Biotechnology Scenarios

2000-2050 Using the Future to Explore the Present

World Business Council

for Sustainable Development

Scenario Unit

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To *Guilia Kramer*, 1966 - 1998,
Professor of Bioethics in Geneva,
who worked on making Biotrust
happen long before we realized we
needed to get involved.

Contents

Sustainable development's aim is to satisfy the fundamental needs of the whole of humanity on a permanent basis. It must happen without depriving future generations of the means to satisfy their own needs in turn. We see biotechnology as the key to meeting these needs.

Jurgen Dormann, CEO, Hoechst AG

Scenarios

Using the Future to Explore the Present

The Future of Biotechnology and the Need for Stories

In fields that change as rapidly as biotechnology, predicting the long-term future – or even short-term developments – is a dangerous game. The landscape changes too rapidly, and the cascading developments in the closely related fields of chip technology and nanotechnology make predictions obsolete almost the moment they are uttered.

And yet too much is at stake simply to ignore the future, especially if companies are committed to the goal of sustainable development – economic growth, environmental health, and social equity. Companies must develop strategic agendas, taking into account many dimensions that influence what happens. Most leaders in the field, for example, realize that the future of biotechnology will not be determined by technology alone, but also by public opinion and the laws that reflect it. Predicting technology breakthroughs or likely market share is not enough to guide decision-making into the future.

Such decision-making, to be effective, must take into account possible future developments without falling into the trap of placing bets, implicitly or explicitly, based on only one vision of the future. Scenarios are intended not as *predictions* of the future but as *stories* about possible futures and the factors that might lead to one future rather than another. These biotechnology stories are designed to challenge the participating companies to think about different future worlds and the factors that might shape such alternative worlds – and by thinking about the future, to explore the present in new ways.

One of the unexpected by-products of any scenario project is that in the course of making the scenarios, certain conversations can occur that otherwise would never come up in the everyday life of an institution. The emergence of "unmentionables" allows difficult issues to be discussed in non-threatening contexts.

After all, scenarios are fictions, not plans for actions or visions for the future that any particular faction is promoting. But even though scenarios are fictions, they can have non-fictional outcomes – not, usually, because people follow specific scenarios but because during the course of the conversations, new possibilities arise.

By their very nature, scenarios are "cartoons" – that is, they are rough sketches, broad-based pictures of different worlds. This roughness offers something of an advantage in that it bypasses what often happens when people gather to plan a future that challenges the present, but end up getting sidetracked by incidental details that prevent them from focusing on the big picture. Disagreements over such details can mislead a group into thinking that no consensus is possible. Scenarios offer the advantage of minimizing these quarrels over details. After all, any particular scenario is a fiction – the details are only representative examples of what we might find in a given world. Consensus is neither possible nor impossible – just unnecessary.

Biotechnology and Sustainable Development

Many of the workshop participants shared a sense of urgency about the future of biotechnology as it moves from basic research to applications. Because these applications have a direct bearing on sustainable development, twelve member companies of the more than 120 members of the World Business Council for Sustainable Development embarked on a biotechnology scenario project under the leadership of the WBCSD Scenario Unit. The explicit aim of the project was to help articulate the context for strategy development in biotechnology for participating companies in light of public values and sustainable development issues.

These biotechnology scenarios form one of a number of WBCSD projects, including "Energy and Climate Change," "Eco-Efficiency," "Corporate Social Responsibility," "Sustainability through the Market," and "Innovation, Technology, Society, and Sustainability." These projects all reflect the ongoing commitment of member companies to sustainable development.

Three Scenarios for Biotechnology

In our biotechnology scenario workshops, we began by asking, "What are the 'givens' that will happen no matter what?" We accepted the "givens" that had arisen from the work on the WBCSD global scenarios for the future of sustainable development: that new technology would continue to emerge, that population would continue to grow, and that connectedness resulting from telecommunications and interdependent global financial systems would continue to develop – "the new, the many, and the connected." But in addition, in relation to the specific area of biotechnology, we concluded that any scenario would reflect the following, although perhaps to different degrees:

- Biotech is here to stay.
- In addition to the obvious intended consequences of biotech, there will also be unintended consequences.
- People are anxious about the unknown.

We next asked, "What are the most important unknowns in relation to these givens?" We concluded that depending on the nature of public reaction to an unintended event that might happen in biotechnology, the acceptability of biotechnology might fluctuate widely – a story explored in the first scenario, *The Domino Effect.*

Apart from any such event, however, the industry could prosper or not depending on factors other than technological success and sustainable development benefits – risk and liability issues, for example, or consumer choice in relation to issues of sustainable development. These variables are explored in the second story, *The Hare and the Tortoise.*

The third unknown had to do with the consequences of a successful and widely accepted biotechnology industry – what kind of world might this produce? And how might wide acceptance come about? The story of *Biotrust* is a response to these questions.

In a way, scenarios can be seen as virtual stage sets for imagining, in detail, many different possibilities for the future – possibilities that push us out of the box of our habitual modes of thinking and into the future, which is always unpredictable.


A. KRAUZE

Hope, Fear, and The Unexpected

Hope Driven by intense, overwhelming curiosity, Pandora opened the box into which the gods had stored all the afflictions: misfortune, disease, famine, sorrow, old age, infirmities, death. One ambiguous gift alone flew out with all the plagues – hope.

Driven by our scientific curiosity to discover who we are and how the world works, we have delved to the very heart of the knowledge of life itself. And in the hope that our knowledge will help alleviate the suffering that has been a part of the human condition from the beginning, we have produced remedies and relief from many of these ills. In this hope that we can cure disease, end famine, and cut pollution, and, by doing so, create whole new industries, we have opened another mystery box. Unlike Pandora's, it is not a box of afflictions with hope at the bottom. But it does have one thing in common with Pandora's box: whatever new knowledge and inventions come out of the box, no one believes they can be stuffed back into the box. The power that knowledge can give us, and the curiosity and continuing hope for alleviating suffering that fuel our actions is obvious. No matter how many laws are passed, or how many protest campaigns are launched; no matter which course the ethical debate takes, or how consumers choose; whether the industries that have arisen in response to the promise of biotechnology flourish or decline – someone, somewhere, will be opening the box a little wider.

Biotechnology is here to stay.

Fear

Fear Biotechnology is here to stay, but the shape of the future for industries in this field is not at all clear. "Terminator technology" and "Frankenfoods" assertions worry some consumers, while science fiction images of vast acres of embryos, hanging in artificial wombs like ripe tomatoes, waiting to be harvested for spare parts, arouse intense ethical disgust.

Even some supporters of biotechnology point out that a number of people fear this new technology more than any other, with the possible exception of nuclear. This fear, like the resistance that has traditionally met the introduction of all new technology, is rooted in the basic human fear of the unknown. But for some people, biotechnology elicits four specific fears that go beyond the predictable human reaction to the new:

- The unintended consequences are potentially disastrous, not just for one person, but for all humans, as well as for other species – and these consequences are irreversible.

- We can't make an individual decision about the use of biotechnology – someone, somewhere else is making it for us, taking the future of our health and maybe even our very survival, out of our hands.

- Biotechnology is technically complicated, and most of us don't understand these complications. We have a deep suspicion of a technical elite making important decisions for us because we suspect that while they are very smart, they may not have much heart or they may not share our values. They may be motivated more by scientific curiosity than by the common good. And if these technicians are located in companies, maybe they are motivated by something even worse – greed.

- Biotechnology alters the building blocks of life itself. Are we smart enough to play God? Is there any evidence in recent history that we are ready for this responsibility? Are we moving too fast, without seriously considering the consequences?

People fear the unknown – especially when they believe that the unknown could affect all of life on earth.

The Unexpected

In addition to the obvious intended consequences of biotech, there will also be unintended consequences. Life itself is full of the unexpected, but in the realm of biotechnology, the three greatest sources of the unexpected are likely to be:

- **Events and the interpretation of events – the story of *The Domino Effect*.**
- **Consumer choices – *The Hare and the Tortoise*.**
- **Consequences of successful technology and social innovation – *Biotrust*.**

Of course, to tell stories about the unpredictable is to make the future predictable – or at least to pretend that it might be. But these are not stories of what will happen, because no one can predict that. These stories focus, instead, on the sources of the unpredictable. What are the wellsprings from which different futures might arise? What imaginative worlds would it be wise to inhabit for a time if we are interested in the future of biotechnology? Why is it important to understand *The Domino Effect?* If we are placing bets on the technologies of the future, why is it to our advantage to consider the relative strengths and weaknesses of *The Hare and the Tortoise?* And if the 21st century is really to be the age of biotechnology, why is *Biotrust* necessary – and how can we build it?

The Domino Effect

Tiny differences in input could quickly become overwhelming differences in output . . . In weather . . . this translates into what is only half-jokingly known as the Butterfly Effect – the notion that a butterfly stirring the air today in Peking can transform storm systems next month in New York

James Gleick, Chaos


A. KARAUZE

In *The Domino Effect*, biotechnology continues to make steady progress until 2010, when a curious incident happens that no one much notices at first. A number of people who had received gene therapy are exhibiting debilitating, AIDS-like symptoms, and 25 of them die over a period of two years. While recipients of gene therapy had died in years past, the cause of these deaths had been addressed, it was thought. In any case, this seems to be a different set of symptoms. In at least half the cases, spouses, also, appear to suffer similar symptoms, and two children of these gene therapy patients also die. Officials at the US CDC (Center for Disease Control) cannot, at first, determine what the cause is or even whether the deaths have anything at all do with the gene therapy. They also can't explain why the spouses and the two children seemed to exhibit many of the same symptoms as the recipients of gene therapy.

When the news of this new "plague" reaches the public, reaction is immediate and intense. Many commentators remark that once again, officials have claimed something is safe when it turns out not to be. The public is especially worried about BBIs (biotechnology-based innovations) because if anything goes wrong in this area, the implications could be profound and far-reaching. Industry representatives counter these accusations by insisting that the gene therapy in question is safe and that the symptoms are most likely associated with some other factor these patients have in common. Whatever is going on has nothing to do with BBIs.

Blame Biotech

A health-related internet magazine picks up the story, and several NGOs make this strange new disease a key issue in the upcoming US elections – candidates must pledge to "do something" about biotechnology. This pledge is easy enough to make because it's vague and doesn't offend very many voters, so all but one of the presidential candidates and most of the Congressional candidates go on record as being "against" biotechnology. Although industry analysts don't know what "against" means, exactly, one analyst, attempting to make a name for himself, attaches himself to this issue and speaks out on a number of popular talk shows about the dangers of investing in biotechnology – liability issues being the chief of the dangers.

The two-tiered agricultural market – where non-BBI-based

products fetch higher prices than BBI-based offerings – looks as if it is poised to develop in the pharmaceutical industry as well.

A consortium of NGOs organizes a movement for a moratorium on all BBIs as well as certain forms of gene research. Industry spokespeople point out that the surplus food enjoyed in the US and the relatively low prices of basic foods owe a lot to BBIs. But European farmers choose this moment to offer their non-BBI-based crops for export – at a price – to the US.

Pharmaceutical companies join in the debate, arguing that their BBIs are crucial for many lifesaving treatments and that nothing has been proved yet about the link between the BBIs and the mysterious deaths. But the newly elected US President, pressed to make good on his pledge, proclaims the moratorium, meanwhile promising industry representatives in private that the moratorium will be short-term. News of the President's private reassurance to the biotech industry leaks out, and angry activists stage noisy protests against the biotech industry in general. Growth in the industry slows down further, and many companies are thrown into relative confusion, with some choosing to move their operations out of OECD countries altogether.

The Revolution that Doesn't Happen

The 21st century was supposed to be the biotechnology century. But by the end of the first decade of this new century, the large bets made by many companies have not paid off. Several Congressional investigations and a growing number of lawsuits have soured the high expectations of many US investors. And in the US and Europe, anti-BBI legislation fences in biotechnology companies with many onerous "safety" requirements and restrictions. The best potential employees do not want to work for biotechnology companies, and daily life in the biotechnology industry is more about fighting fires than moving forward.

Pharmaceutical companies are doing somewhat better than their colleagues in agriculture, but many come under the same onerous and capricious regulations that afflict the agricultural sector. Lawmakers seem not to make fine distinctions among BBI applications, and the increased use of non-standard internet news sources means that the public is awash in misinformation about BBIs.

Fears of Biotechnology

Some people fear that:

Biotechnology will harm their health.

New biotech vaccines will introduce mass vulnerability to new pathogens.

Xenotransplantation will lead to new virus epidemics.

Pest-resistant crops will produce superweeds and superbugs.

Food from BBI-based crops and livestock will not be safe to eat.

The rush to bring new products to market will prevent proper risk-benefit analysis.

Biotechnology will harm the environment.

BBI-based crops will diminish biodiversity and harm beneficial species. When plants are used as bioreactors, unknown viruses will cross-jump between different species.

In developing new products, the precautionary principle will not be observed. Entire ecological systems will be destabilized.

Biotechnology will compromise the decency and integrity of humanity and of other species.

Cloning will diminish our respect for human life. Biotechnology will make mandatory genetic testing more likely.

Private data will not be protected.

Animals will be abused as humans use and modify them to grow human organs or for other "pharming" needs.

"Spare-part" creatures will be developed who are mere "bio-chassis," without heads.

Biological computers will be smarter than humans.

Biotechnology will lead to a less equitable society.

When times are hard, employees with genetic "time-bombs" will be discriminated against.

Even if new cures for gene-based conditions and diseases are developed, only the rich will be able to afford them, so the gap between rich and poor will grow even wider.

Private patents will prevent the development of publicly funded cures for certain rare diseases.

Seed stock for basic grains will be owned by a handful of companies.

Poor countries will be exploited for their genetic resources.

First-world exploitation and colonization of third-world countries will be extended to life itself, with western companies claiming patent rights to life-forms originating in third-world countries.

Most biotech products, including medical diagnosis and cures as well as nutraceuticals, will not be available in the third world.

Genetically enhanced humans will have advantages.

Biotechnology will lead to a more dangerous society.

Some of what is considered "evolutionary trash" at the moment will turn out to be very significant.

Race-specific bioweapons could be created.

Genetically engineered biological warfare agents will be both more devastating to human life and easier to deliver than conventional biological warfare weapons.

Every rumor seems to be magnified. Even when misinformation is corrected, the public seems to be suffering a kind of millennial "hangover," prey to the fear aroused by Armageddon-like prophecies and any health warning that comes along, however tenuous. Numerous self-appointed watch-dog organizations offer a seal of approval to products that are BBI-free. Thousands of school boards in the US follow the example set by Berkeley in the 1990s and insist that school lunches be guaranteed BBI-free.

Somewhere in all these fear-arousing rumors, a small news item appears: the mysterious deaths and AIDS-like symptoms suffered by some of the gene therapy recipients are caused by a new variety of flu – serious enough, but probably nothing to do with gene therapy. But this information receives scant attention, and no one cares anyway, because anti-BBI sentiment seems to have a life of its own.

By 2020, companies whose profits were solely dependent on BBIs are suffering. It has proven impossible to obtain insurance for many BBIs, and many class-action suits pending in the US courts threaten even the few who are hanging on to life by a thread. Most of these suits, it is clear, will be thrown out of court, but the time and expense of dealing with them is enormous.

The Domino Effect

BBIs in agriculture are also suffering from the domino effect. The effectiveness of the WTO is threatened by a long-term impasse over the EU's refusal to import genetically modified argicultural products and the US response in restricting the import of EU agricultural products. Industry spokespeople point out that the surplus food enjoyed in the US and the relatively low prices of basic foods owe a lot to GMOs and that 3rd-world countries will suffer if this impasse is not resolved. But anti-BBI feeling continues to develop, and now begins to spill over into the area of biobased polymers, where the fear of toxic waste is being replaced by the fear of genetic pollution.

By 2030, it is common for any unusual upset in the ecological balance of a region or any new seasonal strain of flu to be blamed on BBIs – the so-called "Unintended Consequence Effect." One example of the Unintended Consequence Effect has occurred with salmon. A gene modified in salmon to help them breed more

productively seems to have resulted in an excess salmon population. When salmon show up where they don't normally occur, environmentalists claim the eco-balance is upset. Nothing is proved, but it doesn't seem to matter. Industry spokespeople claim that the Unintended Consequence Effect is more myth than substance, and that what is really happening is not a material effect at all, but a "domino effect" in which one bad news story creates another, bringing down one product or company after another. Like a giant game of "gossip," a rumor gets more and more exaggerated until after only a few rounds of internet traffic, the distortion has made the original report unrecognizable. Every new product and every event seem to be part of some vicious circle. Introducing new BBIs seems almost impossible, and many BBIs already in the market are withdrawn.

The FDA and the EMEA recall a number of pharmaceutical BBIs for "further testing," in spite of protests by those consumers who feel they benefit from certain BBIs. Emergency exceptions are made – for insulin, for example – but competitors with conventional medications use this opening to make a case to go back to certain "safer" drugs. Drug policies in the developed nations diverge from each other and from policies of less developed nations, and even within individual countries, many regulations fluctuate wildly from year to year. Pharmaceutical BBIs seem to be approved or not approved almost on a whim. No common standards emerge, either among developed nations or from administration to administration. Large companies begin to spin off individual business units as a way of avoiding liability.

At this point, some third-world entrepreneurs begin to buy up these vulnerable little spin-offs, selling new products as cheaply as possible to third-world and even first-world customers, often over the internet. Although many such drugs are by now illegal in Europe and the US, suppliers can usually manage to work around these legal restrictions, especially given the increasing number of internet transactions and the new delivery companies that are formed almost daily. In addition, a number of unscrupulous entrepreneurs set up factories with limited quality, safety, and environmental standards, and observers feel it is only a matter of time until a serious disaster occurs. *The Domino Effect*, by increasing fear, has also, inadvertently, increased the very dangers it feared.


A. HERAUVE

The Hare and the Tortoise

The race is not to the swift, nor the battle to the strong.

ECCLESIASTES 9:11

In *The Hare and the Tortoise*, progress in biotechnology and its practical applications comes to a virtual standstill, not because of protest movements or government regulations or an incident that increases fears of biotechnology, but because consumers and investors choose other, non-BBI alternatives. In a number of areas, "classical" R&D delivers solutions with better performance and higher profits – in part because most consumers, given a choice, follow the precautionary principle of "better safe than sorry." Low-tech, holistic health practices emphasizing prevention and sustainable, non-BBI agriculture prove to be much more popular with consumers in developed nations. In less developed nations, BBIs are often too expensive to be adopted. In this scenario, there is still a niche market for BBIs as analytical tools. But the older, more classical approaches are like the slow tortoise in the old fable, who has a kind of patient persistence that, almost unnoticed, wins the race in the end over the swifter but more erratic hare.

The Hare Takes Off

In the last decade of the twentieth century, biotechnology stocks are among the hottest things going. Patent applications for life forms are being submitted at a breathtaking rate, and in the US, especially, new BBIs are favored with what many perceive to be a fast-track approval process. Some critics point out the relative lack of performance in relation to investment – but most argue that a virtuous circle is developing: more investor money results in more research, which results in news of more potential products, which leads to new investment, more research, and so on.

Emergence of the Tortoises

But other contestants are lumbering along in the same race – alternatives based on high-tech but non-BBI approaches, such as traditional farming techniques and holistic health remedies. BBI advocates point out that traditional farming practices have serious environmental consequences, such as lost topsoil and lost biodiversity due to the habitat encroachment caused by expanding land use for producing food. Where that is true, critics respond, the ill effects can be reversed through better practices – a reversal not so easy to produce when it comes to "genetic contamination." "Better safe than sorry" is the motto of these "tortoise-like" contestants.

The Consumer Chooses

Most consumers just cannot see a clear benefit in BBIs. By 2010, a two-tiered market has developed, with higher premiums being paid for non-BBI-based food and drugs. Public opinion is firmly grounded in the precautionary principle, pointing to the unexpected consequences of the industrial revolution, for example, or of introducing new species into local habitats. It's very obvious that a large part of the next millennium will be spent paying the bill that has become due as a result of the industrial revolution. The cost of global warming and the numerous environmental clean-up chores of polluted air, water, and soil is higher than expected. Many wonder what bills will land on the doorstep of the next generation as a result of the equally dramatic revolution in biotechnology.

Unintended Consequences

The Introduction of Non-native Organisms

From time to time, species have been introduced into new habitats, sometimes with good results, as with many non-native agricultural products, and sometimes with devastating unintended consequences. In the US alone, non-native organisms – so-called "exotics" – have cost billions of dollars and threaten native species.

For example, around 1986, the zebra mussel was released from a ship's ballast water tank in Lake St. Clair. This organism, the size of a kidney bean, and originally from the Caspian Sea region, spread throughout the Great Lakes, encrusting intake pipes and navigation locks. The cumulative costs by the year 2000 of dealing with mussel damage are estimated to be between 3.1 and 5 billion dollars.

In addition, the zebra mussels have encrusted the native mussels so heavily that these cannot open their shells to feed and breath. They have stripped the algae from the water, depriving the zooplankton of their food supply. Several fish species depend on zooplankton and algae when they are young, and this may affect their reproduction. The decline in value of the fish catch in Lake Erie from $600 million before the mussel invasion to $200 million by the early 1990s may be related. The zebra mussels also ingest the organochlorine pesticides, PCBs, dioxins, and other toxins that would have been buried in the sediment. These toxins enter the food chain through the wildfowls, crayfish, and other animals that eat the mussels or their excreta – which may explain why PCB levels are rising again in some predators such as lake trout, and bald eagles.

Other non-native organisms that have caused expensive and widespread damage include the Gypsy moth, Kudzu vine, Dutch elm disease, starlings, Mediterranean fruit flies, the water hyacinth, the Nile perch, and the mongoose. What will the new non-native organisms be, and what damage will they do?

A consensus begins to emerge in many western nations that in relation to biotechnology or any other technology that affects society as a whole, it is best to encourage those choices that leave other options open. In *The Hare and the Tortoise*, a second principle arising from the biotechnology debate is that where a conventional alternative will do just as well, there's no reason to encourage the use of BBIs. Reflecting this development, governments jump on the bandwagon by creating programs to support conventional agriculture and pharmaceuticals: tax breaks and subsidies for non-BBI farming; tax policies favoring unmodified seeds and other "natural" practices; grants and subsidies for development of new pharmaceuticals that don't use gene-based technology; and WTO exceptions to fair trade policies in the case of genetically modified products that importing countries want to resist.

Health Consciousness

The "tortoises," or the non-BBI alternatives, are emerging from many directions, in part because of movements in lifestyle and health. The more affluent and better educated consumers entering the marketplace are highly aware not only of the quality of the products they buy, but also of the circumstances of production. In addition, they are extremely health conscious and fitness oriented, and many of them scan labels thoroughly, using their personal shopping scanners to compare the information embedded in the bar-codes with their personal ethics and nutritional value profile.

When it comes to food and health, consumers are becoming much more personally involved, taking direct responsibility for choosing healthy food and practicing preventive healthcare. Food retailers are increasingly interested in pleasing consumers, especially because the food crises in Europe at the turn of the century have led to an even greater skepticism about the ability of governments to guarantee food purity and safety. A number of private food certification agencies spring up, and most of the popular retail brands voluntarily follow their guidelines. In addition, new labeling laws and aggressive "natural" food and drugs marketing make it difficult for genetically altered products to compete. Consumers seek more local food and gradually become

more willing to accept seasonal variations in their diet. By 2010, market researchers notice a significant trend towards the consumption of more organic produce.

In Europe, habits of eating have changed with the new generation, who remember the mad cow disease scare and other meat contamination incidents from their childhood. Vegetarianism is becoming more and more popular for ethical as well as health reasons, in part because young people are increasingly supportive of "animal rights" and other related issues. In the global marketplace, consumers have the luxury of a wide choice of products – and they tend to choose on the basis of a company's social responsibility profile as well as the quality of its products.

The aging populations in OECD countries are also interested in health, and many people shift their eating preferences lower down on the food chain. Product purity for these consumers means no additives and no BBIs in their food and drugs. Both older and younger consumers now expect to devote a higher percentage of disposable income to high quality food and wellness.

Holistic health, which features exercise, non-BBI food, vegetarianism, and homeopathic rather than allopathic remedies, becomes more popular as the conventional health care safety net in developed nations becomes less able to function. People want to take charge of their own health and are willing to experiment with alternative medicines before turning to BBIs. Pharmaceutical companies still do well with BBIs in certain niche markets, but profits in this sector begin to flatten out. Many new drugs that were expected to be profit sources end up, for various reasons to do with politics and patents, in the public domain. Because expectations were so high, share prices begin to slide, and investor attention turns to those companies that specialize in products derived from new plant discoveries in the Amazon and elsewhere.

These new herbal products seem to work – "mostly through the placebo effect," says a noted skeptic. But new discoveries in the powerful effect of the mind on the body lead many consumers to embrace the placebo effect – so-called "self-administered homeopathic drug therapy." New markets develop in products that are innovative, but based on traditional medicine, a paradoxical combination that seems to suit the spirit of the times. As with other aspects of the world of *The Hare and the Tortoise*, people are not worried about BBIs – they just are not that interested.

Feeding the World

What begins as a health and lifestyle feature quickly becomes a cause. Just as high ideals led to the eradication of polio and smallpox, so now many become convinced that famine, too, can be eradicated. Conceiving of this as a realistic though difficult goal, private foundations work towards food self-sufficiency in every community. This is more than just sorting out the distribution and transportation problems, but has to do with growing small amounts of non-commercial produce in a small space, saving seeds for next year's garden, and practicing low-pesticide farming. Computer technology and laborsaving devices have reached even the most remote parts of the globe, so people have both the time and the information necessary to develop "small plot" permaculture strategies. In the US, the "sprout scout" movement has taken hold, so that by the time children graduate from high school, they know a great deal about urban gardening. Gardening for food is popular, partly in reaction to the increasing sense of vulnerability people feel because they are so interconnected and interdependent. The more sophisticated and "networked" the lifestyle, the more popular food gardens become. This cultural shift is also felt by farmers, who dislike the way that farming based on BBIs makes them feel less self-reliant and more vulnerable to external factors. What has helped this movement enormously is the World Bank Initiative to make high-yield corn, rice, and wheat seeds and plants available to all small-lot farmers. A consortium of multinationals has formed a group that has taken on the daunting challenge of co-ordination and distribution, a challenge aided by the increasing numbers of people in remote villages in Africa, India, and China who have received cell phones through international aid agencies. All these efforts are greatly aided by breakthroughs in high-tech, non-BBI farming and breeding techniques.

In this developing culture of high-value agriculture and self-sufficiency, the goal of ending world hunger seems a real possibility. In addition to exporting new agricultural methods and the principles of simple water purification and permaculture, UN agencies, private foundations, and NGOs all over the world begin to look more closely at the whole issue of distribution. In this climate, the argument that world hunger can be eradicated only through BBIs looks less convincing, especially because the distribution problems associated with conventional large-scale agriculture are still apparent in BBI-enhanced agribusiness. The problem is not the growing method, it's the will to feed to world, argue the reformers. By 2015, biotechnology has lost the sustainability argument, which, critics say, it never made convincingly in the first place.

The remarkable increase in the sales of non-BBI foods lures many smaller farmers back to the farm because the profit margins on such produce are very enticing. In addition, recent research has produced high-tech innovations for conventional farming. New measuring devices allow much more precise inputs of nutrients and water, and discoveries about the interaction of soil, natural fertilizer, light, and plant chemistry lead to significant increases in productivity. These increases are relatively high because information technology allows even poor farmers access to sophisticated analysis of crop needs. Biotechnology becomes an important tool for understanding, but not as important for commodity production. The general attitude is that where possible, it's best to optimize the ecological system as a whole rather than to optimize the seed, a narrow approach which might, in fact, damage the system as a whole.

Diagnostics – a BBI Niche Market

In addition to an increasing sentiment favoring a "go slow" approach to what was supposed to be the "age of biotechnology," another counter-trend is developing: a surprising number of people are not as eager for gene-based diagnostic tests as many had expected them to be. One reason is that the capacity to diagnose disease susceptibility far outstrips the ability to cure the disease. Consumers quickly understand that diagnosis offers them not many upsides and quite a few disadvantages. They don't want the "genomic depression" diagnosed in some people who have been told they will develop an incurable condition at age 35 or 40. Also, they don't trust the ability of diagnosticians to keep confidential information secure – and US citizens, at least, don't want to risk losing employment opportunities or health insurance coverage if a negative diagnosis is discovered. Thus, expensive and sophisticated diagnosis for congenital conditions turns out to be a product without a market.

The Tortoise Wins the Race

While governments encourage conventional agriculture and health practices, they do not attempt to stop the development of biotechnology. But lack of consumer demand and other factors redirect innovation away from BBIs. The cost and uncertainty of patent protection and the perception that biotechnology is a high-risk business lead many companies to invest in alternatives to biotechnology. These investments increase the pace of important innovations in conventional agriculture, such as a joint venture of two startup companies that introduces environmentally friendly insecticide and herbicide based on conventional technology.

As both producers and consumers increasingly choose non-biotech alternatives, and the holistic health and "safe" foods sectors grow, investors become aware that BBI-based enterprises are underperforming. In both agriculture and pharmaceuticals, the race to patent life forms is beginning to be questioned. Some critics denounce this view of life as a utilitarian set of raw materials. It's one thing to prospect for gold and oil in specific geographical regions; but it's quite another, they argue, to "bioprospect" in the material that is common to all. Gradually, a consensus begins to emerge on two fronts: first, that contained

risks, such as those associated with the use of enzymes in paper manufacturing, are supportable, but uncontained risks, such as vaccine production crops, should not be allowed; and second, that process patents make sense, but that product patents on life forms should not be allowed. By the time products appear, however, even process patents have usually expired.

Just as product patents begin to be challenged by courts, the wide sharing of genomic information makes the protection of intellectual property in this area extremely difficult. The human genome sequence is in the public domain, for example, as are SNPs, the places in the genetic code where individual variations take place and which hold the clues to genetic pre-dispositions for various diseases. In *The Hare and the Tortoise*, the biotechnology industry, like the nuclear industry before it, continues to hold a small niche share of the market – but it doesn't produce the expected revolution.

Biotrust

As contagion of sickness makes sickness, contagion of trust can make trust.

Marianne Moore

A Narrow Window for Success

Early in the new century, biotechnology is growing in its number of applications – pharmaceuticals, drought- and disease-resistant seeds, large-weight fishing stock, fast-growing and disease-resistant forestry products, genetically modified bacteria-based mining applications, bioinformatics, bio-plastics and enzyme manufacturing, tissue engineering, bio-remediation, bio-computers, bio-sensors, therapeutic vaccines, and many others. But when it comes to public opinion, the industry is losing ground. Citizen groups, especially in Europe, have organized stiff resistance to BBIs in foods, and this anti-BBI sentiment has spread into the medical arena, even though the issues there are very different. But in this increasingly emotional debate, fine distinctions and scientific arguments are overshadowed by politics and a very effective anti-BBI media campaign. Some US analysts argue that the funding for the campaign has come, in part, from businesses that have a vested interest in keeping US agricultural products out of European markets, and some Congressional representatives from agricultural states propose retaliatory trade

measures. The International Council for Genetics, an institution that has grown out of individual, country-based initiatives, proposes much stricter oversight of pharma research and much broader distribution of what they refer to as "the health technology of the rich."

Distrust grows: NGOs distrust the companies; companies distrust the media; Europe and the US distrust each other's intentions in the ongoing BBI debate; citizens distrust what their governments say about the safety of BBIs, especially in relation to food; and third-world countries distrust both OECD governments and the large biotech firms.

Building Biotrust

In this climate, a number of biotechnology companies along with NGOs, patients' rights groups, and other stakeholders join together in what becomes known as the "Biotrust Project." The aim of this project is to create a common meeting ground on which to build trust among all stakeholders in the short time remaining before any major products based on genome sequencing come to the marketplace. If the 21st century is to be the century of biotechnology, they argue, then all stakeholders must have a part in its development.

The process of building stakeholder involvement is difficult and at times threatens to break down. Media representatives tend to emphasize the David-versus-Goliath aspects of any situation, while representatives from NGOs and other citizen groups are wary of being used as part of a "window-dressing" campaign. But after serving on the Biotrust panel for a year, they tend to modify their positions somewhat, as do the industry representatives – even though the change in stance sometimes creates friction with the individual sponsoring groups.

In spite of the difficulties, participants eventually reach agreement in seven areas of concern:

Transparency and Trust

In building trust with stakeholders, leading companies begin to engage in more open communication. Among the trends that are noted during the period 2000 – 2030 are a change in reporting from:

2000	2030
one-way, passive communication	multi-way, active dialogue
management systems	life-cycles, business design, and strategy
inputs and outputs	impacts and outcomes
public relations	stakeholder dialogue
reporting boundaries decided by company	boundaries set by all stakeholders
environmental performance reports	triple bottom line accounting that incorporates economic, environmental, and social performance
traditional reporting procedures	measurement criteria, the scope of reporting, and overall verification undertaken in partnership with stakeholder advisory panels

- Transparency.
- Ongoing stakeholder involvement.
- Ground rules for risk-benefit analysis.
- A global system of safety standards.
- Inclusion of third-world nations in the benefits of biotechnology.
- Data protection.
- Guidelines for patenting and licensing.
- Responsibility for externality costs and other liability issues.

What makes the agreement more effective than many had initially expected is that it is based on social values as well as science and also, that other groups are involved in similar initiatives. The Biotrust Project is usually considered to have more significance than many of the others because it involves major players on both sides, and it rapidly initiates projects that make a difference. For example, one early project is the setting up of a series of regional seedbanks and genetic databases for public use, designed to eventually become the basis for "libraries of life" in every region in the world. Pharma companies follow the lead of agricultural companies and in conjunction with the World Bank, set up a global trust fund for developing countries that allows them to purchase new drugs and therapies at a price that provides a rate of return competitive with successful product launches in the US and Europe. In addition, not-for-profit virtual drug companies bring together private and public-sector research to create new vaccines and drugs for diseases found in developing countries. These projects along with agricultural initiatives lift more than a billion people from "poverty status" to "customer status."

Transforming an Industry

The Biotrust Project has a profound influence on the development of the industry, helping to guide the biotechnology revolution through the wishes and needs of many people, not just the holders of capital or consumers of products. Some "fundamentalist" capitalist theorists argue that this approach is

creating an anomaly in the free-market system. But others argue that the real capital here is the knowledge of the genome itself, which, it could be argued, belongs to every living creature on the planet. In addition, if biotechnology is to benefit the world and not just the companies that hold patents, human societies need to produce more creative thinking about access to food and medicine. In this climate of public opinion, companies compete for the trust of consumers by competing for the highest standards and for the reputation of being socially conscious, committed to the environment, and transparent in their financial practices as well as in the basis of their risk-benefit analyses. Business learns to adopt its full, comprehensive role in society to help form the new game rules necessary for sustainable development.

The Biotrust Revolution – a Larger Vision

By 2030, the world is transformed. Most infectious diseases have entirely disappeared. A vaccine for Alzheimer's has greatly increased the chances that older people will live an active life right through to the end. And average life expectancy in the west is 120 years, thanks to new diagnostic techniques and cures – including cures for various cancers – that are genomically specific to individuals. Since 2020, 95% of human body parts have been replaceable with laboratory-grown organs, and the costs have continued to come down every year.

In farming, biotechnology means that much less energy and water are used, and food is cheaper, more nutritious, and more plentiful. In *Biotrust*, crops are genetically engineered to be optimally adapted to local growing conditions. Genetic diversity of crops actually increases as plants are more carefully "genetically tuned" to the local environmental conditions. Rather than losing species, the count of known species in 2030 is higher than it was in 2000. For the first time in modern history, the ecosystem is healthy, resource usage is down, the quality of life is high, and poverty is only relative. The seedbank project has grown into a worldwide foundation that has brought biotechnology to third-world countries. Food is now grown much nearer local markets, and so the old disparities between food production and food need are much reduced. Even the water wars of the early 21st century have disappeared, in large part because of the biotech revolution in drought-resistant plants and the clean-up of polluted water which has reduced water usage by 25%.

Building a Base for Biotrust

Stakeholder Dialogue

In 1996, Hoechst AG asked the Öko-Institut (Institute for Applied Ecology), an industry critic, to help the company develop a product sustainability assessment tool (PROSA) designed to integrate ecological and social aspects of sustainable development into the strategy of the company.

PROSA was tested on two products – a food preservative and a technical textile used in roofing – to see whether these products measured up to application alternatives. The entire life cycle of each product was included in the investigation. PROSA is not a rigid checklist, but a flexible tool. It doesn't provide answers but asks the right questions instead. Not only were the products shown to be sustainable, but the process in itself was also a success. Cooperation between Hoechst and its critics helped to eliminate prejudices on both sides, facilitating communication and calling established paradigms into question. Hoechst has concluded, as a general principle, that sustainable development is so broad and complex that it requires the involvement of stakeholders from the different markets and regions within which it operates.

New Paradigms for Business – from Profit to Brand

A group from the WBCSD Scenario Unit observed an example of the New Profit-to-Brand Paradigm at work when we spent a day with a major health care company that was thinking about its future. Health care, though profitable, was not as profitable as it had been. In fact, the company's ROE had fallen significantly and was also much lower than the sector average. So, a new strategy was called for. Not surprisingly, this strategy involved the company moving into the "wellness" quadrant, which was perceived to be much larger and easier to compete in.

The normal path from health care to wellness goes via prevention. And therein lay the rub. The company had tried this several times before, but did not succeed, because, as one participant put it, to make money in health care, you need sick people. Prevention, if it works, limits this number. This situation sets up a dilemma that in the past had always been resolved by simply dropping the prevention effort.

This time, however, the company came up with a different solution – to jump over prevention right into wellness. How could this be done? The answer was to establish a radically new reputation by *doing* something radically different. This, they thought, could be achieved by providing clean drinking water to everybody. The way to do this was to provide low-tech filtration technology so that everyone on the planet, no matter how poor, could have safe drinking water.

The numbers worked out at about $200 million dollars per year for five years, a small faction of this company's R&D budget and a small price to pay for significant brand recognition in the wellness market.

Contributing to the Global Commons

Novartis Seeds has donated its version of the Bt gene, which protects against pests, to the International Rice Research Institute in the Philippines. It has also planted 3,500 hybrid poplar trees around SuperFund sites to help rid ground water of pesticide residues that contaminate the soil. Yet another Novartis project, in conjunction with the World Health Organization, is the elimination of leprosy.

Monsanto donated its high beta-carotene oil technology to subsistence farmers through the US Agency for International Development, making it possible to deliver vitamin A in cooking oils and thereby protect thousands of children from night blindness and other illnesses and even death. Monsanto also has worked with Mexico and is working with Kenya to genetically improve subsistence crops so they can resist damaging viruses.

DuPont, Dow, Ciba Geigy, ICI, Astra Zeneca, GE, the US EPA, the US Department of Energy, and the US Department of Defense have formed a consortium for the bioremediation of chlorinated solvents.

Collaborating to Create an "Opportunity Commons"

Ten of the world's largest drug companies along with five leading gene laboratories and the Wellcome Trust came together in 1999 to create a SNP Consortium. SNPs – single nucleotide polymorphisms – are places in the genetic code where individual variations take place. These variations hold the clue to genetic pre-dispositions for various diseases and so are extremely important in the attempt to find new cures. The aim of the consortium is to create a SNP map and to disseminate it on the internet so that it can be available to all. Collaborating to put such a research tool in the public domain rather than competing with each other to patent the map, piece by piece, gives access to researchers all over the world, enlarging the opportunities for biotech-related cures and products.

Building a Market Framework for Sustainability

In 1996 Unilever, in partnership with the World Wide Fund for Nature, formed the Marine Stewardship Council. This independent, non-profit, non-governmental membership body is responsible for establishing a broad set of principles and criteria for sustainable fishing and for setting standards for individual fisheries. Only fisheries meeting these standards are eligible for certification by independent, accredited certifying firms. Products from certified fisheries are marked with an on-pack logo so that consumers can select those fish products that come from sustainable sources.

By 2040, the world has largely completed the process of shifting from non-renewable energy and chemical feedstocks – coal and natural gas, for example – to biological renewable resources that support a relatively decent quality of life for the global population – now 8.5 billion and soon to be 10 billion. This and all future generations are considered to have the food, fiber, energy, and chemical feedstocks they need, and they receive this bounty from just 30 to 40 per cent of the earth's surface. This development is just in time, as the compelling need to reduce greenhouse gases has been codified, and the resources of fossil fuels have passed from economic recovery. Human creativity has not only muddled through once again, with a solar-powered, renewable-resource-based economy, but future generations of humans have the opportunity to turn their full attention to the age-old questions of tolerance, compassion, beauty, and civility that are within the human potential, knowing that with the management of biological resources, the basic material needs of food, housing, and energy can be met for all.

Just as the social order of hunter-gatherers was replaced by a new way of life associated with crop cultivation and animal husbandry, so, too, the information age has been followed by the century of biotechnology, which has brought new rules to society and a better way of life. The World Bank, in conjunction with pharmaceutical corporations, has created a fund that makes health care developments accessible to all nations and cultures. The importance of "world health" is seen by most societies, as is the importance of genetic diversity, which is assured by global legislative developments initiated by the UN and the WTO.

Business practices, too, have undergone a transformation. So-called "stakeholder business design" has taken hold in most of the developed world, with its emphasis on stakeholder involvement in decision-making, transparency, and commitment to sustainable development. And within this new capitalism, the biotechnology industry has taken the central place as the largest sector of the global economy, not only because most new significant products and services are based in part on BBIs, but also because the companies themselves are quite profitable. Many of them attribute this to turning the corner from being product and technology oriented to becoming market oriented and from emphasizing short-term shareholder value to long-term stakeholder value. Employees in the industry pride themselves on being both "scientifically adept and socially enlightened" – in the

forefront, they claim, of the move from an ethos of "ownership" to one of "stewardship." And even though the gap between the rich and the poor is growing, the poor are relatively better off than ever before, and social mobility is increasing in most countries.

A Transformed Society

From the outside, this new society of 2050 looks like a Garden of Eden. But many of the old folks are a little nostalgic for the good old days. They are grateful for living longer, but feel sorry for young people, who do not have the wonderful illusion of being able to do anything they want to do. Much of what a young person thinks about his or her future is related to the individual genomic profile provided at birth. As each child grows up, part of the ethical and even religious training is focused on what someone with a particular profile is best suited for – and what the ethics are of going against the picture of the future suggested by the profile. Courtship and marriage are often overshadowed by issues of disclosure and genetic compatibility, not for offspring, who can be "fixed" in the womb, but for emotional characteristics suggested by different chemical and neurological profiles. Parenting involves an endless round of gut-wrenching decisions about what genes to fix and when in each child, and children themselves often fault their parents for not providing a better genetic base for intellectual and physical development. Courts both in Europe and the US appear to be increasingly willing to hold parents accountable in cases of gross negligence involving the genetic welfare of an unborn child, such as neglecting to modify the gene associated with schizophrenia.

While procedures of genetic modification are getting less expensive all the time, they still assume a significant proportion of a middle-class budget, which means that while absolute poverty is decreasing, the gap between the rich and the not-rich is growing at an even greater rate than it did in the late 1990s. For many, the developed nations look like the "commercially driven eugenics civilizations" biotechnology critics had prophesied.

In countries where the technology is still too expensive to be used extensively, there are fewer "superchildren" – but a higher proportion of children in relation to the numbers of older people. Most couples in developed nations have only one child because of

the cost of gene therapy in utero and before the fifth year. Thus, global demographics take an entirely novel turn. On the one hand are the less developed nations with many young boys (gender selection in the womb is easy to obtain through over-the-counter drugs to be taken at a certain periods in gestation). On the other are the "geriatric" nations with well-preserved 120-year-olds, many on their third or fourth organ transplant. These nations spend an enormous amount on health in relation to education. Meanwhile, most of the new innovations in science and technology are beginning to come from those nations with younger populations, and observers note a shift of knowledge production from west to east and north to south.

In richer nations, where genetic modification plays a larger role, most employers publish specific genetic profiles of the kind of employee they want, and prospective parents, aware of these ideal gene profiles, tend to demand genetic modifications that will give their offspring the edge in desired fields. Just as in the 20th century, certain names would be popular in cycles ("John" one year and "Michael" the next), in the 21st century, certain genetic profiles are in fashion in particular years. The similarity among children in certain age cohorts is sometimes uncanny. One curmudgeonly social critic complains that you have to go to a remote Pacific island to find an eccentric these days. A deeper complaint is that "modification" of children towards an ideal norm leads to prejudice against those who are even the least bit different – a prejudice that is subtler and more insidious than the old prejudices of race and gender.

These trends are disturbing only to the elderly, however. The young take them in stride, accepting the genetic modification of their children in the same way that their grandparents, liberated from the need for large families by labor-saving technology and antibiotics, accepted the downsizing of families from a dozen children to one or two. Every technology produces new challenges. As in ages past, human beings adapt themselves to whatever world their technology has created. And the world of *Biotrust*, for most observers, is the best world created yet.

Opportunities for Biotechnology

Biotechnology can:

reduce energy and water used in food production.
protect and increase biodiversity.
contribute to the remediation of depleted agricultural land.
facilitate soil conservation.
facilitate carbon sequestration in soil.
increase food production efficiency.
provide effective pest management with less resource consumption.
contribute to enhanced medical diagnosis.
offer medical cures with limited to no side effects.
offer new medical cures.
provide food for growing world population.
help protect the natural habitat.
create plants that can be used as bio-reactors.
provide new mining applications.
contribute to enzyme manufacturing.
contribute to tissue engineering.
facilitate bio-remediation.
provide bio-sensors.
provide bio-informatics.
provide nutraceuticals.
enhance forestry production.
provide therapeutic vaccines.

The Three Worlds Compared

	The Domino Effect	The Hare and the Tortoise	Biotrust
Driver	Fear	Consumer choice	Opportunities
Trust	Low	Limited	High
Biotech penetration	Growing, then plummeting	Specialized niche markets	Growing
Social Equity	Ignored	Locally addressed	Globally addressed
Sustainable development paradigm*	*FROG!* leading to *GEOPolity* with heavy regulations	*Jazz* – but biotech isn't much of a player	*Jazz* plus framework-building aspects of *GEOPolity*

*See WBCSD Global Scenarios for the Future of Sustainable Development (www.wbcsd.ch/publications/scenariosum.htm)

The Business Case for Sustainable Development

Business is about making money. But how business makes money is changing dramatically, and sustainability is one organizing frame for tomorrow's value creation.

Isaac Asimov was asked once, "How many people can this earth sustain?" He answered by saying, "This question is incomplete as it stands. One must ask further: At what level of technology? And ask further still: At what level of human dignity?"

Sustainable development is the language we need to address two central questions: How can six billion people, who know a great deal about each other, live in dignity? And what is their relation to technology?

There are three profound changes we must deal with, as citizens, as organizations, as regions, and as nations.

1 From material constraints to meaning constraints.

Our world is changing rapidly from one in which the removal of material constraints dominated everything we did, to a world in which we will spend less than half of our time on meeting those material needs. While seemingly trivial, this shift is profound and unsettling. The questions this shift begs are: How will we live? What will we value? What will we, as individuals, as companies, as regions, and as societies, do with our time? And, hence, what will each of us need to do to survive and prosper in this world?

This transition will play itself out along three dimensions:

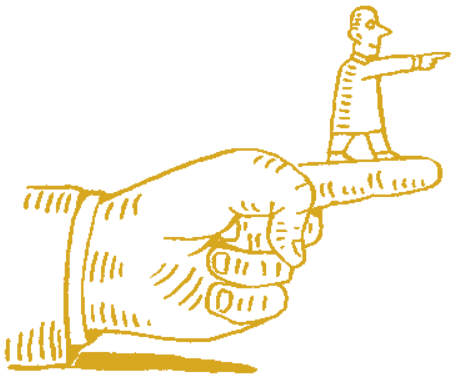
- Dominant constraint – material or meaning.
- Structures of everyday life – linear or closed feedback loops.
- Power base – physical assets or networks.

Sustainable development is an organizing principle that allows this shift from material to meaning to be turned to advantage.

2 From being part of the system to becoming the system.

Traditionally, we were able to rely on the buffering function of the world around us so that the impacts of our activities were independent and self-limiting in space and time. Now that our impacts have reached geophysical proportions – complex engineering, as in Chernobyl; climate change; germline therapy – we can no longer take for granted the ability of nature's buffer to allow us to learn from our mistakes. We need to think through our actions and anticipate their consequences. Because we've never had to do this in the past, we're not good at it. Worse, entire industries (the insurance industry being the most obvious one) have been built on the assumption that the biosphere operates as a "free buffer" system. Sustainable development is an organizing principle that allows us to re-think the place of us humans as part of the biosphere.

3 The shifting of top -line growth.



Traditionally, every product and service competes on a mixture of four attributes: availability, price, quality, and mass customization. But in a globalized world, where it is cheaper when you live in Geneva, Switzerland, to buy a book from Amazon.com than to go to the local bookseller, all these attributes have become commoditized. In a commoditized world, your only strategy is to become a cost leader; yet, by definition, there is room only for one global cost leader.

Just as the Japanese "invented" quality as a fourth, differentiating attribute when the rest of the world was competing on availability, mass customization, and price, so we need to invent a new, fifth attribute to again be able to differentiate ourselves in order to survive and prosper in the future.

Sustainable development is this fifth attribute that will generate competitive advantage for companies and regions.

Shaping the Future

Under these circumstances, companies derive competitive advantage by creating contextual meaning out of sustainability through creating stories (the policy framework) and market-making projects (the business opportunity).

Story building work is the creation of a "new language" that offers a policy tool for shaping the future. The process includes three main aspects. First, the external policy work – which is done through shared scenario projects – aims at building the framework for sustainable business and industry. Then, the internal policy work – which is done by the companies – contributes to the strategy building within the organization. Third, joint projects that increase the health of the market or create entirely new markets – carbon trading, for example – form the ultimate "business work" that creates new sustainable markets that will contribute to shaping the future. Reflection, creativity, and innovation are required to establish new products and services capable of providing clear competitive advantages for the business sector and for society as a whole.

Ulrich Goluke
Manager, WBCSD Scenario Unit

Glossary

BBI	Biotechnology-Based Innovation.
Bioinformatics	The science that uses advanced computing techniques for management and analysis of biological data. Bioinformatics is particularly important as an adjunct to genomic research, which generates a large amount of complex data, involving billions of individual DNA building blocks, and tens of thousands of genes.
Cloning	The generation of a cell or organism that is genetically identical to another cell or organism. In molecular biology, cloning refers to the act of isolating a piece of DNA from an organism and inserting it into another DNA molecule (vector) that is capable of replicating in bacteria or other cell-types. The vector containing the inserted piece of DNA is referred to as a clone.
Diversity farming	Farming that uses many and varied technologies and processes tailored to specific consumer needs.
DNA (deoxyribonucleic acid)	The molecule that carries the genetic information (blueprint) for most living systems. DNA is a linear, double-stranded chain of nucleotides that is packed into chromosomes in the nucleus of every cell.
DNA bank	A storage repository for DNA extracted from blood samples or other human tissue. Analysis of DNA samples stored in the DNA bank may be used to help individuals and their physicians trace the pattern of disease in families, or to aid future medical research areas.
DNA library	A collection of cloned DNA fragments from an organism's genome. A particular library may include clones of all the DNA sequences expressed in a certain kind of cell, or in a certain organ of the body, or fragments from the nuclear DNA (i.e., the genome) of an organism.
Functional food	A food that is marketed with a scientifically based health claim.

Genetic predisposition	Susceptibility of an organism to develop a specific disease due to genetic alterations (mutations). Because environmental factors play a large part in the expression of certain traits, the organism may or may not actually develop the predicted disease.
Genetic testing	Analyzing the hereditary profile of an organism; the use of specific biologic assays to analyze an individual's genetic profile.
Genome	An organism's complete set of chromosomes and genes; the total hereditary material in an organism.
Genome map	A reconstruction of the entire set of chromosomes for a given organism, showing the relative position of every gene.
Genomics	The study of an organism's entire complement of genetic material.
Genotype	The genetic characteristics or description of an organism defined by the nucleotide sequence of the genome.
Human Genome Project	An ongoing, global research effort aimed at mapping and decoding the complete human genome.
Marker	A commonly occurring genetic variation that can be easily tracked in genetic studies. Markers can be entire alleles, repetitive stretches of DNA, or single nucleotide polymorphisms.
Mutation	An alteration in a gene that can be transmitted from one generation to the next. Although many mutations are associated with defects, some have no effect on the health of an organism.
Nutraceuticals	Functional ingredients for food products and food supplements that have a scientifically based health claim.
Organic farming	Farming characterized by a holistic agricultural system that aims to enhance biological cycles in agriculture, and to work with renewable resources within a closed system with regard to organic matter and nutrient elements. It also takes into account biodiversity, animal welfare, and the social and ecological impact of farming. Organic farming does not allow the use of synthetic chemicals for fertilizing and crop potention.

Permaculture	The conscious design and maintenance of agriculturally productive ecosystems which have the diversity, stability, and resilience of natural ecosystems.
Pharmacogenomics	The application of genomics to pharmaceutical research; using genome studies to identify genes that affect how drugs work in different individuals.
Phenotype	The physical appearance or observed characteristics of an organism that are the result of the interaction between the genetic characteristics (genotype) of the organism and its environment.
Sequencing	The process of determining the specific order of nucleotides in a DNA molecule. Sequencing also refers to determining the order of amino acids in a protein.
SNPs (single nucleotide polymorphisms)	Places in the genetic code where individual variations take place. These variations hold the clue to genetic pre-dispositions for various diseases and so are extremely important in the attempt to find new cures.
SNP map	A collection of SNPs that can be superimposed over the existing genome map, creating greater detail, and facilitating further genetic studies.
Transgenic	Modified through genetic engineering.

Acknowledgements

It is rare that people who live the pressures of providing relentless shareholder value, immediate returns, and global competition take time to venture into the future. This speaks of courage, curiosity, and concern: Courage – because business usually celebrates out-of-the-box thinkers only as long as they are not on the payroll. Concern – that doing tomorrow what we did today (perhaps a little more efficiently) is no longer good enough. And curiosity – about what we will see if we do take a fresh look at what might be possible.

This project required more courage than others I have worked on. While conceived long before the concerns, especially in Europe, over genetically modified organisms in food, the bulk of the work was actually done right at that time. It would have been easy to mimic in our stories the debate that was then taking place in the *Economist*, the *Wall Street Journal*, the *New York Times* and other news media. Easy, but not very helpful for companies and others trying to understand the ethical dilemmas of this new technology in all its implications. Hence, our stories are mostly about the pharmaceutical and medical side of the technology. We believe that it is here that the biggest challenges will lie – for companies, NGOs, societies, and every one of us.

Scenarios are not intended to predict the future; working with scenarios, however – for example, exploring different strategies inside alternative scenarios – helps create options for the future. Hence scenario work requires from participants a tolerance for ambiguity. Thus, I want to thank all participants who had, or who developed in the course of this work, a great deal of this tolerance.

When we created global scenarios for the future of sustainable development – *FROG!*, *GEOPolity*, and *Jazz* – the director of the project, Ged Davis, said, "In all my previous work, I have been dealing with a problem relative to a given frame. This project makes the frame the variable. There is nothing left to hold onto."

Only strong, dedicated, and creative teams can work with nothing to hold onto. We had such a team, and it is a privilege to thank everyone for the risks that they took. We were able to assemble a core team that already in this world works like a ”jazzy” team:

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Arthur Einsele	Novartis
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Bob Dorsch	DuPont
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Chuck Hong	Procter & Gamble
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Hans Peter Schelling	Novartis
Hans Rudolf Keller	Novartis
Henrik Gurtler	Novo Nordisk
J. Bordewijk	Unilever
Jill Montgomery	Monsanto
Jim Gooch	DuPont
Jørn Mahler	Novo Nordisk
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Klaus von Grebmer	World Bank
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Lutz Knabe	Hoechst Schering AgrEvo
Michel de Rougemont	Novartis

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Pattie Ward	Monsanto
Per Ivar Abyholm	Norsk Hydro
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