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ALLEN E. GATES - UNIV. OF NOTRE DAME

BIOMEDICAL TECHNOLOGY Booklet Number 00737

The field of biomedical technology promises radical innovation in the coming decades. In light of the explosive headway now being made in the areas of genetic engineering and computer technology, advancements in this field will be a powerful determinant of longetivity, lifestyle, and perhaps psychological well-being a generation from now.

Advances in biomedical technology will affect our lives in myriad ways, some of which will involve serious moral and ethical dilemmas; indeed, which will prompt serious debate over the fundamental nature of our humanity.

Among key developments in this field will be an intensive research and development effort aimed at discovering, extracting, and synthesizing useful chemical substances from existent plant and animal species. The medicinal properties of some plant and animal substances have long been recognized, yet only a very small percentage of existent species have been actively explored for such use. With concurrent advances in the areas of computer assisted microscopy, organic chemistry, and cell biology, this type of research will prove immensely beneficial to man.

Further discoveries about the photosynthetic process will permit new breeds of superproducing plants, capable of more efficiently using available nutrients to provide higher yield, lower cost food. Genetic engineering of plants will result in a much greater diversity of food crops, with improvements in taste, disease resistance, and environmental adaptability.

Seemingly miraculous advances in the fields of biology and human genetics will have a profound effect on our lives. Research into the human brain and pituitary system will have isolated the specific chemical processes responsible for cell growth and repair, transmission of sensory stimuli, and aging. It will be possible to artificially stimulate cell growth in the area of an injury in accordance with the original genetic code of the individual, enabling regeneration of limbs, fusion of spinal cords and major nerves, and generation of new tissue in burn victims.

Vast improvements in microelectronics and materials science will result in exceptionally powerful medical implants, performing such tasks as detecting and repressing epileptic seizures, regulating bodily insulin production, and handling motor control functions.

In the area of diagnostics, extremely sensitive electronic sensors, using Hall-effect and charge-coupled device technologies, will be implemented in passive, highly accurate brain activity scanners. Interfaced with powerful medical diagnostic computers, these scanners will greatly enhance diagnosis and treatment capabilities in neuropathology.

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BIOMEDICAL TECHNOLOGY (continued)

Today's surgical tools and techniques may seem Neanderthal in comparison with those of twenty-five years from now. Laser and fiber optic technologies, aided by computer imaging and analysis, will allow surgical precision and efficiency unheard of in 1983.

The term "electronic eye" will take on a whole new meaning in twenty-five years. Super-quality light sensitive semiconductors, sensors with spectral response like that of the human eye, will be incorporated on the same substrate as optical imaging circuitry. Microsurgical techniques will allow implantation of thousands of tiny platinum alloy electrodes into the optical nerve or optical receptors of the human eye, thus interfacing the sensor chip with the brain. Congenital blindness and blindness as the result of accident or injury may be almost eliminated due to these technological marvels.

Is all this plausible? Certainly! After all, we are still chronologically closer to the first crude commercial semiconductor chip(1962) than to the year 2008, and look at where we are now!

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COMPUTERS Booklet Number 00737

It almost seems cliche' to speculate on the far-reaching effects of computer technology, yet when one considers the potential transformation of society facilitated by this technology, such speculation is not cliche', but rather an attempt to foresee the corresponding changes in our own lives.

Japan's Ministry of International Trade and Industry, widely known as MITI, has plunged head first into the formidable task of developing the fifth generation of computers. Though it remains to be seen whether they will reach their stated goals of "intelligent computers" and vastly improved artificial intelligence(AI) capabilities by the early 1990's, this effort marks the start of a whole new era in the development of the computer.

Given the snowballing accumulation of new technology, however, these systems will have reached maturity by the year 2000 and will have been largely supplanted by an ultra-powerful sixth generation of computers. Extensive breakthroughs in the fields of decision theory and human logical reasoning capability will equip these computers to make sophisticated logical inferences about a wide variety of situations.

Serious programming language limitations inherent in today's AI programs, such as the inordinately large storage needed with Prolog, Japan's language of choice, and the relative insophistication of LISP, long a favorite of the Western AI community, will be overcome within twenty-five years. This advance in software technology, I feel, will be perhaps the most important breakthrough of all.

AI computers of the year 2008 will be able to efficiently rewrite portions of their own operating systems in order to tackle new challenges. Instead of wholesale updating their data bases to equip themselves for future occurences of the new situation, they will use a combination of data base update and operating system rewrite, perhaps including the parts of the operating system responsible for re-write control.

A tremendous amount of new knowledge will be gleaned from this effort. For the first time, we will be dealing with computers possessing a recognizable "personality", dependent on both its initial programming and the circumstances it has encountered in its operating environment. Behavioral scientists will have a field day, as they will be able to reevaluate the nature versus nurture argument in light of their experiences with the new computers. I predict that the relative simplicity of these computers, compared to our incredible human complexity, will provide behavioral scientists with opportunities now undreamt of. In return, we will be able to learn even more about our own learning mechanisms and personality development. As such, advancements in the computer field will yield extensive reciprocal benefits to those studying the human brain. Due to its phenomenal complexity,

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COMPUTERS (continued)

we are now forced to abstract crude operating principles from available data. "Intelligent computer" research, accompanied by advances in biomedical technology, will open up hundreds of new avenues of inquiry into human brain function and provide a superb base upon which to build new knowledge.

On a somewhat more arcane level, the expansion of the microprocessor into almost every conceivable niche will continue unabated. People in the year 2008 will be far more self-reliant than people today, due in large part to the computer. A standard item in new homes will be the command control center, consisting of a complex computer terminal interfaced to a vast array of sensors and controls throughout the house.

Via the command control center, the house will literally possess its own operating system, summoning the homeowner by telephone if problems arise. The environmental conditions within the house will be easily programmed, either from the command control center or remotely. Temperature, humidity, lighting, energy consumption, intrusion detection, and a host of other possibilities will be easily controlled on a room to room basis. The "operating system" of the house will allow for a high degree of self-checking and redundancy, making failures a rarity and allowing the homeowner to perform most repairs and maintenance.

All major appliances will come with ROM cartridges or floppy disks containing detailed service and repair information. Used in conjunction with the command control center, this development will result in almost complete elimination of service calls. New homes will have all the necessary maintenance and repair information built into the command control center operating system.

In twenty-five years, sixth generation computers will undertake with amazing ability such fundamentally important tasks as resource management and energy distribution, allowing analysis of far more variables than is currently possible. These computers will open up exciting new possibilities in the area of trend analysis, "discovering" causal relationships among seemingly unrelated variables and even making predictions based on these discoveries. Computers designed to analyze patterns or trends will be able to perform their tasks free from misconceptions or cultural bias, providing an escape from the "common sense" that often impedes progress on a purely human level.

Computers will be available to help prospective married couples undergo comprehensive genetic screening, in order to provide them with information and advice regarding their heridity and possible consequences for children.

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SOCIETAL IMPACT Booklet Number 00737

For the concept of societal impact, which seems to address the effects of new technology on an essentially static social structure, I will substitute the concept of societal transformation. This is especially important, I think, because lacking the realization that new technology of necessity brings changes in the total society, no intelligent speculation is possible.

The important issues of the year 2008 have already begun to surface. Immensely difficult moral and ethical issues such as inequality in available medical care, genetic engineering, and overpopulation are already prevalent. Far more difficulties face those of us still around in a generation, especially if we fail to adequately pinpoint where those problems will arise.

With the discovery of the biochemical processes that regulate human aging, our society will be presented with dilemmas far greater in magnitude than the development of 1-picosecond semiconductor switches or the operation of a profitable meteoroid mining operation.

By ingesting one's daily dose of age suppressant hormone and barring accidental death, it will be theoretically possible to remain at a desired "age" indefinitely. One can only begin to imagine the possible scenarios.

Who would control the supply of such hormones? Who decides whom shall be permitted to extend his/her lifespan and at what "relative age" will that person be required to live? Will administration of such a chemical be a purely personal decision? For what length of a time will it be considered acceptable to extend one's life? For what reasons?

New forms of capital punishment will arise, perhaps including the administration of massive doses of aging stimulants, resulting in a vastly accelerated "natural death" for the victim. A flourishing black market in aging suppressant hormones would almost certainly exist, perpetuated by would be Ponce deLeon's in search of a chemical "fountain of youth."

How would one generation decide when its time had come, so to speak, yielding to the population and resource demands of the subsequent generations? Would some people be forced to leave the planet and live on a colony away from Earth after having lived a certain number of years? This is one possible solution to the overpopulation problem which might otherwise exist in the world of prolonged life. What criteria would people use, or perhaps be forced to use, to determine whether they had lived long enough? Who would willingly choose to die when alternatives are available? What would happen to the institutions of family, church, and state?

The implications are staggering. What will we decide?

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SOCIETAL IMPACT (continued)

Why indeed, devote nearly the entire societal impact essay to one key development and a series of open-ended questions? Why elaborate on what may seem farfetched in a competition where plausibility is a criterion? Why? To drive home as bluntly as I feel necessary a point which I think is grossly neglected by the great majority of people and by an alarmingly large segment of the technological community.

The point is this: We, as a society, have reached a point in our evolution where technological progress threatens to far outstrip our ability to cope with this progress, ethically, emotionally, and psychologically. To allow the technological juggernaut to roll on without similarly developing other, equally important aspects of our lives is tantamount to plotting a highly complex societal suicide.

These sentiments may engender few feelings of appreciatio among employees of a company notorious for its high technology. The point I make, however, is in no way an indictment of high technology, but rather of our failure to more fully explore the implications of such technology before it is brought to bear on society. If our scientists and engineers are unaware of the vast consequences embodied in their creations, if they are unable to intelligently deal with the issues raised by technological progress, how then, can the less sophisticated technological layman be expected to deal with these issues. Unfortunately, I fear, if we continue to plow ahead into new technology with the same degree of introspection and examination as presently exists, our failure as a society is inevitable.

Taken in the right context, my point should be clear. All the technological impacts we can create are irrelevant if we fail to deal intelligently with the potential consequences before they become fact. I make my point in the hope of promoting responsibility in technological development, so that generations from now our offspring can benefit, rathe than suffer from our developments.

My treatment of this societal impact essay is intended to serve as a kind of well-meaning protest against the kind of mindset that often leads us to progress without contemplation, technology with too little regard for consequences. It is a well-meaning protest against the mindset which promotes a competition in which students are to devote twice as much space to two specific areas of technology as they devote to the impact of those technologies. This competition might better serve both Honeywell and its entrants if it focused more clearly on societal impact. There are few enough worthwhile opportunities for students to take a hard look at the consequences and implications of technological development; a competition such as this, with more emphasis given to the societal impact, could provide just such an opportunity.