CONSCIENCE AND CONSCIOUSNESS IN A WORLD OF EMERGING BIO- AND NANO-TECHNOLOGIES: A WHITE PAPER.

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Part I: Perspective and History

In the wake of the science and technology studies (S&TS) movement that emerged in the late 1960s, we have come to understand technologies as social constructions and social institutions (Dickson, 1977; Bijker, Hughes, and Pinch, 1989; . In this sense, technology embraces the tools, machines, and associated configurations of knowledge and the social relationships of their production, distribution, and usage. The traditional separation of technology and science is no longer viable, and we have even had to revise our understanding of the historical development of science and technology. Science and technology are a paired concept, an idea that in one arena of contemporary S&TS has led to the introduction of the concept "technoscience." Our use of the term "technology" in this white paper should be understood in the context of its conceptual moorings in contemporary S&TS.

We take the term "emerging technologies" (ETs) to refer to contemporary advances and innovations in technology that in our current political climate tend to generate oppositions between advocates and critics. Advocates promote ETs because they promise significant progressive impacts on human lives and human ecologies; at the same time, critics worry about negative impacts that vary from disruptive and disastrous to calamitous and catastrophic. Among the salient emerging technologies on the contemporary global ecological stage are bio- and nano-technologies, information technologies, artificial intelligence machines (social and sociable robots), and artificial creatures. One of the problems with trying to assess the short and long term impacts of emerging technologies is that they are often embedded in networks of old and new converging technologies, creating multiplier effect impacts that are virtually impossible to sort out and analyze in terms of assessment and unintended consequences. Even some advocates of emerging and converging technologies worry about their existential risks (e.g., transhumanist philosopher Nick Boston). The ethical debates emerging technologies provoke focus on distributive justice issues and environmental and ecological rights and equalities.

Our most visible and significant emerging technologies, notably bio- and nano-technologies, may be new in terms of materials, functions, and actual and potential local, regional, and global impacts but they bring with them an old and even ancient sense of doom and danger. In the Phaedrus dialogue, Theuth promises that great things will come from the emerging technology of writing. He tells Thamus, the king of Egypt, that this new technology will make people wiser and improve their memories. The king has a different view and he implies that he is in a better position to assess the value and potential impacts of the new technology than is its inventor. The king concludes that writing will have the opposite of the effects Theuth promises.

The cultural meaning of science has fared no better even with its cloak of purity. From Rousseau to Roszak there have been science watchers who saw danger and alienation where others, from Bacon to Bronowski saw civilization and progress. In 1923, the biochemist J.B.S. Haldane published an essay titled *Daedalus, or Science and the Future*. Haldane painted a glowing portrait of a future society created by applying science to the problem of promoting human happiness. Bertrand Russell replied to Haldane in an essay titled *Icarus, or the Future of Science*. Russell wrote that much as he would like to agree with Haldane's forecast, his experience with statesmen and governments forced him to predict that science would be used to promote power and privilege rather than to improve the human condition. Daedalus taught his son Icarus to fly, but warned him not to stray too close to the sun. Icarus ignored the warning and plunged to his death. Russell warned that a similar fate awaited those whom modern scientists had taught to fly.

Saint Augustine worried over the variety of poisons, weapons, and machines of destruction that had been invented to harm humans. Oswald Spengler predicted that machines will drag Faustian man to his death. It is not only machines that we should be worried about but science itself. In what is generally recognized as the first modern secular treatise on the theory of progress, *Digression on the Ancients and the Moderns* (1688), Fontenelle argued that scientific growth represented the clearest, most reliable mark of progress. This relationship between science and progress was expressed in the works of Comte and Spencer. Rousseau, by contrast, argued that "our Minds have been corrupted in proportion as the arts and sciences have improved".

Progress in our time has come to mean putting men on the moon, splitting atoms, and promising the prolific flow of commodities through the lives of the privileged to the struggling masses of the earth. It is difficult to sustain the idea of progress in the face of the wide range of problems we are burdened with. The essence of the crisis is that the very forces of production we depend on to mark progress are interlocked with the very problems that make us doubt whether there has been any progress. Treating drug abuse and mental illness are the ways we try to tune up, service, and put back into efficient operation humans whose lives are constantly taking them, ourselves, and our planet to the brink of a complete breakdown of the social and ecological order.

In 1957 a panel of distinguished scientists gathered to celebrate – of all things – the centennial of Joseph E. Seagram & Sons, Inc. They were asked to speculate on "The Next Hundred Years". The idea – or better, the ideology – of science and progress required that the scientists speculate optimistically. What is interesting is the way many of them introduced their speculations. The geneticist and Nobel laureate Herman J. Muller said that the future would be rosy if we could avoid war, dictatorship, overpopulation, or fanaticism. Harrison Brown prefaced his remarks with the words, "if we survive the next century"; John Weir began, "If man survives". The most bizarre opening sentence was Wernher von Braun's, "I believe the intercontinental ballistic missile is actually merely a humble beginning of much greater things to come."

The idea of scientific and technological progress was fueled by the seventeenth century advances in science and literature by such cultural giants as Galileo, Newton, Descartes, Moliere, and Racine. The idea of social progress was added later. Early in the eighteenth century, the Abbé de Saint Pierre advocated establishing political and ethical academies to promote social progress. Saint Pierre and Turgot influenced the Encyclopedists. It was at this point that social progress became mated to the values of industrialization and incorporated into the ideology of the bourgeoisie. Scientific, technological, and social progress were all aspects of the ideology of industrial civilization. But there have been attempts to identify a type of progress that is independent of material or technological criteria. Veblen, for example, argued that the various sciences could be distinguished in terms of their proximity to the domain of technology. Thus, the physical sciences were closest to that domain, even integral with it, whereas such areas as political theory and economics were farther afield. We have entered an era of machine discipline unlike any in human history. And now we stand on the threshold of machines that will discipline us with conscious awareness and values, the robosapiens.

Progress, then, can be viewed in terms of “amelioration” or “improvement” in a social or ethical sense. Are we more advanced than cultures that are less dominated by machines and machine ideology? How do we measure the primacy of humans and ecologies and how do we sustain them in any given culture? Can we bring them to fruition and nourish them in any culture, or are some more friendly to the primacy of humans and ecologies than others? These issues are really matters of degree associated with the degree to which individuation has progressed in any given society. Editorials in *Technology Review* (Marcus, 1993) and *Science* (Nicholson, 1993) express the professional concerns of engineers and scientists directly. The first review asks that scientists and engineers “climb off the pedestals”, while the second is concerned with the anti-science threat that “The Postmodern Movement” presents. This last is especially curious; and note the use of capital letters.

One of the issues at the core of this white paper is the very idea of progress. We believe there is a way to define progress that takes it out of the realm of hopes, wishes, and dreams and plants it more firmly on a meaningful (and even perhaps measureable) foundation. Following Gerhard Lenski (1970: 59), we define progress as the process by which human beings raise the upper limit of their capacity for perceiving, conceptualizing, accumulating, processing, mobilizing, and utilizing information and energy in the adaptive-evolutionary process. The relationship between adaptation and evolution is a paradoxical one. On the one hand, survival depends on the capacity to adapt to surroundings; on the other hand, adaptation involves increasing specialization and decreasing evolutionary potential. Adaptation is a dead end. As a given entity adapts to a given set of conditions, it specializes to the point that it begins to lose any capacity for adapting to significant changes in those conditions. The anthropologists Sahlins and Service (1960: 95-97) summarize these ideas as follows:

Principle of Stabilization: specific evolution (the increase in adaptive specialization by a given system) is ultimately self-limiting.
General evolution (progressive advance measured in absolute terms rather than in terms of degrees of adaptation in particular environments) occurs because of the emergence of new, relatively unspecialized forms.
Law of Evolutionary Potential: increasing specialization narrows adaptive potential. The more specialized and adaptive a mechanism or form is at any given point in evolutionary history, the smaller is its potential for adapting to new situations and passing on to a new stage of development.

Perhaps the most important aspect of the ideology of science is that it is (in its allegedly pure form) completely independent of technology; this serves among other things to deflect social criticism from science and to justify the separation of science from concerns about ethics and values. Interestingly, this idea seems to be more readily appreciated in general by third world intellectuals than by the Brahmin scholars of the West and their emulators. Careful study of the history of contemporary Western science has shown both the intimate connection between what we often distinguish as science and technology and also the intimate connection between technoscience research and development and the production, maintenance, and use of the means (and the most advanced means) of violence in society. Not only that, but what we have just written is true in general for the most advanced systems of knowledge in at least every society that has reached a level of complexity that gives rise to a system of social stratification.

Let us remember that contradiction and ambivalence about science, technology, and progress may be built into the very core of our cultural machinery. Agricultural activities in the ancient Near East reduced vast forests to open plains, and wind erosion and over-grazing turned those areas into arid deserts.
Deforestation in ancient China led to the development of the loess plateau. Loess sediment gives the Yellow River (nicknamed "China's Sorrow") its signature color and flooding pattern. Was deforestation necessary for building China into the greatest civilizational area on earth between the first and sixteenth centuries of the common era? Or were there conservation principles that the ancient Chinese could have relied on without detracting from their cultural development? There is some evidence that at least some of the deforestation they caused could have been avoided. The deforestation experiences of China, Rome, and other civilizational areas of the ancient world are being repeated today and offer cautionary tales for an era of erupting emerging and converging technologies.

Given the historical evidence that new technologies generate social and environmental problems in conjunction with some form of progress, it might be useful to consider new technologies as mutations. If we think analogically of new technologies as cultural mutations, most will be "neutral" or "harmful." This adds another level of argumentation to the case for the precautionary principle. The case for the precautionary principle, however, does not depend on this analogy but has a powerful rationale grounded in the human experience over the history of its development and evolution.

Part II: Issues and Problems in Contemporary Bio- and Nano-technologies

1. How would you define an 'emerging technology' and an 'emerging biotechnology'? How have these terms been used by others?

"Emerging": 1) Not yet in common use nor accessible to the general public
2) "Technology" implies a *telos*, or use. Therefore, a (bio)technology for which an application has not yet been associated.
3) Not yet commercially available
4) Not yet recognized as a standard by an expertise community

"Technology" vs "Biotechnology"

A *bio*technology can be tightly or loosely defined. Tightly defined, a biotechnology would be a technology that manipulates biological processes toward an intended end. Loosely defined, a biotechnology would be any process or product that impacts biological processes and/or systems on any level: cell, tissue, organ, body, population, biome, trophic.

Tighter definitions are more convenient for disciplinary focus and development of a technology.

Looser definitions should be used when regulatory concerns are being developed to avoid "falling through the cracks." An example of this is how genetically modified crops "fall through the cracks" between the FDA (U.S. Food and Drug Administration), USDA (U.S. Department of Agriculture), and EPA (U.S. Environmental Protection Agency); because these technologies straddle different regulatory categories (food, chemical, drug), they are excluded from the purview of all three agencies, resulting in inadequate oversight.

2. Essential features: involves technologies that impact or manipulate biological processes that are not yet established in the commercial or research arenas.

Common features: challenge categorical divisions of impact and responsibility, upend conceptual frameworks and assumptions, significant amounts of uncertainty as to effects

3. "Important implications" implies one or more of the following:

- significant overlap between diverse fields (e.g., legal, medical)
- challenges conceptual assumptions
- negates or disrupts natural self-correction cycles or checks/balances that exist in biological systems
- initiates or contributes to a positive feedback cycle that is uncorrectable

Ethical impact:

"What is human?" – e.g., human-animal chimeras, OncoMouse

"What is life?" – e.g., synthetic biology, engineered viruses

"What is inherited*?" – e.g., epigenetics *inherited traits are contrasted with fault-associated behaviorally or environmentally induced conditions that have implications for medical coverage

"What is controllable?" – e.g., biocontamination, nanotechnology

Social impact:

Epigenetics – changing ideas of inherited traits

Advanced transplantation techniques: face, uterus transplants

Fertility technologies: PGD (Pre-implantation Genetic Diagnosis), ICSI (Intracytoplasmic sperm injection).

Legal impact:

Chimeras – personhood and rights questions

Liability for biological contamination: GM (Genetically Modified) crops

4. Climate: temperate vs. tropical climates contribute to different agricultural patterns and different selection of staple crops. A majority of GM crops developed are temperate-climate staple crops, but are being exported to non-temperate regions for growing, which results in more external inputs required for growth (water, fertilizer, labor).

5. The European Union has been more resistant to adoption of GM crops than has the United States. One factor indicated is that the EU has deeper connections to food culture and prioritizes the human connection to food over lowered costs.

Sex-screening via amniocentesis has been accepted quickly in India because it allows parents-to-be to selectively terminate female fetuses while keeping males, which are culturally preferred. The use of this technology has resulted in a significant shift in the sex ratio in India.

7. Korean media recently discussed how many current varieties of GM soybeans can trace their heritage back to soybean samples collected from Korea by U.S. officials during wartime. Many of these varieties no longer exist in Korea, yet these samples are still in U.S. seed vaults and given freely to biotech corporations to develop patented seeds. The social disruption caused by war allowed these samples to be collected for later development, but there has been no effort by the U.S. to return samples to Korea to bring back these parts of Korean culture.

8. Common ethical/policy issues among biotechnologies include:

- Category breakdown (chemical? food? product? organism?)
- Rights, liabilities, and responsibilities are called into question or need to be assigned
- National sovereignty and diversity of culture
- Global markets / enterprise
- Neoliberal scientism as an invisible motivation
- Disciplinary conflicts

Specific issues from biotechnologies include:

- Life and death distinction becomes problematic
- Living organisms as common resources ("the tragedy of the commons")
- Personhood: derived from genetics, cognition, development, social?
- Health as a basic human right
- Fundamental structures of perpetuating biological systems (sustainable agriculture)

9. Overlooked Themes:

- Interconnectedness of living organisms and systems
- Value of "natural" or "nature-compatible" technologies for self-correction/checks-balances
- Hidden economic interests and paradigms that don't recognize non-monetary costs/benefits
- Futurism, benefits for future generations
- Nature misconstrued as an infinitely receptive sink

11. Ethical principles:

In discussing ethics, the two main philosophical branches that have been used are consequentialist (ends-focused) and deontological (intent-focused) modes of evaluation. The major consequentialist mode used is some variation on Utilitarianism, measuring and comparing harms and goods; cost-benefit types of analysis are derivatives of this mode. Deontological modes usually focus on rights or moral ideas about inherent worth or good. Values discussions, rights analysis, and appeals to "the natural" are examples of this.

A less-used branch of ethical philosophy is virtue ethics, which focuses primarily on the process, rather than on outcomes or intentions. This mode of analysis exposes the shortcomings of an emphasis merely on product, rather than considering the process by which an end is achieved. Examples of biotechnical issues where virtue ethics evaluation would have been helpful are with GM crops, which have been classified as GRAS – "generally recognized as safe" – because they are recognized as foodstuffs, and with LEISA (Low-external input sustainable agriculture) methods that emphasize working with natural soil enrichment cycles rather than tracking only individual chemical levels in soil (which leads to soil degradation over time). Virtue ethics methods would also encourage proper labeling of origin and production method to enable consumers to choose between different types of products; this practice would be compatible with the ideals behind a free-market, consumer-driven economy.

12. There is no clear chain of accountability in food production in the United States. For example, in the case of Starlink corn there was no control preventing contamination of the food supply with the Starlink GM corn. As a result, many consumers, including many children, became ill. Although produce now commonly has "country of origin" labels, there is still no consistency in standards of food production (organic, conventional, GM), and centralized processing and distribution of foodstuffs make it difficult to trace infection sources in the event of foodborne illness outbreaks.

14. A single framework for regulation carries the advantage of letting fewer potentially dangerous innovations "fall through the cracks." In the U.S., GM crops have often failed to be regulated because they do not fit within the purviews of the FDA, EPA, or USDA, even though they qualify partially for all three agencies. Introducing a biotechnology oversight entity that initially examines and sorts emerging biotechnologies would provide a first line of defense against overlooked innovations.

17. Biotechnologies, because they have the potential to challenge existing socially- and legally-accepted definitions of fundamental concepts – life, death, human, person, free, owned, natural, artificial – require engagement beyond the usual policymaking levels. These key concepts must be redefined in ways that are compatible with social and cultural norms while accommodating the change resulting from the introduction and adoption of new technologies. This requires that values be engaged as well as concepts of fact, and the diversity of norms held by people affected by these changing dynamics necessitates pluralistic discourse. The stakes are potentially very high: native crop species are becoming extinct, nanoparticles are being released into the environment with no method for cleaning them up, and synthetic organisms are being made with the looming threat of errors that could lead to disastrous unchecked growth. Without drastic changes to regulatory mechanisms as well as to the intellectual tools used to analyze these issues, life at its most fundamental level could be irrevocably changed for the worse.

References

The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology by Wiebe E. Bijker, Thomas P. Hughes and Trevor Pinch
MIT Press, 1989.

David Dickson, The Politics of Alternative Technology, University Books: New York, 1977.

Technology Review (Marcus, 1993) and *Science* (Nicholson, 1993)
Marcus,Steven J. (1993) “Editorial,” Technology Review, 96, 6 (August/September), 5
Nicholson, Richard S. (1993), “Editorial,” Science , 261, 5118 (July, 9):143.

Sahlins and Service (1960: 95-97)
Sahlins, M.D. and E.R. Service (1960), Evolution and Culture, Ann Arbor: University of Michigan Press.