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FUTURES

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Energy

The challenges of energy technology in 2008 fall into several areas: inventory, production, storage, transportation, conservation and safety. The assumption behind my predictions is that the present oil glut represents a deviant episode within the larger picture of growing scarcity in petroleum. The glut reflects volatile political conditions and not objective geological realities. I believe that the USA will eventually have to pursue a vigorous national policy on energy, essentially along the lines of President Carter's dictum about the energy crisis being "the moral equivalent of war."

The main unknown parameter is how much fossil fuel is left and where. In 25 years we will have an answer to this question by using a method of random oil drilling and analyzing the data by computer simulation. The method will result not only in an accurate estimate, but also in rapid discovery of as many oil fields as have previously been discovered in U.S. history. On a global scale the prospects are even rosier. Oil fields, though, will be much smaller in size so that a more efficient technology of drilling and transportation will be developed. Offshore oil platforms that can resist 100-to-200 foot waves in waters 1000 to 2000 feet deep will be built, opening new territories to oil searches. By 2008 we will have access to deep layers of earth's mantle, where evidence points to the existence of methane of non-biological origin. The access to this vast resource will be facilitated by the identification of tectonically active sites. Development of electronic micro-sensors or employment of animals sensitive to changes in methane concentrations in the atmosphere will enable the detection of "leakage" sites and, thus, of possible locations for drilling.

In the field of conservation, storage, and transport, improvements will follow the massive introduction of superconductors such as niobium-titanium alloys and organic crystals in linear and coiled forms. The efficiency rate in production and transport of electricity will reach 95-100%. Superconducting, stabilizing devices will facilitate storage in large power networks, taming fluctuating sources of energy such as electrical, solar, and geothermal. The potential of classic and modern methods of storage will be realized in mega-reservoirs where combined technologies such as underground pumped hydroelectric storage, compressed air, electrolysis, storage of hydrogen as metal hydride, and sodium-sulfur batteries will be used for both static (houses, factories) and mobile (cars) needs. Further contributions to conservation will come from advanced material technology, with the development of ultralight machines, cars, and airplanes that will consume 25-75% less energy per unit of useful work.

In the realm of energy safety, developments will come from three unrelated areas: applied statistics of risk assesment, genetic engineering, and computer technology. Risk assessment of ecologically controversial sources like coal and nuclear energy will become much more sophisticated and exact, thus allowing the development of a rational policy on energy matters. Computer-facilitated automation, especially in fission reactors and coal-fueled operated power plants, will lessen the risk of human error and will revive these energy technologies. Genetically engineered microorganisms will be employed to diffuse even major ecological catastrophes such as oil spills, sulfur and lead contamination of air and soil, and reduction in the concentration of ozone. Simultaneous production of nutrients and energy will be made possible by simulation of natural processes such as photosynthesis and cytochrome electron transfer and by the use of bacteria for manufacturing methane and higher hydrocarbons in artificial ponds.

Incidentally, today's "locker room futurism" may not be terribly far-fetched. Aerodynamic strategems have already brought human-powered land vehicles (HUPLAS) that can go 60 miles per hour on a level road, suggesting that short-range urban commuting, at least, is on the verge of being revolutionized.

Biomedical Technology

By 2008, all branches of medicine -- symptomatic, preventive, and corrective -- will be altered, mainly by techniques associated with gene cloning. Prenatal diagnosis by means of restrictive enzymes and DNA sequencing will be employed in patients at risk for hereditary diseases with known metabolic bases. This will be accomplished either by direct visualization of the gene or by probing linked polymorphic areas, replacing the need for detecting the gene product. While protein analysis is useful only in the very few cases where the enzyme is expressed in amniotic cells, DNA probing requires neither expression nor prior knowledge of function. The entire genome will be exposed, and 20-50% of the approximately 1700 known genetic diseases will be detectable in utero, following which corrective treatment and genetic counseling will be prescribed. In addition, carriers of deleterious genes will be ascertained by molecular methods. Moreover, conditional risks with environmental exposure given a genetic makeup will be assessed. Since associations between genetic markers and diseases of environmental origin are known, individuals will be advised as to professional and personal habits. We will no longer treat carcinogens, mutagens, and teratogens in general terms, but will be able to specifically identify individual risks. Given the polymorphic status of humans, it is certain, for instance, that some individuals will be found genetically capable of smoking or working with asbestos without compromising their health. As to diseases for which the genetic contribution, if any, is not known, molecular techniques will be used for diagnostic purposes. By correlating changes in the biochemistry of the body with symptomatic changes, people will be able to avoid traumatic interventions such as biopsies.

Preventive medicine will witness spectacular developments in immunology and somatic cell manipulation. Tailor-made monoclonal antibodies will enable the production of multivalent vaccines and boosters for protection against a multitude of bacterial, protozoan, fungal and viral diseases (approximately 15 diseases per injection). These will include several forms of cancer and also caries. A potential of eradicating the diseases caused by obligatory parasites of man will be developed. Given geo-political realities, however, the potential will remain largely unused.

Multivalent immunology will also enable us to fight new variants of diseases, such as influenza, where antigenicity (sites) of the virus change rapidly. Antigens directed against invariable sites, such as the active sites of hemaglutinin (the symptomatic protein), will be constructed, thus, avoiding the need for frequent changes in immunization schemes. Another breakthrough will occur with development of methods for excision-modification of oncogenes in somatic and germ cells, thus reducing the prevalence of cancer for future generations.

Exciting developments are expected in corrective or manipulative medicine, specifically in gene transplants, directed mutagenesis, control and direction of differentiation and pharmacology involving human products manufactured in bacteria, yeast, and cell cultures. Gene transplants and directed mutagenesis will be employed to correct genetic deficiencies in specific cells. Diseases such as adult insulin-dependent diabetes or hemophilia will become nonexistent. Directed differentiation by hormonal control will be routinely used in treatment of neural traumata, which otherwise have an irreversible effect. The treatment will involve artificial control of axonal growth. The challenge of the year 2008 in basic research will be to introduce some order into our knowledge of the endrocine system, which seems to be as complex as the "zoo" of elementary particles in physics. As to pharmacological products manufactured via genetic engineering, problems of gene processing, post-transcriptional modification, and gene splicing will be solved, and mass production of hormones, growth factors, interferons, oxygen transport systems, antibodies, and histocompatibility compounds will enable treatment of thousands of diseases of diverse etiology.

Societal Impact

By 2008, the societal impacts of my predictions will be best described as "hard choices." Due to biomedical breakthroughs in cure and rehabilitation of acute chronic diseases, we can expect a significant aging of the healthy population. On the other hand, the computerized automation of work will radically reduce the number of employed people. Unless "revolutionary" changes are introduced into both the infrastructure of employment and the public social services, we may expect in industrialized countries a routine unemployment rate of about 25% and rising, accompanied by a two- to three-fold increase in economic disparity. One solution could be to reduce the weekly working hours from 40 to 30 with no change in remuneration. A second solution could be for the government to routinely intervene and provide livelihood subsidies for the unemployed and the employable. Both solutions are difficult to implement, and their economic and political effects could range between calamitous and catastrophic. Mass unemployment will result in reduced influence exerted by unions, such that the feasibility of increased pay per hour work, as in the first solution, is at best remote. The second solution will result in the destruction of capitalistic incentives and practices, with disastrous implications for the standard of living. A practical solution should employ elements from both suggested solutions, gradually administered in moderate dosages. In addition, compulsory exclusion from the working force should be mandated by various means, such as prolonging mandatory education for the young and adjusting curriculum to new employment horizons such as health services or paramedical industries, which are likely to provide employment for about one quarter of the work force.

On another level, since industrialized countries will depend less and less on imported raw materials and fuel, the disparity between developed and undeveloped countries will grow to monstrous proportions.

Consequently, the industrialized countries, especially the U.S., will face massive waves of immigration. The immediate effect will be a large brain drain from Third-World countries, which will create a cascade effect and increase economic disparity even more. In order to protect the employed, the most probable policy to be pursued by industrialized nations will be the tightening of immigration laws and their strict implementation. This, in turn, will lead to both destruction of consensual moral codes and strengthening of racist tendencies. A possible alternative will be to make huge investments in developing nations, combined with strict control to avoid their misuse. This path, however, introduces an element of interventionism. In addition, the policy will be difficult to exercise in an atmosphere of economic crisis when funds are scarce.

On the personal level, individuals will face increasingly numerous life and death decisions. Since personalized risk estimates of ailments with environmental factors will be available, questions concerning private matters like smoking, eating, and drinking habits; employment; sexual activities; and habitation will be made acute by a priori knowledge of individual perils. Much of the spontaneity and irrationality that distinguish our lives from that of automata will disappear.

In the ethical realm, society will have to decide, especially in fields such as genetic manipulation and prenatal prevention (eugenics), whether or not to play God and who should decide in concrete cases. A decision of this kind should, naturally, start with the definition of "deleterious" versus "benign." In some cases, such as multiple sclerosis or infant retinoblastoma, this should be easy, but what about treatable diseases like diabetes and phenylketonuria? Both situations carry an ambivalent message. Eugenics, on the one hand, decreases genetic load, but it also reduces the polymorphism in the human race and, consequently, its chances of survival. Moreover, a paternalistic choice for somebody else (i.e., future generations) implies the legitimacy of totalitarianism.

The hardest of all decisions is that we will have to make them!