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ENERGY Booklet Number _____

Sorting through her mail, she opens a bill from the power company and a check falls out. Surprised, she reads the accompanying letter and finds that the electrical output generated by the photovoltaic panels on her roof has exceeded the electricity she must draw from the Solar Grid Power Co. Though Mary Fuller usually spends little on energy costs, this is the first time she has received a check from her power company. This is possible because Mary lives in the year 2008, a time when photovoltaics dominate the power industry, which allows consumer energy independence and transforms power companies into "energy brokers" distributing energy produced by others.

In the year 2008 there is a network of solar power stations on land and in space spread over a wide geographical area and united by a grid to ensure reliable energy service through the dark night and inevitable cloudy days. Consumers interacting with these power stations use and sell the solar power as needed by utilizing an electricity inverter and meter to draw and regulate power from distant solar power plants at low-solar times, and to allow excess electricity produced by privately owned photovoltaic panels to be bought by utility plants for further allocation.

Formerly, in the twentieth century fossil fuel created energy for heat, light, and power, but the finite supply, 1973 Arab oil embargo, and seemingly ever increasing consumption of oil contributed to an energy problem prompting scientists to search for an economic, plentiful, and clean energy supply. The difficulty of storing wind and thermal gradient energy, the fears generated by the Three-Mile Island nuclear accident, and the unanswered question of toxic waste disposal left nuclear fusion and solar energy as the primary fuels of the future.

Nuclear fusion occurs when scientists force the nuclei of two light atoms such as deuterium, titrium, or helium-3 together to make one atom or two nuclei with a smaller mass thus producing energy. But though it seemed an ideal potential fuel source, fusion in 2008 is still not ready for commercial distribution. This is not surprising when we see that fusion's first chain reaction took place in 1986 about thirty years after its inception.

Meanwhile, due to photovoltaics, the solar industry became the fastest growing energy industry of the time. Photovoltaic solar cells, normally made of silicon sandwiched between two layers of metal, use photons striking silicon atoms to free electrons and produce an electric current. Photovoltaic power is abundant, clean, cheap, and as quiet as "sunlight striking a leaf."

The two major problems preventing widespread photovoltaic commercialization in the 1980's have been overcome. The first problem, storage, is no longer an issue as utility grids, and electricity inverters distribute solar power to areas when needed, making storage unnecessary. Cost, the second problem, is now an asset, for photovoltaic power per kilowatt unit is now less than conventional power sources of the twentieth century. This reduction results from the more than 50% growth rate the industry experienced in the 80's which drew many large investors and led to intense competition among monied manufacturers to find the cheapest and most efficient method of manufacturing and using photovoltaic cells. Research resulted in the utilization of computerized, robot-operated assembly lines, the development of cheaper materials as effective as silicon in the photovoltaic effect, and new solar design systems featuring collectors that concentrate solar rays collected in a very large area into a miniscule cell area.

Even the remotest areas have modern conveniences powered by their own low-cost photovoltaic systems or by orbiting photovoltaic satellites, called SATPOWER, that supply energy to isolated or relatively

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ENERGY (continued)

sunless areas of the world. Electric cars, invented in the twentieth century, employ photovoltaic cells as their electrical source, and have led to the much more commonly used, efficient, country-wide rapid transit system, which has replaced the outdated freeway and highway system.

Hence, with the advent of photovoltaics, consumers once again know cheap energy without total dependence upon monopolizing power companies, and without the fear of pollution, radiation contamination, or a diminishing supply. Homes, businesses, and commercial industry may be energy-sufficient, depending on solar power companies for back-up only. Traditional electrical power companies have disappeared or converted to solar, for solar is the power source that pays. Considering the economy, reliability, and simplicity of creating electricity directly from sunlight, it is only sensible that photovoltaics has become the major power industry by this year 2008.

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BIOMEDICAL TECHNOLOGY Booklet Number _____

Walking slowly towards the door he realizes he has forgotten his briefcase. He walks back to the kitchen table, picks up his briefcase, and this time reaches the door, opens it, walks outside, and closes the door behind him. These are functions most of us can do unthinkingly everyday, but Sam Neuman, an active man living in the year 2008, must think about these actions, for since 1980 he has been a quadriplegic. Was Sam the recipient of a miracle cure from God, or a traveling faith healer? No, he has benefited from the work of doctors who are also engineers. Later you will meet a 20th century man who has benefitted from another significant trend in biomedicine, the advent of non-invasive surgery, which has, as its' name implies, permitted this nonintrusive surgery to replace radical surgical procedures.

Sam, though still a quadriplegic, uses a neural prosthesis which enables him to lead a normal, active life. A thought-activated miniscule computer implanted in Sam's brain sends messages through a transmitter to micro-thin electrodes implanted in muscles throughout his body. Based on the simple principle that electricity makes muscles contract, Sam is able to walk. And though the computer coordinates the intricate pattern of muscle contraction, Sam has had to learn to interface with his computer, thinking commands and often using intensity modifiers such as "very soft," "soft," "hard," and "very hard." At first this procedure was difficult, but it soon became as automatic as breathing.

Joe Hartman, Sam's neighbor, has arteriosclerosis of the heart which, unless corrected, will lead to a massive heart attack and probably death. But doctors, making only a small incision instead of the complicated, costly, and dangerous heart-bypass operation of the twentieth century, will use a laser to zapp Joe's arteries free of the plaque threatening to shut off those arteries. Is Joe a character in Star Wars sequel #14? No, benefiting from the other major biomedical trend of the twentieth-first century--noninvasive surgery--Joe will avoid a risky bypass operation with the use of a highly refined version of the laserscope. A computer, given the dimensions of the plaque, adjusts the laser to the necessary duration and intensity, and begins the three-channeled laser's blasting process. The channels, enclosed in a tube one-twelfth of an inch in diameter and surrounded by optical fibers which transmit light, shoot out the laser, allow viewing, and flush and vacuum out the target site before and after the laser blast. Joe will recover quickly.

Though neural prothesis and the laser process (laserscoptomy) are prime examples of the doctor as engineer and noninvasive surgery trends, other advances have resulted from this technology. Genetic engineering has been highly significant, enabling doctors to replace non-functional genes with genes that will code for the proper enzymes to rid people of inherited diseases such as diabetes melitis, taysachs, sicle-cell anemia, and cancer even in utero. Man-made spare body parts are available and include computer-operated spare limbs covered with artificial silicone skin, prosthetic ears, blood substitutes, and even a super efficient artificial heart. Many of the blind, aided by hundreds of electrodes implanted in the brain, a T.V. camera built into an eyeglass frame or even implanted somewhere in the body, are able to see. Accurate drug-delivery systems utilizing antibodies will allow doctors to use weaker drugs by targeting them directly to needed areas. The days when chemotherapy destroyed all cells healthy or cancerous alike are gone.

Both neural prosthesis and laserscoptomy were developed in the twentieth century and needed only further refinement to reach these advanced states. Doctors, beginning with a larger, clumsier version of the neural prosthesis, stimulated a quadriplegics arm to grasp a cup and bring it to his lips. The laserscope's first human application was

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BIOMEDICAL TECHNOLOGY (continued)

on leg vessels. But more advancement was needed, as everyday doctors told people incapacitated by violent accidents or disease that they would never walk or move again, and even the simplest surgical procedure caused the body to go through trauma. But the widespread use of noninvasive surgery today means virtually no risk of anesthetic or postoperative complications, faster recoveries, and a difference between life or death for many already weakened patients.

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SOCIETAL IMPACT Booklet Number_____

Everyday, twentieth-century man is bombarded with choices. When he wants to be entertained, he may watch a program on cable, regularly programmed television, his video-player, or even go out to a show. When he wants to eat breakfast, he may choose new nutritionally balanced breakfast bars, sugar-coated cereal, healthy granola, or the traditional bacon and eggs. While today's choices seem overwhelming, future advances in areas such as biomedicine and solar energy will bring about an even more astounding range of choices, but each field will have quite a different impact on society.

In the year 2008, the widespread use of solar energy will express the prevalent attitude of energy conservation over consumption. Cities will no longer be plagued with choking traffic-jams and pollution, as a quiet rapid transit system streaks below ground powered by photovoltaic cells above ground. This Photovoltaic Organized Wonder--called POW--will be so convenient that the barbaric custom of sacrificing over 50,000 people a year to death on our roads will be abandoned. This may lessen stress and feelings of isolation as people ride together instead of in their own private cars, each competing for a place on the road.

The energy independence photovoltaics will bring to nations, communities, and individual households will bring a spirit of self-sufficiency to our world. Each of these units may be energy sufficient if they choose, and individuals may contribute to others' as well as their own energy needs.

However, the advent of biomedical technology will have a very different social impact. Noninvasive surgery, such as the laserscoptomy performed on our heart patient Joe Hartman, while decreasing surgical trauma and increasing surgical success rates, will allow many operations which now require a lengthy hospital stay to be performed in a doctor's office. This will enable patients, in some cases, to go home the very day of the operation and avoid an expensive and often dehumanizing hospital stay. Doctors, such as the one who made it possible for our quadriplegic Sam Neuman to function normally, may have an engineering degree to effectively deal with advances such as laser surgery, genetic engineering, drug targeting, and the integration of mechanical parts into the human body.

In spite of the gains brought about by these advances, serious moral questions raised by this advanced technology will have to be faced. For example, as today's Olympic athletes have been tested for the presence of drugs in their systems, or--as in the case of some female athletes--the existence of a Y chromosome, tomorrow's athletes may be tested to see if their genes have been manipulated for enhanced athletic traits, or their heart has been replaced by a super-efficient artificial heart. Or, how much more human will a person be than a robot with the same man-made parts? And what about economic status: will only those who can pay benefit from these advances?

Again this will be a future with more freedom of choice, and though it is impossible to step backwards in time, how many choices can the human mind adequately deal with? We are faced with a paradox, wherein this future technology will not only bring a multitude of choices but also information to help us make these same choices.

Indeed, with seemingly unsolvable problems such as possible environmental ruin, death by cancer, and the possibility of nuclear war it is easy to predict a rather grim future. But in seeing the advances made in such areas as energy and biomedical technology, and realizing the progress that is possible, I have gained confidence and hope for the future through man's ability to solve his problems using this technology.