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The Biotech Century

Genetic Commerce and the Dawn of a New Era*

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For years, futurists have heralded the Information Age, championing the computer as the prima donna of global revolution. But what the titans in the computer industry–notably Bill Gates–and Wall Street insiders now understand is that the computer is merely the handmaiden to a much more profound business, namely genetic commerce. Increasingly, it is being used to manage and organize genetic information–the raw resource of the new global economy. The 20th century was shaped by spectacular breakthroughs in Physics and chemistry, but the stars of the 21st century will be the biological sciences, and those deciphering the genetic code of life. After thousands of years of fusing, melting, soldering and forging, we are now splicing, recombining, inserting, and stitching living material.

At the heart of the revolution is the ability to create a second genesis–a synthetic one, geared to human productivity. With the newfound ability to store and manage genes, we can, for the first time in history, engineer life itself, reprogramming the genetic codes of living entities to suit our own needs. Before us lies an uncharted landscape whose contours are being shaped in thousands of laboratories in universities, government agencies and corporations around the world. If the claims already being made are partially realized, the consequences for future generations will be enormous.

Indeed, our lives are likely to be more fundamentally transformed in the next few decades than in the past 1,000 years. As increasing amount of food and fiber will be grown indoors in tissue culture in giant bacteria baths. Animal and human cloning will be commonplace, with replication increasingly replacing reproduction. Individuals will be able to obtain a detailed genetic readout of themselves, allowing them to gaze into their own biological future and plan their lives in ways never before possible. Parents may choose to have their unborn children gestated in artificial wombs.

Genetic changes could be made in human fetuses to correct deadly diseases and disorders, as well as enhance mood, behavior, intelligence and physical traits. The consolidation of the life sciences industry by global commercial enterprises rivals all other mergers and acquisitions in the telecommunications, information or entertainment arenas-but to date, has received little attention. Typical of the trend is the decision last year by Monsanto Corporation, long a world leader in chemical products, to sell off its entire chemical division and anchor its research, development and marketing in bio-tech products. Using the most advanced computers and software technology, molecular biologists are mapping and sequencing the entire genomes of creatures from the lowliest bacteria to human beings. By the end of the second decade of the 21st century, they hope to have catalogued a vast library of evolutionary blueprints. Says Gates, "Biological information is probably the most interesting information what we are deciphering and trying to decide to change. It's all a question of how–not if."

Global life science companies are quickly manoeuvering to exert their influence and the concentration of power is already impressive. The top 10 agrochemical companies control 81 percent of the $29 billion global agrochemical market. Ten life science companies control 37 percent of the global seed market, worth 1.5 billion annually. The world's major pharmaceutical companies control 47 percent of the $197 billion pharmaceutical market. Ten

global firms now control 43 percent of the $15 billion veterinary pharmaceutical trade. Toping the life science list are 10 transnational food and drink companies whose sales exceeded $211 billion in 1995.

Several of the largest life science companies are extending their commercial activities to virtually every bio-industrial field. Novartis, a giant new firm resulting from the $27-billion merger of two Swiss companies-Sandoz (pharmaceuticals) and Ciba-Geigy (argochemicals)– is the world's largest agrochemical company, the second largest seed company, the second largest pharmaceutical company and the fourth largest veterinary medicine company. The increasing consolidation of control is alarming, especially considering that the biotech revolution will affect every aspect of our lives: the way we eat, the way we date and marry, the way we have our babies, the way our children are raised and educated, the way we work, the way we perceive the world around us and our place in it.

For those corporate giants, genes are "green gold." The economic and political forces that control the genetic resources of the planet will exercise tremendous power over the future economy. The awarding of patents on genes, cell lines, genetically engineered tissue, organs and organisms, as well as the processes used to alter them, is a huge commercial incentive, In the years ahead, the planet's shrinking gene pool is going to become a source of increasing monetary value. Multinationals and governments are already scouting the continents for microbes, plants, animals and humans with rare genetic traits that might have future market potential.

A battle of historic proportions is raging between the high-technology nations of the North and the developing nations of the South. Most of the planet's genetic treasures are found in the biologically rich tropical regions, and the Southern Hemisphere nations contend that genetic resources are part of their national heritage. Transnational corporations argue that patent protection is essential if they are to risk years of research to bring new products to market. And a growing number of organizations are beginning to take a third position, arguing that the gene pool ought not to be for sale, at any price.

What has made the debate even more urgent are increasing reports of bioprospecting: scientists sampling the genotypes of the few indigenous peoples that have remained isolated, in the hopes of finding genetic surprises. The entrepreneurial scramble has picked up substantial momentum, thanks to the quickened pace of mapping and sequencing the approximately 100,000 genes that make up the human genome. Companies are quickly securing patents on human chromosomes, cells, tissues and organs, giving them commercial ownership over virtually every part of the human body. Dr. Ian Wilmut, who cloned the sheep Dolly, has filed for a patent on all cloned animals, including cloned human embryos. If granted, Wilmut and his corporate partner PPL will be able to claim all cloned human embryos as their intellectual property. While the biotech age threatens, it also holds great promise: a cornucopia of new plants and animals to feed a hungry world, new wonder drugs and genetic therapies to eliminate human suffering, new sources of energy. But the nagging question remains: at what cost? will the artificial creation of cloned animals mean the end of nature? Will the mass release of thousands of genetically engineered life forms into the environment cause genetic pollution and irreversible damage to the biosphere? What will it mean to live in a world where babies are genetically engineered and customized in the womb, and where people are increasingly identified, stereotyped, and discriminated against on the basis of their genotype? What are the risks we take in attempting to design more "perfect" human beings?

The globalization of commerce makes possible the wholesale reseeding of the biosphere, an artificially produced bio-industrial nature designed to replace the evolutionary scheme. The growing arsenal of biotechnologies is providing us with powerful new tools to engage in what will likely be the most radical human experiment on life forms and ecosystems in history. Imagine the wholesale transfer of genes between totally unrelated species. Imagine clonal propagation mass-producing countless replicas of these new creations, releasing them into the biosphere to propagate, mutate, proliferate and migrate. This is, in fact, the great scientific and commercial experiment underway, as we turn the corner into the Biotech Century.

Corporate leaders in the new life industry promise an era where evolution itself becomes subject to human authorship. But critics worry that the re-seeding of the earth could lead to genetic pollution: destroying habitats, destabilizing ecosystems, and diminishing the remaining reservoirs of biological diversity on the planet. Each new synthetic introduction is tantamount to playing ecological roulette. The long-term cumulative impact of thousands of introductions of genetically modified organisms could well exceed the damage that has resulted from the release of petro-chemical products into the earth's ecosystems.

When Aldous Huxley wrote his distopian novel Brave New World in 1932, few would have guessed that his vision of a eugenic civilization would be in place by the end of the 20th century. Breakthroughs in genetic screening, including DNA chips and somatic gene therapy, are paving the way for the wholesale alteration of the human species and the birth of a commercially driven eugenics civilization. Gene screening raises the real possibility that we might be able to re-engineer our won genetic blueprints of our own species. It would be difficult to imagine parents rejecting genetic modifications that promised to improve, in some way, the opportunities for their progeny. According to a 1992 Harris poll, 43 percent of Americans "would approve using gene therapy to improve babies' physical characteristics."

Increasingly, parents will be asked to decide whether to take their chances with the traditional genetic lottery, or undergo corrective gene changes on their sperm, egg, embryo or fetus. If they choose the traditional approach, they could find themselves culpable if something goes wrong, something they could have avoided through corrective genetic surgery. Proponents argue that it would be cruel not to use new technology to eliminate serious disorders. But if diabetes, sickle cell anemia, and cancer are to be prevented, why not proceed to other so-called disorders such as myopia, dyslexia or short stature? What makes the new language of molecular biology so chilling is that it threatens to create an unattainable archetype: a flawless human being, without the vulnerabilities that have defined our essence.

Should humanity even begin the process of engineering future generations? New studies on the genetic basis of human behavior are providing a cultural context for the widespread acceptance of new biotechnologies. Researchers are already linking an increasing number of mental diseases to genetic disorders. Some scientists are even beginning to suggest that various forms of antisocial behavior, such as misanthropy and criminality, may be evidence of malfunctioning genes. The Minnesota Center for Twin and Adoption Research has published its findings on the power of heredity in a number of common personality traits: in determining extroversion, heredity registered at 61 percent; for aggressiveness, the figure was 48 percent. Many sociobiologists go even further, contending that virtually all human activity is determined by genetic makeup. It is important to remember that from the end of the Second World War through the 1980s, social scientists argued nurture over nature. Now, plagued by deepening social crises, industrial nations seem unable to effect significant changes through institutional and environmental reform. Sociobiologists and others contend overhauling the economic and social system is at best palliative, and, at worst, an exercise in futility. The

master molecule is an explanatory tool for understanding personality development, adolescent behavior, ethnic and racial differences, collective psychology, and even the workings of culture, commerce and politics. If we wish to change society, we must first change our genes-the agents most responsible for individual and group behavior.

The radical shift from nurture to nature is attributable, in part, to the intense interest generated by the multi-billion dollar Human Genome Project. Dr. James Watson, who served as the first director of the U.S. government-funded effort to decipher the human genome, has boldly asserted, "We used to think our fate was in our stars. Now we know, in large measure, our fate is in our genes." A few lone voices continue to caution about genetic reductionism. Dr. Jonathan Beckwith, a professor of microbiology and genetics at Harvard University, and one of the early pioneers in the field of molecular biology, argues for a more balanced presentation of the relationship between genetics and environment. He stresses that many diseases, including cancer and depression, are the result of the interactions of genetic predispositions and environmental triggers. Reforming the environment is one remedial strategy not to be ignored.

Genetic engineering represents our fondest hopes and aspirations, as well as our darkest fears and misgivings. The new gene splicing technologies promise a better way of life. Some of the new products and services will even deliver on those promises. On the other hand, they raise one of the most troubling questions in all of the human history. In whom should we entrust the authority to decide which gene is a good one and which is a bad one? The federal government? Corporations? University scientist? We appear caught between our instinctual distrust of the institutional forces and our desire to increase our own personal options. The problem is that biotechnology has a distinct beginning, but no clear end. In the decades to come, we might well barter ourselves away, a gene at a time, in exchange for some measure of temporary well-being. In the end, the freedom and security we fought so long and hard to preserve may well have been irreversibly compromised in pursuit of our own engineered perfection.

The fact is, the corporate agenda is only one of two potential paths to the Biotech Century. Molecular biologists are now inserting genes into the biological code of food crops to make them more nutritious and more resistant to herbicides, pests, bacteria, and fungi. Many are trying to find an approach to agriculture that relies on integrated pest management, crop rotation, organic fertilization, and other sustainable methods designed to make farming compatible with the surrounding ecosystems. Similarly in medicine, molecular biologists are focused on somatic gene surgery, pumping altered genes into patients with illnesses and disorders. Others are exploring the ties between genetic mutations and environmental triggers, with the hope of fashioning a more sophisticated approach to preventive health.

In the coming Biotech Century, it is possible that society will accept some sues of genetic engineering and reject others. To believe that genetic engineering is the only way to apply our new knowledge keeps us from entertaining other options, ones which might prove even more effective in addressing the needs of current and future generations. The biotech revolution will force each of us to put a mirror to our deeply held values, of existence. This may turn out to be its greatest contribution. The rest is up to us.