies joined forces to create what *New Scientist* calls 'the era of personalised medicine' by agreeing to cooperate in the study of human genetic variation that could allow the companies to build designer drugs tied to the exact genetic structure of every patient.[60]

The GMO labelling debate may be about to experience a paradigm shift. In the future, it may be the genetic integrity of people that will have to be vouchsafed. It may be the consumers and workers who have to wear the labels not the MMOs (materially modified objects).

How sage is all this? Bear in mind, once again, that the pharmaceutical majors are also agriculture's gene giants – the 'geniuses' that came up with Generation One transgenics. They are also the same companies with the same scientific philosophy and corporate logic that invented the chemicals and plastics industries of the Sixties. Already, 'Generation One' in gene therapy development is in serious trouble. The United States has permitted experimentation with gene therapy on human subjects for seven years. All 'adverse events' are to be reported to a special committee established by the National Institutes of Health (NIH). It took the sudden death of an 18 year old boy late in 1999 to reveal that only 5 per cent of these adverse events (39 of 691 cases) had been reported over the seven years.[61] There is no better evidence that this is an industry that cannot be trusted with our lives.

From ashes to assets? Some human genomics companies now argue that aging and dying are nothing more than a succession of preventable diseases. There is no longer a natural life cycle. If this view takes hold those who can afford it will be with us a long time and the Bible will be proved wrong – the poor will not always be able to be with them!

Will the genetic information in the hands of the company be treated as confidential? Or will employees surrender their rights to employers, accepting corporate rights to a new kind of 'freedom of information'? A family that buys into genetic determinism will likely also submit to employer determinism in the hope of securing careers for their children. This erosion of collective rights and the creation of corporate rights rank among the great trends of our times.

Indeed, this scenario is so commercially and scientifically logical that it is close to inevitable. The only remaining commercial issue is whether or not the corporate kings in this scenario will be the Gene Giants or the insurance companies who might buy them. After all, who stands to gain the most by accurately predicting your life span?

Future information – the silicon industry
From 'content' to 'conduit' integration and control

The ties that bind the food system and the health system are strands of DNA wrapped around technologies that twine between microbes and mammals. The ties that bind the telecommunications and media industries are bands of electrons riding through computer chips, moving down fibre-optic cables and criss-crossing between satellites. Just as *input* and *output* strategies are merging in food and the *well* and the *sick* are coming together in health, *conduit* (communications hardware) and *content* (text, audio, and image software) are merging in the New Information Order.

Sony, the giant Japanese electronics company, is a case in point. As *The Economist* said, 'there might be synergy between making television sets and making the pictures they show'. On this assumption, Sony has broken into the media market by buying up TV stations, networks and production facilities in all the major markets of Asia, Latin America and now Europe. To the delight of UNESCO and other media positivists (but prematurely expressed), Sony seems, at least initially, to be carving out a niche for itself in the non-English market. In 1999, for example, it produced 4,000 hours of non-English regional programmes compared to only 1,700 hours of English programmes throughout its television enterprises. Although Sony still does not rank among the world's biggest information players, it is one of the industry's most watched innovators. It has 24 channels in 62 countries and is now rivalling India's most popular commercial TV network. The company also has music (number three in the world), film production and movie distribution subsidiaries in India and in Latin America.[62]

From the 'content' side: US cross-platform mergers

This kind of synergism should be something less than a revelation for electronics and telecommunications companies. Eighty years ago, Westinghouse, a pioneer in the then young electronics industry, joined with AT&T, an up-and-comer in telephones, and United Fruit, to form RCA which, in turn, launched ABC – the first US broadcasting network. Seven years later, RCA also formed the USA's second broadcasting giant, NBC – only to have the Justice Department force it to divest both networks in 1932. Not to be held back, ABC forged one of modern media's first cross-platform mergers in 1953 with Paramount Pictures. However, during the more permissive (indeed promiscuous) Reagan era, General Electric, Westinghouse's old electronics rival, bought RCA and soldiered on to buy NBC a year later. So much for anti-combines control. Not to be outdone, Westinghouse bought CBS (the only US TV network it had never owned) in 1995. That same year, Disney bought Capital Cities and then took over the much-bandied ABC network. That left only the fate of media maverick CNN to be determined. What was then considered to be a huge cross-platform merger took place in 1998 when Time Life (with most of America's leading magazines including *Time* and

Life and several book publishers) swallowed up Warner Brothers (film studios and cinema distribution companies) to create Time Warner. In 1996, the media monolith added Turner Broadcasting and the whole CNN cable empire to its domains.[63] That seemed to be about as big as anything could get – until Time Warner itself was seduced by a still larger deal in 2000. Stay tuned.

In March 1999, the company that started it all, Westinghouse, sold off its extensive nuclear power and defence businesses and decided to devote itself fully to media and communications. In doing so, it dropped the name it began with in 1896 and opted for the name it created in 1919, CBS. The moniker was not destined to last much longer. In September 1999, Viacom, an anti-Trust spin-off from the 1970s, re-united with the new CBS in a merger worth approximately US$36 billion. The move created a sprawling new information giant.

If 1999 was a breathtaking year for media mergers, the early days of 2000 set a new standard for media concentration. On 10 January, Time Warner announced that it had agreed to merge with a company that is still too young to drive. With a price tag of US$156 billion – then the largest merger in world history – America Online, born in 1985 as an Internet e-commerce glamour child, swallowed up Time Warner, born in 1923. The announcement ignited a stunning new round of information industry mergers.

AOL Time Warner (as the media monstrosity is to be known), General Electric, Viacom and Disney all rank today among the world's ten most powerful information enterprises. They have *content* running from newspapers, magazines and books to radio, television and cinema. They have *conduit* systems ranging from cables to satellites to the Internet. They are in control.

Ranked high among other important players coming from the content side (aside from the irrepressible Sony) is News Corp – Rupert Murdock's empire – including the intercontinental Fox network with its Star (in Asia), Sky (in Latin America), and BskyB (in Europe) satellites. There is also Bertelsmann AG in Germany, now the world's biggest English language book publisher and one of the four Titans of music. These companies are joined by a number of new and not-so-new conduit rivals. Chief among them: Microsoft, AT&T, Vodaphone, and other Internet miracle workers like Yahoo. Table 11 summarises the positions held by the major media moguls.

Theatre of the acquired

The pressure to cross information platforms is tremendous. In 1996, it was not only the major US TV/radio networks that were on the block. Trans-

Historic Cues: You Say 'Banana', I Say 'Binano'

At that time we had a treaty with about every foreign country except Belgium and that banana republic, Anchuria.

O. Henry, *Cabbages and Kings* (c.1899)

It was about one hundred years ago (somewhere after 1896 but before 1904) that William Sydney Porter ('O. Henry'), the famed writer and infamous embezzler, coined the phrase, 'Banana Republic' when writing about life in Honduras. He described the country as a government created by the United Fruit Company whose sole purpose it was to maintain a comfortable corporate environment for banana exports. It was the United Fruit Company that joined with Westinghouse and AT&T to create the world's first electronic media empire. What O. Henry said of Honduras and United Fruit a century ago he might now be tempted to say about all countries in the new Binano Republic just around the corner.

actions in the whole US media/telecommunications business tallied just under US$140 billion. In 1997 there were 24 US mergers worth more than a billion dollars each. Among the biggest deals in 1997 was Westinghouse's (now Viacom's) purchase of American Radio Systems for US$2.6 billion.[64] Viacom, in fact, went on a rampage and now owns Paramount Pictures, Blockbuster Video and cable networks including MTV, ShowTime and Nickelodeon.[65]

What is happening on television screens has already taken place in movie theatres. In 1998, it was estimated that five companies controlled 40 per cent of the world's cinema screens. In total, the value of all mergers in radio and television in 1999 was US$245 billion.[66] Film industry mergers alone, in the first half of 2000, fell just a hair short of US$200 million.[67]

Not much music

The huge AOL Time Warner merger almost succeeded in obscuring another pairing that took place in January 2000. Warner Music and EMI's record divisions were united under the AOL Time Warner banner to take command of 27.5 per cent of the global record industry. The move brought control of the record industry down to four companies controlling almost 78 per cent of the market. Most recently, Vivendi of France (once a hydro utility) acquired all of Seagrams' entertainment businesses (Universal Studios including films, TV and music) making it one of the top four. Then there's Sony and Bertelsmann (BMG). The other three may all be looking for new acquisitions in order to counter Warner Music's distribution potential on the Internet.[68] Chart 9 shows how the musical pie is sliced today.

How can you march to a different drummer if all the drummers have been signed by Warner Music?

Table 11 Empires of the mind

Segment	AOL Time Warner	Disney	Viacom	General Electric	Sony	News Corp.
1998 revenue (US$ billion)*	15	23	13	112	53	13
Global Fortune 500 rank	282	150	374	9	31	333
News	CNN	WTN	Reuters	Reuters	•	Reuters
Network	CNN	ABC	CBS	NBC	Telemundo	Fox
TV	•	•	•	•	•	•
Radio	•	•	•	•	•	•
Cable	CNN	•	•	•	•	•
Internet	AOL	ESPN/GO	MTV	•	Listen	The Street
Films	Warner Bros	•	Paramount		•	•
Theatres	•		•		•	•
Video	•		Blockbuster		•	•
Newspapers	•	•				•
Magazines	Time					
Books	Time-Life	•	•			
Music	Warner/EMI	•	•		Sony	
Sports/Other	•	•	•			

* Fortune Rank and Revenues, in each case, are significantly out of date and underestimated due to merger activity during 1999–2000.
Note: Company or brand names have been given only as examples.
Sources: Numerous sources including 'How AOL Time Warner deal may affect other players', *Wall Street Journal*, 11 January 2000, p. B12.

News with a jingle?

If concentration is rampant on the entertainment side of information, the oligopoly appears close to complete in electronic news. Not surprisingly, almost exactly the same firms that dominate entertainment also dominate the news we all watch on television, listen to on the radio, or read in newspapers and magazines. The only surprise is that news is controlled more from London than from Hollywood – and that the ruling enterprises don't seem fully aware of their own, newfound powers. 'Disney', according to Christopher Paterson, a US media analyst, 'has yet to discover that it owns the second largest provider of international television news.'

The world's news is determined by a handful of media wholesalers and retailers. The largest wholesaler, Reuters, has 70 news bureaus with 260 client broadcasters in 85 countries. In 1992, Reuters merged its press agency with Visnews and some British news services and now provides the majority of international news footage for both NBC and CBS in the USA and ITN and

News Corp's Fox network. Disney's ABC gets most of its international news from its partly-owned subsidiary, WTN (Worldwide Television News – the 1985 union of UPI and old newsreel companies in Europe and North America). The world's third most important wholesaler was created by Associated Press in 1994: APTV, which services much of the BBC's global media needs. Beyond this, AOL Time Warner's CNN provides most of its own wholesale services. Most European news retailers receive their international images through Eurovision, which in turn, depends heavily on (partly Disney's) WTN.

International news coverage in the non-English world is no less tightly controlled. Germany's VOX network, for example, is owned by News Corp and receives its international images from Reuters, as does its German competitor, N-TV owned by AOL Time Warner. TF and Canal One in France have a news link with ABC (Disney) and obtain their international news images from Reuters.[69]

The control the big news agencies exercise over the South is particularly disturbing given the strenuous efforts undertaken in the 1980s to establish pro-South news agencies. A study by Mohammed Musa in 1997 revealed that NAN, the News Agency of Nigeria, obtained more than 37 per cent of its foreign news through APU, UPI and Reuters with Reuters commanding a third of all international news stories itself. Reuters also accounted for 90 per cent of foreign news stories distributed by the Caribbean News Agency (CANA).[70] The top media enterprise in Asia is News Corp.,[71] while there is a general consensus that Sony dominates television screens in Latin America. This is not pluralism.

Private pluralism

As grating as anything else is that the mass homogenisation and global monopolisation of the tools of information are taking place under the banner of media *pluralism* and information democratisation. Under the pressure of globalisation and privatisation, the companies now merging across national boundaries were, until the 1990s (in most cases), either state-funded or -managed telephone, radio or TV networks. The net effect of this trade liberalisation has been the cheap takeover of nationally oriented and culturally sensitive media to multinational multimedia monoliths. Where there were once dozens of (remarkably independent) public broadcast media sources in Western Europe, for example, we are moving toward a handful of private global enterprises. This is a far cry from pluralism, the New World Information and Communications Order of the early 1980s, or even UNESCO's muted New Communications Strategy of more recent years.[72]

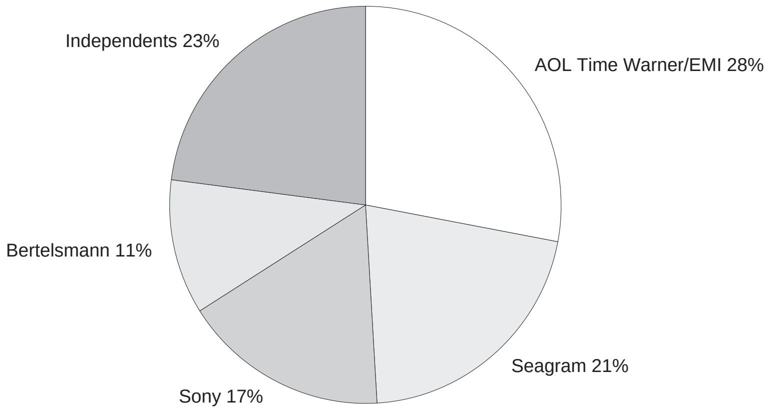

Chart 9 The global music market

Source: 'The record industri takes fright', *The Economist*, 30 January 2000.

From the 'conduit' side

Telecommunications

As momentous as the transformation has been on the *content* side, most of the merger pressure has actually come from the *conduit* side of the information industry. Since 1996, the global industry has experienced more than one trillion dollars in mergers with more than half of that sum (US$569 billion) in 1999 alone. The telephone (fixed and mobile) and satellite hardware companies – along with software giants such as Microsoft – have been building bridges to one another and to the *content* companies. In 1999, AT&T bought MediaOne[73] for US$68 billion and went on to scoop up Telecommunications Inc. for another US$37 billion. Then Seagram (Canada) bought Polygram from Philips Electronics for US$10.4 billion.[74] Added to Seagram's Universal Music Group, the merger made the once-back alley bootlegger – briefly – into a titan of Tinpan Alley. Then Vivendi bought Seagram's entertainment businesses in mid-2000 en route to becoming a very powerful new media giant after decades as one of France's least glamorous water utility companies.[75] British Telecom failed in its bid to buy MCI in the USA, but Britain's Vodaphone did buy AirTouch in a US$62 billion deal.[76] Hardly pausing to inhale, Vodaphone AirTouch then went on, in the early days of 2000, to take over Mannesmann of Germany to form the world's largest telecommunications enterprise with the world's largest merger ever (US$182 billion).

The Vodaphone and AT&T acquisitions eclipsed other recent deals such as those engineered in 1999 by Global Crossing, a Bermuda-based telecom sporting the world's only (for the moment) undersea fibre-optics cable across the Atlantic. Global Crossing made a US$11.2 billion bid for long-distance phone operator Frontier and then another US$800 million bid for the undersea cable business of Britain's venerable Cable & Wireless. In May, US West (a 'Baby Bell' based in Denver) agreed to merge with Global Crossing under the Bermuda firm's name.[77] A month later, Qwest Communications made a bid for the whole operation.[78] Also in the spring of 1999, Deutsche Telekom (Germany's largest phone company) and Telecom Italia (its counterpart in Italy) agreed to merge. Deutsche Telekom is in a joint venture called Global One with France Telecom and Sprint. Global One is managing telephone companies in Italy and Eastern Europe. Global One is also in competition with AT&T and British Telecom, which together bought 15 per cent of Japan Telecom and also have global aspirations.[79] Third only in the ranks of world mergers to the phenomenal Vodaphone deals and the union of AOL and Time Warner was the 1999 mega-merger of Sprint and MCI Worldcom – for an estimated US$126 billion. The spin-offs, ramifications and copycat acquisitions from these corporate couplings will dominate telecommunications for some years to come.

At the end of 1999 and in the early days of 2000, it was impossible to track the real and potential mergers in this industry. Not a day went by without news stories of major takeovers or acquisitions. Then too, there was a possibility that regulatory authorities might forbid some of these trusts. In November, Microsoft appeared to be on the verge of break-up ('Baby Bills' as the *Wall Street Journal* put it) when a US court accused it of monopoly. The bottom line is that massive change is underway.

Monopolising medium and message

Why is all this happening? Because we (those of us in the rich part of the world) are moving at breakneck speed toward single-screen communications. Soon, newspapers will neither be printed nor delivered. They will appear on a wireless wafer-thin screen that can be carried, folded, and read on buses. Similarly, books and magazines will be downloaded off the Internet and read wherever you would like to read them. Music, including the latest releases, movies, TV sitcoms, and the local weather will also be accessible through the single screen (perhaps attached to the home stereo or a yet bigger family-viewing screen). There will be no 'hard' production, distribution or retailing costs for the intellectual property holder. Consumers will pay per track or per view or by subscription. Telephone (and teleview) e-mail and computer/Internet functions will also be conducted via the single screen along with a vast array of e-commerce including banking and bill-paying. This is not 'pie in the sky'. This is in the immediate future and the information industry is scrambling for control of the screen.

There are some very large financial and political forces at work here. By 1995 – and the consolidation pace has much quickened since then – the top 20 information/communications enterprises had annual revenues greater than the GDP of the UK (US$1 trillion).[80] In the real commercial world we can no longer segment the constellation of new technologies that create and convey information. An obvious synergy is emerging between those enterprises that produce semi-conductors (or ‘chips’), develop software, launch satellites, lay fibre-optic cable, and establish mobile phone towers, and those who create multimedia entertainment or claim to report the news. ‘The medium is the message.’ Within a very few years, middle-class consumers in industrialised countries will receive all their information and entertainment – and conduct their own communications – through a single unified system. That system will be controlled by an oligopoly.

The convergence is clear to all. Total mergers in the telecommunications segment of information stood at about US$6.8 billion when the RAFI board first contemplated ‘ETC’ in 1988. In 1998, industry mergers totalled almost US$266 billion. In 1988, mergers within the computer segment tallied an impressive US$21.4 billion. In 1998, the segment ‘maxed out’ at nearly US$247 billion.[81] This trend will continue until there is one tightly knit information industry. As this document was being prepared for publication, Deutches Telekom made an offer to buy Qwest and there were rumours that Microsoft and AT&T could merge. Following the AOL Time Warner model, there were also rumours that Disney might seek a union with Yahoo! Or another major Internet portal.

None of this is actually ‘news’. The scientific and popular press is full of stories about the unification of new communications technologies. The financial press is rife with information about industry mergers. As noted earlier, Telecom and other communications equipment companies chalked up almost US$300 billion in mergers in the first six months of 2000.[82] Yet there is almost no information about how the technologies and the corporations (the ‘T’ and the ‘C’) relate to one another or our fast-eroding (the ‘E’) democracy.

Future matter – the macromaterials industry
From ‘matter’ to ‘no matter’

In 1972, the Club of Rome issued *The Limits to Growth*, a landmark (computer-aided!) assessment of the world’s finite raw materials supply. According to this report, unless immediate steps were taken (by 1975, the Club predicted), the combined implications of population increase, environmental degradation, food shortages, and the disappearance of non-renewable energy and metal resources would lead to collapse. A quarter-century after the deadline date, the world is a long way from taking the kinds of policy steps commanded by the Club of Rome. Our exact relationship to renewable and non-renewable resources seems also to be muddled. While RAFI – and many other CSOs – still hold the basic tenants of the Club's analysis to be true, if nanotechnology is commercialised successfully, Armageddon may have to be put on the back burner.

If this is good news for the planet's GDP over-achievers, it could be bad news for energy and mining companies unless they take control of the new technologies themselves. Nanotech could bring down the curtain on thousands of years of digging holes in the earth and the terrible risks taken by generations of miners to bring us metals and precious stones. Whether this spells an end to the mining companies or puts them in the driver's seat in the new economy depends on the companies' agility and energy.

One reason that the collapses predicted by the Club have been detained, is that for three decades now, research in materials science and biomimetics has radically altered the world's demand for basic metals. Materials science has created a demand for specialty metals unheard of prior to Sputnik and jet aircraft. The mining industry, perhaps sluggishly, has adapted. Where once there were gold companies, tin companies, nickel companies and iron ore companies, now there is a single non-fuel (other than coal, uranium, oil and gas) 'raw materials' sector. This has led to the kind of corporate concentration we have witnessed in seeds and chemicals. Today, the top ten raw materials companies account for almost one-third of the global non-fuels mining industry. In 1998, the industry experienced US$25 billion in mergers and acquisitions and the predictions of further mergers are universal. In August 1999, in fact, Canada's leading aluminum manufacturer, Alcan, proposed a merger with its leading European competitors and Alcoa (USA) responded with another merger offer for Reynolds Aluminum. If both combinations are allowed, the top five aluminum enterprises will collapse into two. There is little doubt that the pace of mergers has been powered by the all-consuming enthusiasm for 'globalisation'. Yet industry observers also cite the pressure to devote large sums to research. An industry totally unused to high levels of research spending is finding itself forced to invest heavily now to meet environmental standards, to benefit from the cost-cutting opportunities of bioremediation (ore purification) and to conjure the new alloys demanded by aerospace and microelectronics industries.

Marriages have also come to the fabled Seven Sisters of petroleum. Only four remain and the missing three have moved in with their stronger sisters. As always, more change is predicted.

Table 12 Nano-nabobs and nano-nichers. Examples of leading institutions involved in patenting nano-related technologies.

Enterprise	Area	Country
3M	Materials	USA
Alcoa	Materials	USA
BASF	Life	Germany
Bayer	Life	Germany
Boeing	Transportation	USA
Exxon	Energy	USA
Harvard	University	USA
Hitachi	Informatics	Japan
IBM	Informatics	USA
Matsushita	Materials	Japan
Michigan Tech	University	USA
MIT	University	USA
NanoCram	Nicher	USA
NanoFrance	Nicher	France
Nanogen	Nicher	USA
Nanomaterials	Nicher	USA
NanoTech	Nicher	USA
Nanoway Oy	Nicher	Finland
Pennsylvania State	University	USA
Rice University	University	USA
Rutgers	University	USA
Texas Instruments	Informatics	USA
Toshiba	Informatics	Japan
Toyota	Transportation	Japan
University of Calif., (Oakland)	University	USA
US Navy	Military	USA
Xerox	Informatics	USA

Source: RAFI material drawn from numerous industry sources.

The battleline is drawn between the raw materials suppliers (*input* enterprises once again) and the consumer product (*output*) providers. Will it be General Electric, General Motors, Exxon, or Anglo-American? Table 12 describes the leading groups involved in patenting nano-related technologies. The *nano-nabobs* come from every corner of industry. The outcome is impossible to predict at this time.

Who wins and who loses in the corporate world is largely irrelevant to anyone but stockholders. The fate of the world's mines, miners, and the countries that depend upon them, is another matter. From Jamaica's bauxite to

Table 13 On the eve of nanotech: Global Top Ten (non-fuel) industrial raw materials suppliers

Enterprise	Country	Percentage of global supplies
Anglo American Corp	South Africa	8.03
Rio Tinto	UK	5.53
Broken Hill	Australia	4.27
Cia Vale do Rio Doce	Brazil	3.27
Codelco and Enami	Chile	2.50
Phelps Dodge	USA	1.59
Noranda	Canada	1.57
Freeport McMoran	USA	1.54
Asarco	USA	1.40
Cyprus Amex	USA	1.31
Total		31.01

Source: Who Owns Whom in Mining, 1998.

Peru's copper, Bolivia's tin and Indonesia's nickel, millions of people depend upon the unearthing of non-renewable raw materials for their survival. Table 13 identifies the leading traditional mining companies in 1998.

We have so long lived by the assumptions of The Limits to Growth, *it is hard to contemplate alternative possibilities. If nanotech does work, we might console ourselves with the knowledge that we were not really wrong all this time, it is just that* The Limits to Growth *have been postponed a few billion years!*

A gradual change is manageable. A sudden change spells ruin. Table 14, taken from the original *Limits to Growth* study, does a better job of identifying the limits to survival of the countries that may lose out if the new technologies succeed than it does of describing the limits to non-renewable resources.

The future *Binano* Republic

When 'bio' and 'nano' converge

It is possible that future generations will look upon the 19th and 20th centuries – or that brief period circumscribed by the uprisings of the post-Napoleonic era and the rise of 'globalism' in the final quarter of the 20th century (a remarkable period of experimentation in popular democracy) as little more than a class 'adjustment' as power transited from the landed gentry to industrial baronies. After all, democracy has been the exception among sedentary societies, not the rule.

The crowd of new technologies clearly discernible on the horizon takes us well beyond monopolisation of the food and health systems to control of a new global society. This control comes in three forms.

Table 14 The limits to growth or the limits to survival?

Resource	Countries or areas with highest reserves	Percentage of world total	Resource	Countries or areas with highest reserves	Percentage of world total
Aluminum	Australia	33	Molybdenum	USA	58
	Guinea	20		FSU	20
	Jamaica	10	Natural gas	USA	25
Chromium	South Africa	75		FSU	13
Coal	USA	32	Nickel	Cuba	25
	FSU-China	53		New Caledonia	22
Cobalt	China	31		FSU	14
	Zambia	16		Canada	14
Copper	USA	28	Petroleum	Saudi Arabia	17
	Chile	19		Kuwait	15
Gold	South Africa	40	Platinum	South Africa	47
Iron	FSU-China	33		FSU	47
	Latin-America	18	Silver	FSU	36
	Canada	14		USA	24
Lead	USA	39	Tin	Thailand	33
Manganese	South Africa	38		Malaysia	14
	FSU*	25	Tungsten	China	73
Mercury	Spain	30	Zinc	USA	27
	Italy	21		Canada	20

* FSU – Former Soviet Union
Source: Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, William W. Behrens III, *The Limits to Growth*, Universe Books, New York, 1972.

First, informatics technologies enhanced by robotics, sensors, aerospace technologies, and the miniaturisation of these technologies through nanotech, make it feasible to monitor and control dissent and to impose a police state.

Second, biotechnology in conjunction with work in the neurosciences is making it feasible to control human behaviour. The so-called HPEs that can either increase or decrease human responses and brain functions – and the medical manipulation of employees – could become a 'voluntary' prerequisite for employment – and survival – in the new world that awaits us.

Third, the coming merger of the 'micros' – microbiology and nanotechnology – proposes an unprecedented and uncertain transformation in the agents of production. The future 'bionic' world will have hybrids of living and non-living materials woven together. Because the same biotechnologies now link crop production to human and animal health care, we are witnessing the merger of the Life Industry segments into a powerful oligopoly. For the same reasons, we may see the merger of the Life Industry with traditional manufacturing industries. The result will be a world wherein the systems of production and distribution can be dominated by a still more powerful oligopoly. In such a world, 'state' institutions – perceived democratic institutions – once again return to being servants of the oligopoly. Government exists to maintain the veneer of democracy while collecting taxes to maintain a rudimentary social safety net (to prevent unacceptable levels of commercial disruption) and to enforce the wishes of the oligopoly via a police force. Robert Kaplan of the *Atlantic Monthly* talks about the 'democratic moment', arguing that the world will see the rise of hybrid states – states with the trappings of democracy in the service of military or corporate elites. Kaplan assumes that these states would become more common in the South – and in the former Soviet Union.[83] Given the ETC factors, the trend is as likely to be repeated in the OECD countries as in the South.

Nanotechnology will lend itself to more subtle uses than do nuclear weapons. A bomb can only blast things, but nanomachines could be used to infiltrate, seize, change, and govern [underlining not in original] *territory. Even the most ruthless police have no use for nuclear weapons, but they do have use for bugs, drugs, assassins, and other flexible engines.*
C. Shipbaugh, 1991 (as cited by SAIC)

Great Galloping Oligopolies GATTman!

Which oligopoly will win the race to dominate the Atomic Economy? Perhaps there are too many variables to allow intelligent prediction. If the Fortune Global 500 corporations list is used as a guidepost, the finance (banking and insurance) sector looms most powerful with 1999 revenues of US$3.2 trillion (the total Fortune Global 500 had revenues of US$12.7 trillion). The banking/insurance group also had combined profits of just over US$201 billion – or 6.2 per cent of revenues. (More to the point, the financial sector, in 1999, claimed about a quarter of the 500's revenues and almost 40 per cent of its profits!) The financial sector has the cash and its insurance segment may well have the incentive. That the conventional anti-combines/competition watchdogs would allow the industry to move in this direction would seem unlikely – under normal circumstances. However, these days, such a powerful force could ultimately overcome any regulatory authority. Nevertheless, the problem might leave finance slow off the starting block and incapable, as well, of matching the scientific acumen of some other groups.

If the determinant for victory is profitability (as a percentage of revenues), the informatics (silicon-based) industry is slightly ahead of finance at 6.4 per cent. The group's revenues, however, are lower. Informatics (including computers, telecommunications and entertainment) had a little less than US$2 trillion in revenue and US$126 billion in profits. Unlike finance, this is a technology-driven group that invests heavily in – and understands – science and research.

The food and agriculture sector (biomaterials – including food and forest products from production to retail) is sixth in revenues, with returns of more than US$1 trillion but with profits a small fraction of finance or informatics – just US$44 billion. Profits are a lowly 4.1 per cent of revenues. Biochemicals (health and chemicals – agriculture's 'sister' industry) fares better. The sector includes pharmaceuticals, personal care products, managed care enterprises, and industrial chemicals. With revenues at only US$653 billion, the sector manages US$60 billion in profits – or 9.2 per cent of revenues – the highest of any sector. Together, however, the two *bio*-based industrial sectors exercise significantly greater clout. And together they are becoming!

It is not Multinational Corporations we need to worry about in the future, it is Multisector Corporations. If the super-technologies command the entire stage and Multisector Corporations direct the script, how will narrowly defined 'development' or 'environment' or 'health' or 'agriculture' CSO's maintain perspective? If someone is not watching the whole performance, CSO programmes and policies will always be miscued and potentially counter-productive.

Nanotechnology and its associates could adversely affect three other industry sectors if they don't make a bid to control the technologies for themselves. The transportation, macromaterial (including mining, construction and heavy industry), and combustion (energy) sectors tend to have lower profit ratios (thus less flexible finances), but at least, transportation and combustion are comfortable with high-tech research. In the end, the only sector that is possibly out of the running is the catering/service category of miscellaneous wholesale and retail or service enterprises not associated directly with the other sectors.

Even this is not certain. Convergences taking place on the production side could suggest the devolution of the marketplace to one big manufacturer and one big retailer. At that point, of course, the logic of *their* union would be unstoppable. Much depends upon the extent to which – and the speed with which – nanotechnology occupies manufacturing. There is no need for Wal-Mart if there is no need for walls. On the other hand, Wal-Mart is already merging groceries, consumer goods, drugs and retail financial services within its 'Super-Centres' and, with US$156 billion in retail sales in 1999, Wal-Mart already controls an astonishing 5 per cent of the total US$3 trillion US retail market. Is Wal-Mart passé – or the wave of the future? If nanotech eases into consumer goods gradually, then the companies closest to the consumer, the retailers, are the most likely to benefit. If nanotech leaps into control in the hands of its inventors, then physically sited retailers will lose out to e-commerce on the Internet.

A superficial examination of the Fortune Global 500 is far from a study of the major innovative forces in the global economy. At best it suggests 'weights' that might be given to some configurations of financial power. The

Table 15 Elementary industry – 1999

Industry	Revenue in US$	Profits in US$	Percentage of R/P	Assets in US$	Employees
Macromaterial	586,906.3	5,934.0	1.0	844,704.5	2,735,339
Biochemistry	653,212.7	60,206.7	9.2	919,688.8	2,429,332
Biomaterial	1,075,693.5	44,371.7	4.1	796,737.2	5,535,907
Combustion	1,418,047.5	65,605.6	4.6	2,248,172.0	4,590,313
Transport	1,855,611.5	45,265.2	2.4	2,499,091.4	8,427,664
Cater/service	1,877,019.7	5,477.3	0.3	1,063,338.2	4,838,259
Silicon	1,985,310.3	126,133.0	6.4	3,086,547.7	8,428,540
Finance	3,244,149.7	201,017.7	6.2	32,544,491.3	6,970,634
Total	12,695,951.2	554.011.2	4.4	44,002,771.1	43,955,988

Source: Fortune Global 500, *Fortune Magazine*, 1999.

numbers of enterprises in each sector in the. Fortune Global 500 ranges from a low of 84 in transportation to almost double that in the general sector. Nevertheless, the Fortune 500 indicates the major actors in the world economy and suggests the economic power these actors could wield to gain dominance over a technology-transformed society.

Our un*Common Future*

For many CSOs working for the advancement of farmer-led food security, technology takes them into fields they never anticipated. Twenty years ago, RAFI released *Seeds of the Earth* – the first political analysis of the genetics supply industry and life-patenting regimes. No one was aware of – or had even named – biotechnology at that time and no one anticipated the world we face today. Today we are beyond the point where we can tackle either crisis or technologies in single file. We are beyond the point where we can isolate special sectors like agriculture from pharmaceuticals from security. While we have always understood the theoretical links (and, of course, the interconnections are ever apparent in rural cultures), those linkages are now being made universal. Civil society organisations need to take stock and begin thinking in new ways along new time lines. We are on the eve of the new global and corporate Binano Republic.

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ETC: Searching for Solutions in the New Era

From *Binano* to Plato?

To escape the endless profusion, fragmentation and complication of modern science and recover the element of simplicity, we must always ask ourselves: what approach would Plato have taken to a nature which is both simple in essence and manifold in appearance?

Goethe[1]

Democracy passes into despotism.

Plato, *The Republic*, Book VIII

Cue – The 'heroes' are missing their lines

- *Five decades ago, NGOs were most concerned about famine and disaster relief. Few were involved in what later became known as 'development' and fewer still had ever heard of the environment.*
- *Four decades ago, the buzz word was 'development' and the focus was on agriculture, health and education.*
- *Three decades ago, since 'development' was not making much progress, NGOs expanded their horizons to include trade and political change.*
- *Two decades ago, NGOs discovered the 'environment' and 'gender' and some began to make the links between development, the environment and political inclusion.*
- *One decade ago, CSOs became aware of 'globalisation' and started to move beyond issue ambulance-chasing in search of a more comprehensive agenda.*
- *Today, we still have a long way to go, institutionally, programmatically and intellectually, before we are prepared to successfully take on the challenges of the ETC Century.*

Early drafts of this document were submitted to two quite different meetings in the first few weeks of 1999. The first, in Cuernavaca, Mexico, convened for the Global Forum on Agriculture by IATP (Institute for Agriculture and Trade Policy), brought together agricultural activists from around the world. Its primary focus was agricultural biotechnology and concentration in agribusiness. The second meeting was held in Luleå, Sweden, organised, among others, by the Dag Hammarskjöld Foundation, and brought together people of different viewpoints to discuss the wider implications of all forms of biotechnology. In both cases, the paper seemed to stimulate more shock and depression than energy or action. In early April 2000, I had the opportunity to present a more extensive draft to a group of concerned academics and CSOs at the Dag Hammarskjöld Centre in Uppsala, Sweden. A final airing of the almost-finished text was shared with about 25 biotech activists from all corners of the globe who came together in the almost pristine wilderness of

Blue Mountain in upstate New York in the first half of October. Again, the paper seemed to do for CSOs what the Terminator does for seeds – encourage suicide.

This is not my intent. Neither am I without optimism. Up to this point, I am only suggesting what will happen if civil society does not respond – and respond quickly. Although I will summarise here rather briefly, I believe that actions can be taken on several fronts.

Erosion

The erosion of cultural rights and freedoms must be forcefully connected to the erosion of the ecosystem and the general decline in human rights in national and international fora. Of course, this is easier said than done, but there is already notable momentum in this direction. In the Human Rights Commission's excellent work on the right to food and its continuing work on the rights of indigenous peoples, there is ample room to link to the Universal Declaration and begin to build operational and organisational models that can both safeguard the environment and the people who live here. FAO's pioneering work on farmers' rights and UNESCO's important work on cultural rights are part of this. Most significantly, UNDP's Human Development Report 2000, *Human Rights and Human Development*, opens the door to a much fuller discussion of the links between erosions and human rights than ever before.

Old-line environmental organisations have failed to recognise the connection between indigenous knowledge and ecosystem survival; between equity and erosion. They should either close shop or help to transform their organisations into a new diversity movement that can integrate equity and erosion with human rights.

The central task here is to weave the issues of rights and erosion together. However, it is also urgent and necessary to extend this to an examination of the conventions or protocols that could help to safeguard dissent and discipline the introduction of untested technologies.

Among the steps that could be taken immediately:

- CSOs and multilateral and bilateral agencies should evaluate their literacy programmes to ensure that they are contributing to the conservation and advancement of indigenous and local knowledge and not inadvertently destroying that knowledge.
- UN agencies such as UNESCO, UNDP, WHO and FAO should undertake an evaluation of their own genetic and eco-system conservation programmes to ensure that the role of indigenous and traditional knowledge is fully recognised, respected and protected.
- CGIAR, botanical gardens associations, and academic societies involved

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Proposal for a United Nations
Human Rights/Erosion Inventory

Rationale: Intergovernmental initiatives related to the ecosystem – the UNCED platforms for biodiversity, forestry, desertification and climate change – make very limited connections to cultural erosion and fewer still to the destruction of equitable relationships. Other intergovernmental work in support of cultural diversity – by UNESCO and ILO, for example – possibly underplay the linkages to environmental erosion. There is a need for an inventory of what is being done to integrate the rights and erosion concerns within the UN system and to develop capacity to integrate these elements into a shared programme of work among UN agencies and at the national level.

Elements of the inventory: The inventory should highlight and identify instances of simultaneous environmental and cultural erosion of vulnerable groups (those generally most abused in human rights terms). Based on these findings, the inventory should examine commitments already made within the UN framework. Examples of areas of inventory in relation to various forms of erosion would be:

- The status of Indigenous Peoples at the conclusion of their decade of focus.
- The status of Farmers' Rights and the Right to Food since UNCED and the World Food Summit.
- The role of women since the first major UN Conference on Women.
- The intergovernmental mechanisms used and needed to conserve and integrate these elements.

Political process: This initiative could be launched through the Office of the UN High Commissioner for Human Rights as a contribution to the UNCED+10 Conference scheduled for 2002 in South Africa.

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in the conservation and enhancement of biological resources should act to ensure that they integrate the role of indigenous knowledge in their activities in a way that is respectful and does not pirate that knowledge.
- Communities and countries should give consideration to the criminalisation of cultural piracy and biopiracy (including human genetic material and local knowledge) through community, country and international legislation.
- Professional bodies representing agronomists, plant breeders, doctors, anthropologists, ethno-botanists, etc. should review and update their ethical codes in order to take into account the need to conserve and enhance diversity in all its manifestations.
- Environmental CSOs and government agencies should review their priorities to ensure that they tackle environmental erosion also from a human rights and social justice perspective and pay due attention to the disproportional burden of environmental destruction on marginalised groups.
- CSOs and consumers should demand equitable environmental and social justice labelling of consumer products, but avoid 'monopoly trademarking' that further marginalise poor farmers.
- A United Nations Human Rights/Erosion Inventory should be set up to monitor and ensure that the human rights agenda is integrated with programmes and activities concerned with cultural and environmental erosion (see above).

The configuration of CSOs that could, if they chose, give leadership here are obviously indigenous peoples' and farmers' organisations. The women's movement and the environmental movement should also play important roles.

Technology

Those of us who have fought through the history of biotechnology have, along with many other things, learned to address, politically, the complexity of a fast-evolving science. This is an important lesson. It should allow us to formulate the legislative, regulatory and social framework necessary to guide the assessment – and (where appropriate) the introduction – of new technologies. As we contemplate nanotechnology and its near relations, we should be in an early position to postulate the following:

- Negotiators finalising revisions to the Biological and Toxin Weapons Convention should take full account of the dangers of state-based agro-terrorism and ethno-bombs and accept the proposals made for monitoring by such groups as the British Medical Association and the excellent academics at the University of Norwich.
- The same negotiators should also condemn Terminator technology as an example of biological warfare.
- In keeping with concerns expressed by the Sunshine Project, the USA's experimentation with (and possible use of) agro-terrorism with respect to narcotics crops should be condemned by governments in all appropriate intergovernmental fora.
- The Convention on Biological Diversity and the FAO Conference should both 'drop the other shoe' and call for a complete ban on Terminator technology.
- Governments should impose a moratorium on the development of self-replicating nano-machinery unless and until intergovernmental agreements can be adopted that set standards and guarantee the safety of nanotechnologies.
- The regulations and resources necessary to ensure genuine social understanding and informed discourse on the appropriate social goals for, and possible introduction of, a new technology must be established nationally and internationally.
- Impact assessments of the possible 'erosion' (environmental, ethical, cultural, other human rights) must be made and discussed before any new technology can be introduced.
- The appropriate benchmark studies and monitoring instruments required to track and control the proposed introduction of a new technology must be in place.

ICENT
Proposal for an
International Convention for the Evaluation of New Technologies

Rationale: All those involved in the development of the Cartagena BioSafety Protocol (even industry) would have to agree that the protocol is 'too little too late'. At least in part because agricultural biotechnology was in commercial use years before the protocol, the political pressures exerted by the biotech industry and by civil society organisations distorted the social and scientific evaluation of the technology and the risks and opportunities attributed to it. This need not – and should not – happen again. There is universal agreement on some important basic points, which should lead governments to negotiate a technology convention:

- The earlier a technology is evaluated the more likely the evaluation is to be free of distortions.
- The earlier the evaluation the less likely acceptable technologies are to be slowed down or halted when they are being made ready for public use – meaning fewer costs and risks for the proponents and beneficiaries.
- There is need. There are powerful new technologies on the horizon – and many more over the horizon – that could match or exceed the impact of biotechnology.

Elements of a convention: Understandably, each new technology will require specialised forms of evaluation much as patent offices develop technology-specific capacities for determining the eligibility of inventions. However, a global convention can provide a 'template' that lays out social participation, timetables, and other process issues. The United Nations could create a legally binding intergovernmental convention that could include the following elements:

- Put in place accessible and transparent mechanisms capable of identifying potentially significant new technologies that require evaluation under the terms of the convention.
- Determine the benchmark studies and developmental signposts necessary to allow evaluation of the technology and to track its evolution.
- Ensure the full and effective participation in the evaluation of all sectors of society, especially those identified by its developers as likely to be exposed (positively or negatively) to the technology – but also including all social sectors customarily excluded of such as the poor, women, disability associations, indigenous peoples, labour, consumers, and public sector scientists.
- Establish accessible and transparent consultative processes and timetables for the evaluation of each technology.
- Through fact-finding and consultative processes, set the terms and conditions under which a new technology might be introduced into society and the environment and the terms and conditions under which the technology might be recalled if later found threatening.
- Monitor the impact of a new technology following its introduction.

Political process: The Tenth Anniversary of the 1992 'Earth Summit' (UN Conference on Environment and Development, UNCED) will be the occasion for a major UN review of Agenda 21 in 2002. The process leading up to that review conference is the perfect time for governments and CSOs to press for an International Convention. At UNCED+10, the international community should agree to establish such a convention and set the timetable and process for its negotiation and implementation.

UNCED+10 will have little to celebrate. Rather than simply review its failures, we should adopt programmes that reverse them.

- The legal mechanisms necessary to revise effectively and/or recall an introduced technology that turns destructive must be available and operational.
- An International Convention for the Evaluation of New Technologies should be negotiated in the UNCED+10 process (see below).

The present fast-growing social concern over biotechnology – coupled with the sometimes shocking implications of other new technologies – should make it possible for civil society to prod governments, responsible scientists and consumers to address these issues now before it is too late.

This is terrain in which those involved in the biotech debate could join forces with the broader labour and consumers' movements to support legislative actions.

Concentration

The International Forum on Globalisation and the many parties that fought so well against the MAI (Multilateral Agreement on Investment) would appear to have both a clear leadership role and an opportunity to counter transnational corporations. But they will need additional allies, data and resources. They will also need the energetic involvement of the labour movement. Once again, national and international initiatives could be very helpful in defining the necessary framework to defend society against concentration of corporate power. Among the specific possible actions:

The three tenets of biotech activists have been: transgenics are unnatural; life-patenting is immoral; and technology is a corporate trap. What will we do when species genetically modify themselves; corporate oligopolies no longer need patents; and the erosions are so complete that we will depend on new technologies for our survival?

- The further development of benchmarks and legal mechanisms necessary to monitor democracy and democratic institutions with a special emphasis on inclusion and information.
- The further legal development of the right to dissent and the necessary monitoring and enforcement mechanisms to safeguard this right.
- In a related initiative, the modernisation of legislation that protects the individual and the community from not only new technological intrusions, but also new state and corporate demands.
- The development of new technology-based anti-combines/competition laws that make it easier to monitor techno-concentration across sectors and ensure regulatory capacity to prevent it.
- The revival of competition policies and laws, as well as codes of conduct.
- Re-establishment by the United Nations of the UN Centre on Transnational Corporations and abandonment of its disgraceful Global Compact with TNCs.

Proposal for a
Genomics Summit:
A Special Session of the UN General Assembly on New Genomic Technologies – Conservation, Control and Use

Rationale: Although the science and technologies are similar and many of the uses are becoming interwoven, government regulatory mechanisms and intergovernmental institutions address the conservation, control and use of genetic resources very differently depending on whether the end use is agricultural, medical, environmental or in other industries. The development of nutriceuticals and pharmaceuticals and the merging of biotechnology with other new technologies such as nanotechnology makes clear that this separation is artificial. As much as the instruments of manipulation are similar, so too are the tools for ownership and control of genomics and its related technologies. In this vital and fast-changing situation, the UN needs to address the whole set of issues involving genomics in society.

Elements of the Special Session: Among the key elements that the General Assembly could review would be:

- Ownership issues – including intellectual property, other biological, mechanical and legal mechanisms that might provide monopoly control.
- Ethical issues – including codes and guidelines for researchers, collectors and those commercialising genome-related products and processes.
- Weapons issues – including the potential for biological warfare against people and their livelihoods.
- Sectoral issues – including specific consideration of the agricultural, medical, environmental and other uses of genome technologies.
- New threats issues – including examination of potentially negative impacts of emerging genome technologies.

Political process: A Special Session of the UN General Assembly would make it possible for governments and UN agencies to come to grips with the complexities of genomics and the implications for human societies in the years ahead. The initiative would support CSO efforts to widen understanding of the issues and encourage the media to make a more careful and thorough evaluation of the technologies.

- The strengthening of efforts to reform the dominating global financial system in order to curb destructive financial speculation and corporate megamergers.
- Consideration by the UN General Assembly of convening a Special Session of the Assembly on ‘genomics and related technologies’, a ‘Genomics Summit’ (see above).

This listing is not intended to exclude other initiatives to repeal or redefine corporate charters or ‘limited liability’ institutions. These are useful and valid goals, but ones that RAFI regrets are only achievable towards the end of a major societal transformation.

Who decides?

In considering solutions, we constantly return to the issue of governance and inclusion. Who gets to decide about future science? Who negotiates policy? In fact, very few people are ‘deciding’ and those who are in positions of power

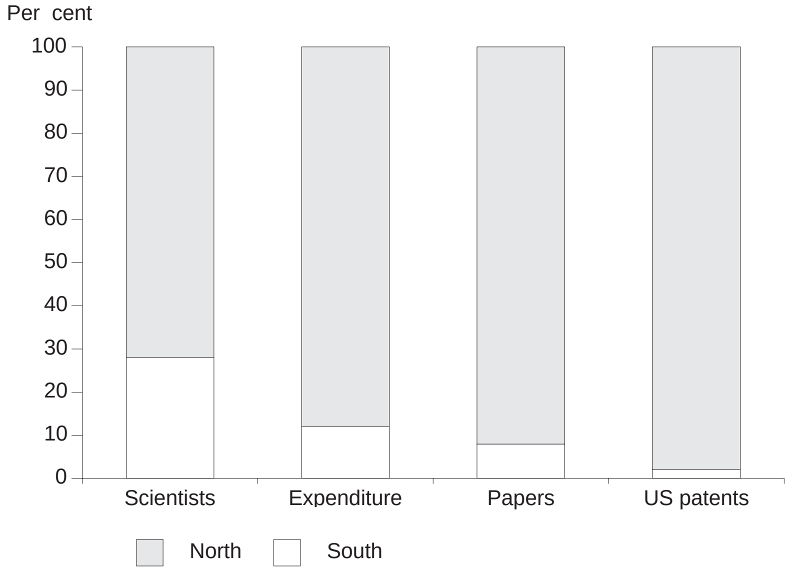

Chart 10 Who decides future science? Comparison between Northern and Southern countries.

Source: *World Science Report 1996*, UNESCO.

come from a handful of corporations, a still smaller number of countries, and tend to be male, white, middle-aged and middle-class. (A lot like the author!)

However, it is politically possible to improve (though perhaps not solve) the problems of participation in at least three fora: negotiations in the UN System; action within the faith community; and, through CSO efforts, the inclusion of marginalised peoples (women, indigenous peoples, farmers, and the much-ignored disability groups) in science and science policy formulation.

Negotiation in the UN System

Although cynicism about the UN has never been greater, the UN has never been more needed, and it has rarely shown a greater potential to act than today. There is new leadership in the System. At the Human Rights Commission, ILO, FAO and WHO there are experienced, energetic and independent leaders who, separately and collectively, could make an enormous difference. The World Court and the new International Criminal Court both indicate new opportunities for global legal action. The UN has many highly skilled and politically able professionals with strong progressive histories. They should understand that this is a time for risk-taking. If it is the *Age of Lilliput* for technology, we need greatness from our leaders.

UN Secretariats themselves need to address the gross inequities involved in intergovernmental negotiations. Studies underway through Sweden's Sida and the World Bank have exposed painful disconnections in government policy formulation as ministries of trade, environment or agriculture

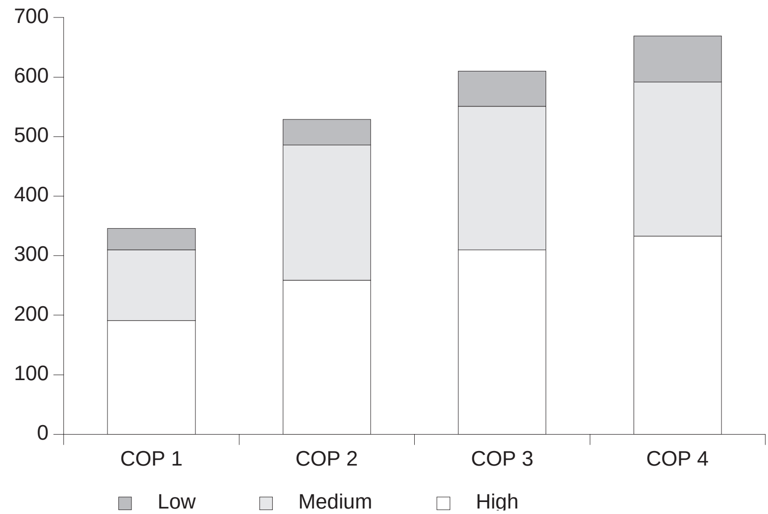

Chart 11 Who decides biodiversity policies at CBD? (Numbers of delegates according to *Human Development Report*, Index categories.)

stumble from UN meeting to UN meeting. While this is not a problem unique to the South, the consequences for G77 countries are often more severe.[2] This inequity is further exacerbated by the differences in access to communications and information. At the outset of the 1990s, for example, as the world negotiated vital trade, environmental, patent and genetic resource issues, more than 90 per cent of the databases on Africa were to be found exclusively in Europe.[3] Not only was the information not accessible to the policy-makers most in need of it, but the ability to communicate was also inequitable. There are more telephones in Tokyo or Manhattan than in all of Africa[4] and, while it costs negotiators in Madagascar and Ivory Coast US$75 to exchange a 40-page text by courier (and it takes five days), the same text can pass (in two minutes) from Canberra to Geneva for 20 cents – with copies to every other OECD negotiator at little extra time or expense.[5] Travel costs, too, work against the fairness of negotiations. Kate Harrison of IDRC (International Development Research Centre, Ottawa) recently reviewed the participation of governments in the scientific subcommittee of the Biodiversity Convention over its four meetings to mid-1999. Using UNDP's three-tiered Human Development Index as her measuring stick, Harrison found that the participation of governments from among the world's poorest nations was not only much lower than their wealthier neighbours but that it also declined significantly over time as rich country donors grew less interested in funding the participation of obstreperous states. The situation has been only marginally better for the four 'COP' (Conference of the Parties) meetings of the Convention on Biological Diversity. Chart 11 shows that while attendance has

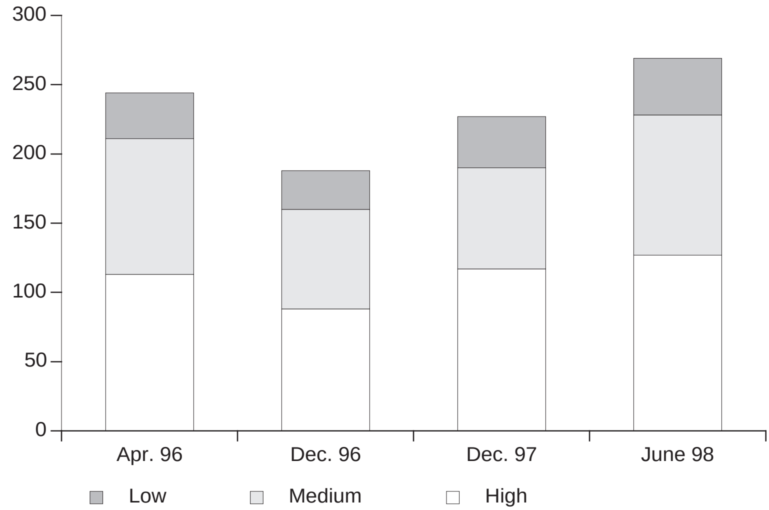

Chart 12 Who decides about crop germplasm? (Numbers of delegates negotiating FAO's International Undertaking according to *Human Development Report*, Index categories.)

increased, the share for the poorest countries has not. Kevan Bowkett, a RAFI volunteer, also found that the participation of the third-tier countries in FAO's germplasm negotiations (for a legally binding agreement on the exchange of the South's germplasm) was also unconscionably low (see Chart 12). Dedicated and resourceful UN agencies can do much to apply pressure on governments to end this kind of inequity. CSOs also have a role to play here.

Among the specific steps that could be taken within UN Secretariats:

- Agencies should document and report on the geopolitical and Human Development Index categories of state participation in every meeting, including careful documentation and disclosure of the numbers of participants from each country.
- In describing the participation of governments in negotiations, agencies should identify those individuals coming from capitals and those attending from the local mission.
- Agencies should guarantee that the number of parallel negotiating sessions at any given meeting does not exceed the number of delegates from any member country unless the countries affected unanimously waive their right to participate in each session.
- At the outset of each meeting, agencies should publicly report on the dates of distribution of each meeting document by language along with a formal report gathered from delegations as to when documents were actually received.

- Agencies should also report on the number of delegations (including individuals) able to participate in each negotiation meeting in their mother tongue.
- All of the above information should be provided in a format that permits comparison over time, and in a manner accessible to governments and the public immediately before or after each meeting.

CSOs who customarily monitor specific UN meetings should lobby for the adoption of these procedures and, if secretariats fail to agree immediately, commit themselves to providing their own data analysis of each meeting along with a full discussion of the agency's refusal to comply.

Moral participation and the faith community
It was 20 years ago that the World Council of Churches held its watershed conference on Faith, Science and Society. It is time for another meeting. Despite very many inspiring and effective exceptions, the religious community has functioned these past 20 years with anything but a 'prophetic voice'. In general, the 'faith community' has lacked courage, competence and conviction. It is entering an era in which the *nature* of life and the *dimensions* of living will change possibly beyond recognition. It must prepare itself – and not through prayer alone. The diplomatic alliances of the faith community have been disgraceful. If it has lost faith in its ability to engage in moral discourse, others still believe that these issues must be set before society.

Science policy inclusion – marginalised peoples
Beyond political negotiation, the South's participation in conventional science is also poor. Although 28 per cent of the world's ('Western') scientists are in the South, they have access to barely 12 per cent of the research funds, produce only 8 per cent of the peer-reviewed papers, and are granted less than 2 per cent of all patents. This is not a reflection on the quality of science in the South but on the biases of the mainstream scientific establishment. The critical issue here is not the adequacy of patents or papers but the inclusion of the South's needs in science policy and planning.

The involvement of women and other marginalised people is still more serious. Most observers concur that indigenous and rural women tend to be the major repositories for local scientific knowledge as well as the major innovators in community-based research systems. Women's perspectives and participation in reversing erosion and evaluating technology is, therefore, vital. Their analysis of the impact of concentration is also essential. Civil society's capacity to increase the involvement of women and indigenous peoples in policy formulation should be substantial. Thus far, we are failing.

In the mid-1990s, the ratio of women participating on key governmental science advisory bodies was stunningly low. For example, the EU's Commission for the European Development of Science and Technology, with 30 members, had only one woman. Of the 40 members of France's Higher Council for Research and Technology, only two were women. The top scientific advisory panels in Netherlands and the UK – each with 12 seats – surrendered only one seat each to women. The highest score went to the US President's council where six of the 18 advisors were women.

One would expect OECD countries to be particularly sensitive to women's participation on high-profile scientific panels. In fact, their *political* participation on these panels lags behind their participation in science education. In the mid-1990s, illiteracy among women in the South was almost double that of men (557 million as compared to 315 million). The proportion of women enrolled in science and technology courses has risen to almost 40 per cent in Latin America and about 35 per cent in Asia and the Pacific. In Africa, however, where women occupy only 10 per cent of the classroom seats in science and technology courses, their share has been stagnant or declining since the early 1970s. The role of women in nanotech-related sciences such as physics is particularly poor. Of those taking physics in universities in 1990, fewer than 5 per cent were women in such high-tech countries as Japan, USA, Germany, Canada and Switzerland and just above 5 per cent in the UK and Netherlands. The highest percentage of female physics students are found in countries such as the Philippines and Portugal where their share is still barely 30 per cent.[6]

The role of women in agricultural research – an area where their expertise has long been absent and is urgently required – is especially worrying. In countries such as Burkina Faso, Ethiopia, Niger and Zambia, far less than 10 per cent of students are women. One in five Brazilian and one in three Mexican agricultural students is a woman. Among those taking university courses in medicine, the percentage of women runs between a fifth and a quarter in Africa but closer to two-thirds in Latin America.[7]

What of the participation of other marginalised people? There are no useful statistics available. Nobody even thinks to count. Could there be anything worse?

From seeds to ETCetera

There are three reasons why we should find these proposals possible and encouraging. First, we may have some years before nanotech and its associates are able to exercise the kind of political force they would need to prevent such laws. Second, CSOs have a mushrooming expertise in addressing such complex socio-scientific issues and these are things we might well be able to achieve. Third, we are supported by growing societal concern over the direction of privatised science.

These possible areas of action are not intended to be limiting. Much discussion and debate among concerned peoples is needed. The analysis needs improvement. Also, this brief listing of some possibilities clearly plays to national and international legislation and the interests of lawyers and legislators. The ever-strengthening capacity of civil society to develop alternative communities and strategies at community and family levels is not discussed here but is certainly a major resource and – better still – goal.

An underlying message of this whole analysis is that for the world to tackle the serious challenges posed by the ETC Century, civil society must take the lead – at all levels. Although we need to work in tandem with progressive researchers, decision-makers and many others, civil society is uniquely positioned to take the initiative and press for real changes.

With much of our energy – and more of our heart – still fighting for the 'Law of the Seed', the route that has taken us to ETC is not as distant as we might think and the way ahead remains filled with the uncertainties we have learned to challenge.

RAFI's law of technology introduction

$E=TC^2$: Erosion is created by Technology introduced in the context of corporate/class power Concentration. For every 'Luddite' trying to establish social controls over the introduction of untested technologies, there is a more powerful 'Eli-ite' using social controls to impose new technologies. Any major new technology introduced into a society which is not, by its nature, a 'just' society will exacerbate the gap between rich and poor.

> *To some extent seeds act as the masks in our silicon technology: … one must find the way to replace seeds by some manufactured object. That replacement is physically conceivable. (…) micropatterned substances might be used as seeds to grow self-organized active elements such as nanostructures or molecules …*
>
> D. Bois, France Telecom [9]

> *I'm convinced that the next century is going to make this century seem rather calm by comparison.*
>
> Dr Richard Smalley, nanotech guru and Nobel Laureate in Chemistry, in *Christian Science Monitor*

Notes

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