From Forges of Fire to the Creation of Life: Persistance in the Biotechnical Age

by Dwayne Minton

Introduction

There is no such thing as the present, only the immediate past and the immediate future

Rich Somerville

Many visions of the future exist&emdash;a vision for every man, woman, and child that inhabits this Earth. Visions are individualized, colored by the experiences of the dreamer, the prophet, or the futurist, but some visions share common threads and agents of social change, that is, what drives the evolution of human culture. Jim Dator (1993) has outlined what he calls five "tsunamis" of change. These include demographics, economics, the environment, technology, and politics. This paper will examine only one of these "tsunamis"&emdash;technology. Specifically, one aspect of technology that will be important in shaping human society in the coming years will be investigated. That technology is genetic engineering, the ability to mechanically alter the basic plan of life and, in essence, manufacture living organisms.

This paper will focus on the work of two futurists. Jeremy Rifkin[1] is President of the Foundation on Economic Trends, an organization opposed to the implementation of biotechnology. Rifkin has been at the forefront of the genetic engineering debate for nearly two decades, and he foresees dire consequences if humanity proceeds to pursue mastery of life. Susantha Goonatilake[2] is a futurist and proponent of biotechnology, Goonatilake believes this new science will bring renewed vigor and diversity to the planet.

This paper will examine and critique the future images of these two men. These images will be expanded, and the importance of biotechnology to the future of humankind will be examined.

What is biotechnology?

Just as we have manipulated plastics and metals, we are now manufacturing living materials.

Lord Ritchie-Calder

Before the effect of biotechnology on human culture and society can be examined, a clear understanding of biotechnology is needed. This section will discuss the biology of DNA, the basic techniques behind genetic engineering, and the current state of the field.

Biotechnology is the ability to manipulate the basic plan of all life. It is the ability to take life and shape into whatever one desires. This is done by selectively altering the ultimate blueprint of every living being, deoxyribonucleic acid or DNA.

DNA is made up of four units, called bases: adanine, guanine, cytosine, and thamine. These bases are linked together in a long chain or polymer. Each base binds with a complementary base creating a base pair. When pairing, adenine always binds with thamine; guanine always pairs with cytosine. This highly deterministic pairing allows DNA to be replicated. At a stage just prior to cell division, the double strand of DNA is "unzipped" and complementary bases are added to each resulting single strand. At the end of replication, two identical strands of double-stranded DNA result. One set of DNA is then passed on to each of the two daughter cells when the parent cell divides.

The DNA bases contain the information to produce cellular proteins. This vast library of DNA information is called the genome. Through proteins, the cell is able to construct itself and obtain what is needed from the environment to survive. The bases that code for a specific protein in a cell are called a gene. If a gene lacks part of the DNA code (it is possible, for reasons not discussed here, that genes might not contain the entire code for a protein), the resulting protein from that gene is either not produced or is faulty. This can be, but is not necessarily, fatal to the organism.

With current modern technologies, it is possible to isolate and determine the function of genes. The genetic code, that is the base pair sequence, of the DNA can be determined. The genetic code and function for many housefly genes already have been deciphered. Using techniques such as Polymerase Chain Reaction (PCR), it is possible to create multiple copies of DNA sections, to isolate them using electrophoresis techniques, and reinsert them into a genome using recombinant DNA methods. Recombinant DNA methods are powerful enough to cross species' boundaries; genes from one species can be inserted into another. These new organisms, which contained another species' DNA in its own genome, are called transgenic organisms.

An understanding of gene identities and locations along with these biotechnical techniques make it possible to alter a gene, remove it entirely, or place it in another genome. This changes the organism at its most basic and heritable level. Offspring from this transgenic organism, if the proper insertion techniques are used, will carry the transgenic gene.

Currently underway and slated for completion around the new millennium is the Human Genome Project. This government funded research project is deciphering the entire human genetic code; it is identifying and locating genes. From this effort and related studies, genes linked to obesity (Anonymous, 1994) heart ailments (Muller, 1994) memory (fully, 1994), and several other hereditary disorders have been identified in the past year.

Recombinant DNA techniques have created transgenic tobacco plants that glow in the dark (Weaver and Hedrick, 1989). Spliced into the tobacco genome are genes for the firefly enzyme luciferase. When expressed in the cells of the tobacco plant, the enzyme emits light much like a firefly would at night. This technological feat was accomplished over a dozen years ago. Transgenic mice also have been created. A strain of laboratory animals that are more than twice the size of normal mice have a human growth hormone gene inserted into their DNA (Weaver and Hedrick, 1989). In 1990, the first transgenic humans were created (Anonymous, 1990; Raffaele, H.S., 1993)). Patients suffering ADA, a disorder better know as the "Bubble Boy Syndrome" received a human gene along with a bacteria plasmid (to activate the gene once inside the patient). These transgenic humans are alive and well today, having been successfully treated for their ailment through gene therapy.

Soon to be on the commercial market are transgenic bruise and rot resistant fruits (Stephens, 1992), oil eating bacteria, and a frost resistant potato fungus that protects potato plants from freezing (Stephens, 1992). On a disconcerting note, biotechnology is being used by the U.S. government in its newly resumed biological weapons research (Dickson, 1986).

The Flows

The world is perpetually in flux the only constant is change.

The human world can be divided into three flows or lineages: the genetic, the cultural, and the technological. Each flow consists of information that can be acted upon and changed in time through the process of evolution. Each flow has its own inherent rate of change and its own direction, and therefore can be described as a vector in its own environmental continuum. These three flows, when taken together, characterize the human system.

Each flow operates in a flow-specific environment (Goonatilake, 1991, 1993b). This environment is constantly changing in a non-deterministic manner and is modified by interactions with each of the three flows. The environment can be complex or simple, independent of the flow complexity. The environment, though modified by the flows is external to the flow. In order to persist, a flow must adapt to its environment. All flows must evolve using not only the historical information contained with in its lineage, but also by using novel information spontaneously arising through mutation.

Each flow gains complexity as it progresses through its evolutionary life (Goonatilake, 1991, 1993). Complexity results from the gradual accumulation of information through time. Greater complexity results in more interactions among the flows and with the flow environments.

In order for the human system to persist, a low level of inherent complexity must be maintained and all three flows must be present. Low complexity reduces the interactions between the three flows and between the flows and the flow environments. Though not intuitively obvious, the Eltonian concept of complexity begetting system stability has been shown to be inaccurate (Pimm, 1979, 1988; Pimm and Lawton, 1980). Low complexity systems are generally more stable than highly complexity systems. A complex environment may allow a complex flow to persist through compartmentalization; the increased diversity in the environment may help to reduce interactions among the flows. To eliminate any of the three component flows will lead to the destruction of the human system, though it is possible that the system may continue in some other form.

The following sections, will examine the three flows individually

Genetic

DNA is the code of life. All carbon based life is coded for from the four base nucleic acids. DNA has existed for at least 3.5 billion years (Futuyma, 1986). At the beginning of the genetic information lineage, the amount of information and complexity was low (Goonatilake, 1991). The genetic environment, that is the physical environment of the Earth, was relatively simple. No unbound oxygen existed (Futayma, 1986). Through mutation, single celled organisms began to photosynthesize and produce free oxygen as a biproduct (Futoyma, 1986). This interaction with the environment is believed to be a major catalyst for the further evolution of the genetic lineage; the genetic flow became more complex. The human genome alone now contains over 6 billion base pairs and an estimated 20,000 genes (Weaver and Hedrick, 1989). If every base in the human DNA were to be represented by a single letter of the alphabet (i.e. A, T, C, or G), and recorded on the pages of a book so that each page contained 1500 letters, and each book contained 1000 pages, it would take over 4000 volumes to record the entire information in the human genome. The human genome represents only a small portion of the information in the genetic flow (Ayala, 1994). Genetic homology studies have demonstrated relatively low similarity between humans and distantly related organisms such as plants&emdash;humans share approximately 40% of their DNA with plants (Washburgh, 1978)).

The genetic information lineage constantly changes through time. Mutations result from imperfect replication of the DNA prior to cell division (Weaver and Hedrick, 1989). The new combinations of base pairs may change the function of a gene. If this mutation occurs in the reproductive cells of an multi-cellular organism, the mutated gene is passed along to the offspring. Through time, the genetic environment acts on the novel productions in what appears to be a neutral manner: lethal genes disappear from the lineage and beneficial and neutral genes persist (Kimura, 1979).

Cultural

The cultural flow contains the information that defines all societies, whether they are animal or human societies. Altman (1965), a biologist, defined societies as "an aggregate of socially intercommunicating, conspecific individuals that is bounded by frontiers of far less frequent communication."

Learned interactions among society members constitute the bulk of information in this flow. Even "simple" animals display learned responses. In humans, learned behaviors are important for inclusion in a cultural community. In human societies, learned behaviors, ideas, and morals are culturally determined (Rifkin, 1983, 1985, 1991). Human society is what makes humans distinctly human.

Like genetic lineage, cultural flow has increased in complexity through time. Evolutionarily older societies are less complex than their younger counterparts. The cultural lineage, like the genetic flow, changes through slow mutations&emdash;by adding and deleting "cultural bases," in much the same way nucleic acids are mutated in biological organism. Again neutral selection acts on the novel cultural "genes" (Goonatilake, 1979,1991, 1993). Changes in the cultural information flow are more rapid than in the genetic flow, occurring on the order of decades or centuries (Goonatilake, 1993).

Technological

Technology is the implementation of exosomatic information (i.e. tools, techniques, etc.) in an attempt to better one's existence. For this reason, Goonatilake (1991) has termed this flow the exosomatic information lineage. Many animals use some form of technology. Chimpanzee's use sticks to obtain food. Pack animals such a wolves and lions use specialized, learned hunting tactics; sea otters employ stones to hammer open clam shells. Technology, however has reached its most complex state in humans.

Humans employ technology to alter the environment (Goonatilake, 1991; Rifkin, 1983, 1985, 1990, 1991). The implementation of fire was the first great technological discovery. By using fire, humankind forged a highly controllable, exceedingly complex, physical environment (Rifkin, 1983, 1991). Rifkin (1983, 1985, 1991), among others, has argued this is done to achieve security.

The technological flow has increased in complexity with time. Evolution has been rapid, and it is estimated that human technological knowledge doubles every two years (Goonatilake, 1991).

Interactions

...[P]lants and animals, remote in the scale of Nature, are bound together by a web of complex relations.

Charles Darwin

The flows do not evolve independently of each other (Goonatilake, 1991, 1993). Flows interact with each other and through each in a complex manner. The more complex a given flow, the more it interacts with each of the other two and with the various flow environments. Through these interactions, each flow experiences its own individual, mediated evolution. Goonatilake (1991) has examined each of the six possible flow-flow interactions. Rifkin (1983, 1991), though he only recognizes the flows in principle, examines three of the six possible flow-flow interactions: technology's interaction culture and genetics, and culture's interaction with technology. Goonatilake (1991) briefly addresses the interactions of the flows on the flow environments.

Cultural and Genetic Flow Interactions

Our genetic make-up determines our phenotype (Futuyma, 1986). Through our phenotype, we experience the world. Genetically controlled sensory organs[3] mediate interactions with the external world, and thus the various flows and flow environments. The manner in which we perceive the world is critical to how learn and how we are accepted in the social community. The inability to communicate effectively has drastic and dire consequences on the individual and the culture. The cultural world is a product of sensory limitations.

Genetic links to memory have been uncovered (fully, 1994); memory plays a pivotal role in the passing and maintaining of cultural information.

Indirectly, culture has interacted with the genetic flow through technology (see below).

Cultural and Technological Flow Interactions

Technologies are socially manifested (Goonatilake, 1982, 1984, 1988, 1990,1993; Rifkin, 1980, 1983, 1985, 1991). Every time a technological device is created, it carries with it the cultural information of the inventor. Every technological device is a congealing of a particular evolution of a discipline as it is influenced by a particular social history. It is an amalgamation of the outcome of human discussions and of human struggles, and reflects, for example, the outcome of social interactions between the inventor and his peer group as well as socio-economic forces such as those related to funding levels, market shares, and national policies.

In biotechnology, culture will dictate what genes get examined and spliced (Goonatilake, 1991). Culture will dictate what diseases get cured and what disorders or malformations get attention (Rifkin, 1983, 1991). Heart disease, a distinctly western ailment, already receives considerable funding from the various agencies including the National Science Foundation (NSF). Genes linked to heart disease have now been isolated (Muller, 1994).

Technology has direct and far reaching interactions with culture. This is most evident in traditional societies that received new, foreign (Western?) technologies. Introduction of televisions, batteries, radios, etc. to tradition Pacific island cultures has led to a rapid shift in the societal values of the indigenous people. Technologies such as air travel and electronic communications have had enormous historical effects on culture. Whereas different societies seldom had contact with each other in historical time, these new technologies have brought these diverse cultures into frequent interaction.

The creation of sensory enhancing technologies has allowed an expansion of the perception of the human world. Through prosthetics and modern medicine, sensory impaired individuals are able to interact with the external world. Their input into cultural flow is not removed as it may have been a hundred years ago.

Genetic and Technological Flow Interactions

Currently, the genetic flow interacts with the technological flow primarily through culture (see above). However, attempts to use molecular switches or DNA based switching elements as computer circuitry are currently under investigation (Goonatilake 1993). "Biochips" hope to incorporate biological elements directly into future hardware.

Technology has interacted with genetics by increasing survivorship. New medicines and prosthetics have allowed lethal genes to survive. With these lethal genes, novel neutral or beneficial genes may be preserved in the human genetic library.

Through technology, organisms can be preferentially mutated to obtain novel gene combinations. The practice of selective breeding has a long and varied history, involving organisms as diverse as maize and apples, houseflies and humans. With biotechnical techniques, species boundaries can and are crossed. Species boundaries are dissolving and the entire genetic pool will be available to all organisms. The genetic changes will have far reaching "feedback effects" on every aspect of the human system.

Profile: Jeremy Rifkin

Jeremy Rifkin, born in Denver Colorado on January 26,1945 and raised in Chicago, earned a bachelor's degree in economics from the University of Pennsylvania and a masters in international affairs from the Fletcher School of Law and Diplomacy at Tufts (Contemporary Authors). He became a political activist in 1967 when he organized a march against the Vietnam war.

In 1977, Rifkin established the Foundation on Economic Trends, an organization that has focused on the issues surrounding genetic engineering and biotechnology. Rifkin, alarmed by these advances, envisions a future in which humankind controls and exploits the genetic composition of all life, including its own, through cloning, selective breeding, gene transference, and discrimination based on cultural and commercial eugenics. He fears biotechnology is outpacing society's ability to identify and assess its negative social, moral and economic implications (Anonymous, 1985).

"I don't think you have to be a molecular biologist to be informed about the issues on genetic engineering and to speak out

forcefully and passionately and intelligently on those issues.... [I]n many ways the expert are the least capable of judging the overall context in which their science and technologies are being introduced, because their disciplines are so specialized and their thinking so narrowly constrained and so reductionist in outlook that they don't have the kind of broad based framework needed to make judgments that affect the entire culture (Anonymous, 1985)."

Rifkin uses a variety of techniques to pull his vision together. He quotes often from scientific literature, and displays a wide breath of knowledge in many fields of science, philosophy, history, religion, and economics. He has a keen eye for emerging trends.

Embraced by many as a true activist and leader, Rifkin is reviled by many scientist, government officials, and business people. Of Rifkin's most controversial book Algeny, Stephan J. Gould (1985), a respected evolutionary biologist wrote, "I regard Algeny as a cleverly constructed tract of anti-intellectual propaganda masquerading as scholarship. Among books promoted as serious intellectual statements by important thinkers, I don't think I have ever read a shoddier work." Gould continues: "[Rifkin] uses every debater's trick in the book to mischaracterize and trivialize his opposition, and to place his own dubious claims in a rosy light." Even with the criticism against Rifkin's approach, Gould does "not disagree with Rifkin's basic plea for respecting the integrity of evolutionary lineages."

Rifkin is often criticized for being opposed to science, progress and freedom of inquiry (Marshall, 1984; Gould, 1985). Rifkin denies these accusations, saying that he is opposed to our "view on the nature of knowledge, how we pursue it, what are goals are." He wants to "develop a wholly different perspective on science" where knowledge is not power, but "empathy with the environment.... [E]mpathy allows us to establish a new type of security by becoming a member in good standing in the community of life" (Anonymous, 1985).

Rifkin has been aligned with the religious right, though he is quick to downplay this association (Contemporary Authors). "One or two press accounts singled that out. [The religious right] was one of scores of religious [groups], including ... the National Council of Churches, the U.S. Catholic Conference, the Rabbinical Assembly, the United Methodist Church, the United Church of Christ, the Lutherans, the Episcopalians" (Anonymous, 1985). In 1983 he circulated among church leaders a 10 page "Theological Letter Concerning the Moral Arguments Against Genetic Engineering of the Human Germline Cells" (Marshall, 1984). Described by Science (Norman, 1983) as "apocalyptic in tone," this petition laid out a case against tampering with human germline cells based on an ecological and a moral argument.

Ecologically, Rifkin (1991) fears that the removal of "bad" genes will narrow the genetic diversity of the human gene pool. Rifkin (1991) argues that attempts to "cleanse the germline over tens or hundreds of years will lose traits that we later realize are important."

The moral argument concerns negative eugenics: "the elimination of so-called biologically undesirable characteristics" (Contemporary Authors). Rifkin colors his moral arguments with Judeo-Christian allusions and in his 1979 book The Emerging Order: God in the Age of Scarcity, Rifkin examines the emerging strength of the evangelical movement, a theme that stays in his writing through his recent book, Biosphere Politics (1991), a culmination of his previous works.

The Effect of Biotechnology

Today biology and science inform and extend each other in a bizarre feedback system.

Mark Lesney

The three information lineages&emdash;genetic, cultural, and technological&emdash;are all advancing and evolving at their own rates and in their own vector directions through the time/environment continuum. As the flows evolve, they are forever increasing in complexity. If this complex system is to continue to exist, the overall complexity of the system must be reduced. The interactions between the component flows must be reduced to a more energy efficient level. This will be accomplished through biotechnology.

Biotechnology will create a direct interaction between the genetic and technological flows. Instead of altering genetics through the slow processes of conventional medically increased survival and selective breeding, biotechnology will allow rapid, and permanent alterations of the genetic information. Through genetic engineering, the rate of evolution of the genetic flow will match that of the technological flow. Biotechnology will also pull both the genetic and technological flows into the same vector direction, unifying them into one indistinguishable biotechnical flow. This will reduce the three flow human system to a two flow system. As such, the complexity of the system will decrease and the stability will increase.

The effect of this new two flow system has been a focus of both Goonatilake and Rifkin's work. In the light of the theory outlined above, several alternative futures will be examined.

A Biotechnical Mosaic

With humanity's ability to accelerate the evolution of life itself to match the rate of technological change, the genetic and technological information lineages will unite into one biotechnical flow. The cultural lineage, influenced by both technology and genetics (as discussed above) will eventually accelerate its rate of evolution and merge with this biotechnical lineage forming a cultural-biotechnical flow that will move at one rate, in one vector direction through a single time-environment continuum. By combining these once independent and evolving lineages, the overall complexity of the system is reduced.

This single flow vector will evolve at a rate that matches or exceeds the current evolutionary rate of the technological flow (Goonatilake, 1993). As this single flow now evolves, genetic, culture and technology will rapidly diversify and perpetually change as the single cultural-biotechnical flow gains complexity. The Earth will be a mosaic of diverse biological life, culture, and technology. Patches in the mosaic will be ephemeral, emerging and falling extinct with great frequency.

The cultural flows unification with the biotechnical flow will be mediated by the spread of genetic engineering into non-western countries. As more diverse cultures begin to use biotechnology, the attractive forces between the biotechnical and the cultural flows will become increasingly strong. Already, India and China are making advances in the field of genetic engineering, and in order to accelerate the unification of all three lineages, biotechnology should continue to spread throughout the world. Africa, Latin America, and the Islamic nations all need to increase their expertise in the field.

" Brave New World "

As the genome and technology begin the evolve at the same rate, these two information lineages will feedback into the cultural lineage and drive it forward into increasing diversity and complexity. Rifkin (1983,1985,1991), however, looks upon this development with considerable concern. Culturally driven biotechnology, according to Rifkin will lead to the reemergence of eugenics. Rifkin argues that biotechnology will cause western culture to engage in cultural cleansing and to dominate the world. But Rifkin's concerns do not end here. He also writes of a physical and commercial eugenics. What parent would not want to, or possibly have to by law, give her child the best possible set of physical and mental attributes that science can offer? Who is to decide what these attributes are and how much they cost?

Any form of eugenics will reduce the attractive forces between the cultural flow and the biotechnical flow and the two will not unite. The eugenics simplified cultural flow will continue to evolve at its own rate, in its own vector direction, and in its own changing cultural environment. This environment will continue to interact with the rapidly evolving biotechnical flow, and will continue to change. With the information in the cultural flow eugenically reduced, the flow will be unable to adapt to its rapidly changing environment, and will eventually go extinct, as the cultural environment changes beyond the point to which the cultural flow can adapt. This will result in a system without a cultural lineage, and thus a world that is devoid of social groups and a human society that is decidedly not human. Without human culture, humanity will cease to exist, and our rapidly evolving biotechnical organisms, now sentient, will replace us as the dominant lifeform on the Earth.

Rifkin's New Consciousness

Another possible path, which is the preferred vision of Rifkin (1991),is a society where biotechnology is not allowed to advance. If biotechnology is not pursued, the information lineages will continue evolve along their current, discordant routes. The flows will continue to grow more complex and eventually the system will collapse into extinction unless an alternative means to reduce the system complexity can be found

The collapse of the human society will occur after a tumultuous period. As the system continues to increase in complexity, the flow environment will be able to mediate the increasing interactions for a limited time . A period of technological and cultural instability will precede the collapse and will be characterized by increased tensions and hostilities as the world resources become depleted and the numerous and diverse components of the flows come into increasing interactions as the environment is no longer able to "mediate" conflicts through environmental compartmentalization.

Rifkin is not so naive as to believe that this "business as usual" approach will be productive. In his writings, Rifkin calls for humanity to reexamine the way in which it views itself and nature. Rifkin writes that we should seek not to masters of nature, but members in the community of nature. In order to do this, humans must sacrifice something is inherently human: our desire for security. By using our technology, humankind is able to achieve security through the alteration of the surrounding environment. For all of its existence, humanity has used technology to make their surroundings more comfortable and safe. Elliot Marshall (1984), among others, has noted that to sacrifice such a basic human instinct will dehumanize humanity. I can only agree, and also wonder how such a change in the most basic of human desires can be accomplished. Rifkin offers only weak possibilities, and I can see no way such an possibility can occur.

Conclusions

Man's yesterday may ne'er be like his morrow; Naught may endure but Mutability.

Percy Bysshe Shelly

The world is at a critical junction in its history. The three information lineages&emdash;the genetic, the cultural, and the technological&emdash; are discordantly evolving. With the emergence of biotechnology, the world sits on the threshold of a entire change in the way things will operate. Before this transformation can occur, however, we will experience period of chaotic upheaval. Fossil fuels will run dry, the physical as well as the political environment well continue to dissolve under the pressure of increasing overpopulation and cultural tensions. The system will continue to persist for a short time through environmental compartmentalization. Biologically, culturally, and technologically diverse subunits will be tucked away into more a complex physical and political environment. But even the complexity of the flow environments will not allow the system to survive as it continues to increase in complexity. Eventually, a complexity threshold will be reached, and, if by this time the human system has not reached the transition threshold of the Biotechnical Age, it will begin the careen chaotically toward extinction.

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Footnotes:

1 See personal profile on page 9.

2 Personal profile forthcoming.

3 See almost any recent issues of Cell or Cell Biology for articles on genetically controlled visual receptors, olfactory recptors, other chemical recytors, and touch sensitive receptors.