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Can Science Be Ethical?

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One of my favorite monuments is a statue of Samuel Gompers not far from the Alamo in San Antonio, Texas. Under the statue is a quote from one of Gompers's speeches:

What does labor want?

We want more schoolhouses and less jails,

More books and less guns,

More learning and less vice,

More leisure and less greed,

More justice and less revenge,

We want more opportunities to cultivate our better nature.

Samuel Gompers was the founder and first president of the American Federation of Labor. He established in America the tradition of practical bargaining between labor and management which led to an era of growth and prosperity for labor unions. Now, seventy years after Gompers's death, the unions have dwindled, while his dreams, more books and fewer guns, more leisure and less greed, more schoolhouses and fewer jails, have been tacitly abandoned. In a society without social justice and with a free-market ideology, guns, greed, and jails are bound to win.

When I was a student of mathematics in England fifty years ago, one of my teachers was the great mathematician G.H. Hardy, who wrote a little book, *A Mathematician's Apology*, explaining to the general public what mathematicians do. Hardy proudly proclaimed that his life had been devoted to the creation of totally useless works of abstract art, without any possible practical application. He had strong views about technology, which he summarized in the statement "A science is said to be useful if its development tends to accentuate the existing inequalities in the distribution of wealth, or more directly promotes the destruction of human life." He wrote these words while war was raging around him.

Still, the Hardy view of technology has some merit even in peacetime. Many of the technologies that are now racing ahead most rapidly, replacing human workers in factories and offices with machines,

making stockholders richer and workers poorer, are indeed tending to accentuate the existing inequalities in the distribution of wealth. And the technologies of lethal force continue to be as profitable today as they were in Hardy's time. The marketplace judges technologies by their practical effectiveness, by whether they succeed or fail to do the job they are designed to do. But always, even for the most brilliantly successful technology, an ethical question lurks in the background: the question whether the job the technology is designed to do is actually worth doing.

The technologies that raise the fewest ethical problems are those that work on a human scale, brightening the lives of individual people. Lucky individuals in each generation find technology appropriate to their needs. For my father ninety years ago, technology was a motorcycle. He was an impoverished young musician growing up in England in the years before World War I, and the motorcycle came to him as a liberation. He was a working-class boy in a country dominated by the snobberies of class and accent. He learned to speak like a gentleman, but he did not belong in the world of gentlemen. The motorcycle was a great equalizer. On his motorcycle, he was the equal of a gentleman. He could make the grand tour of Europe without having inherited an upper-class income. He and three of his friends bought motorcycles and rode them all over Europe.

My father fell in love with his motorcycle and with the technical skills that it demanded. He understood, sixty years before Robert Pirsig wrote *Zen and the Art of Motorcycle Maintenance*, the spiritual quality of the motorcycle. In my father's day, roads were bad and repair shops few and far between. If you intended to travel any long distance, you needed to carry your own tool kit and spare parts and be prepared to take the machine apart and put it back together again. A breakdown of the machine in a remote place often required major surgery. It was as essential for a rider to understand the anatomy and physiology of the motorcycle as it was for a surgeon to understand the anatomy and physiology of a patient. It sometimes happened that my father and his friends would arrive at a village where no motorcycle had ever been seen before. When this happened, they would give rides to the village children and hope to be rewarded with a free supper at the village inn. Technology in the shape of a motorcycle was comradeship and freedom.

Fifty years after my father, I discovered joyful technology in the shape of a nuclear fission reactor. That was in 1956, in the first intoxicating days of peaceful nuclear energy, when the technology of reactors suddenly emerged from wartime secrecy and the public was invited to come and play with it. This was an invitation that I could not refuse. It looked then as if nuclear energy would be the great equalizer, providing cheap and abundant energy to rich and poor alike, just as fifty years earlier the motorcycle gave mobility to rich and poor alike in class-ridden England.

I joined the General Atomic Company in San Diego, where my friends were playing with the new technology. We invented and built a little reactor which we called the TRIGA, designed to be inherently safe. Inherent safety meant that it would not misbehave even if the people operating it were grossly incompetent. The company has been manufacturing and selling TRIGA reactors for forty years and is still selling them today, mostly to hospitals and medical centers, where they produce short-lived isotopes for diagnostic purposes. They have never misbehaved or caused any danger to the people who used them. They have only run into trouble in a few places where the neighbors objected to their presence on ideological grounds, no matter how safe they might be. We were successful with the TRIGA because it was designed to do a useful job at a price that a big hospital could afford. The price in 1956 was a quarter of a million dollars. Our work with the TRIGA was joyful because we finished it quickly, before the technology became entangled with politics and bureaucracy, before it became clear that nuclear energy was not and never could be the great equalizer.

Forty years after the invention of the TRIGA, my son George found another joyful and useful technology, the technology of CAD-CAM, computer-aided design and computer-aided manufacturing. CAD-CAM is the technology of the postnuclear generation, the technology that succeeded after nuclear energy failed. George is a boat-builder. He designs seagoing kayaks. He uses modern materials to reconstruct the ancient craft of the Aleuts, who perfected their boats by trial and error over thousands of years and used them to travel prodigious distances across the northern Pacific. His boats are fast and rugged and seaworthy. When he began his boat-building twenty-five years ago, he was a nomad, traveling up and down the north Pacific coast, trying to live like an Aleut, and built his boats like an Aleut, shaping every part of each boat and stitching them together with his own hands. In those days he was a nature-child, in love with the wilderness, rejecting the urban society in which he had grown up. He built boats for his own use and for his friends, not as a commercial business.

As the years went by George made a graceful transition from the role of rebellious teen-ager to the role of solid citizen. He married, raised a daughter, bought a house in the city of Bellingham, and converted an abandoned tavern by the waterfront into a well-equipped workshop for his boats. His boats are now a business. And he discovered the joys of CAD-CAM.

His workshop now contains more computers and software than sewing needles and hand tools. It is a long time since he made the parts of a boat by hand. He now translates his designs directly into CAD-CAM software and transmits them electronically to a manufacturer who produces the parts. George collects the parts and sells them by mail order to his regular customers with instructions for assembling them into boats. Only on rare occasions, when a wealthy

customer pays for a custom-built job, does George deliver a boat assembled in the workshop. The boat business occupies only a part of his time. He also runs a historical society concerned with the history and ethnography of the north Pacific. The technology of CAD-CAM has given George resources and leisure, so that he can visit the Aleuts in their native islands and reintroduce to the young islanders the forgotten skills of their ancestors.

Forty years into the future, which joyful new technology will be enriching the lives of our grandchildren? Perhaps they will be designing their own dogs and cats. Just as the technology of CAD-CAM began in the production lines of large manufacturing companies and later became accessible to individual citizens like George, the technology of genetic engineering may soon spread out from the biotechnology companies and agricultural industries and become accessible to our grandchildren. Designing dogs and cats in the privacy of a home may become as easy as designing boats in a waterfront workshop.

Instead of CAD-CAM we may have CAS-CAR, computer-aided selection and computer-aided reproduction. With the CAS-CAR software, you first program your pet's color scheme and behavior, and then transmit the program electronically to the artificial fertilization laboratory for implementation. Twelve weeks later, your pet is born, satisfaction guaranteed by the software company. When I recently described these possibilities in a public lecture at a children's museum in Vermont, I was verbally assaulted by a young woman in the audience. She accused me of violating the rights of animals. She said I was a typical scientist, one of those cruel people who spend their lives torturing animals for fun. I tried in vain to placate her by saying that I was only speaking of possibilities, that I was not actually myself engaged in designing dogs and cats. I had to admit that she had a legitimate complaint. Designing dogs and cats is an ethically dubious business. It is not as innocent as designing boats.

When the time comes, when the CAS-CAR software is available, when anybody with access to the software can order a dog with pink and purple spots that can crow like a rooster, some tough decisions will have to be made. Shall we allow private citizens to create dogs who will be objects of contempt and ridicule, unable to take their rightful place in dog society? And if not, where shall we draw the line between legitimate animal breeding and illegitimate creation of monsters? These are difficult questions that our children and grandchildren will have to answer. Perhaps I should have spoken to the audience in Vermont about designing roses and orchids instead of dogs and cats. Nobody seems to care so deeply for the dignity of roses and orchids. Vegetables, it seems, do not have rights. Dogs and cats are too close to being human. They have feelings like ours. If our grandchildren are

allowed to design their own dogs and cats, the next step will be using the CAS-CAR software to design their own babies. Before that next step is reached, they ought to think carefully about the consequences.

What can we do today, in the world as we find it at the end of the twentieth century, to turn the evil consequences of technology into good? The ways in which science may work for good or evil in human society are many and various. As a general rule, to which there are many exceptions, science works for evil when its effect is to provide toys for the rich, and works for good when its effect is to provide necessities for the poor. Cheapness is an essential virtue. The motorcycle worked for good because it was cheap enough for a poor schoolteacher to own. Nuclear energy worked mostly for evil because it remained a toy for rich governments and rich companies to play with. “Toys for the rich”means not only toys in the literal sense but technological conveniences that are available to a minority of people and make it harder for those excluded to take part in the economic and cultural life of the community. “Necessities for the poor”include not only food and shelter but adequate public health services, adequate public transportation, and access to decent education and jobs.

The scientific advances of the nineteenth century and the first half of the twentieth were generally beneficial to society as a whole, spreading wealth to rich and poor alike with some degree of equity. The electric light, the telephone, the refrigerator, radio, television, synthetic fabrics, antibiotics, vitamins, and vaccines were social equalizers, making life easier and more comfortable for almost everybody, tending to narrow the gap between rich and poor rather than to widen it. Only in the second half of our century has the balance of advantage shifted. During the last forty years, the strongest efforts in pure science have been concentrated in highly esoteric fields remote from contact with everyday problems. Particle physics, low-temperature physics, and extragalactic astronomy are examples of pure sciences moving further and further away from their origins. The intensive pursuit of these sciences does not do much harm, or much good, either to the rich or the poor. The main social benefit provided by pure science in esoteric fields is to serve as a welfare program for scientists and engineers.

At the same time, the strongest efforts in applied science have been concentrated upon products that can be profitably sold. Since the rich can be expected to pay more than the poor for new products, market-driven applied science will usually result in the invention of toys for the rich. The laptop computer and the cellular telephone are the latest of the new toys. Now that a large fraction of high-paying jobs are advertised on the Internet, people excluded from the Internet are also excluded from access to jobs. The failure of science to produce benefits for the poor in recent decades is due to two factors working in combination: the pure scientists have become more detached from the mundane needs of humanity, and the applied scientists have become more attached to immediate profitability.

Although pure and applied science may appear to be moving in opposite directions, there is a single underlying cause that has affected them both. The cause is the power of committees in the administration and funding of science. In the case of pure science, the committees are composed of scientific experts performing the rituals of peer review. If a committee of scientific experts selects research projects by majority vote, projects in fashionable fields are supported while those in unfashionable fields are not. In recent decades, the fashionable fields have been moving further and further into specialized areas remote from contact with things that we can see and touch. In the case of applied science, the committees are composed of business executives and managers. Such people usually give support to products that affluent customers like themselves can buy.

Only a cantankerous man like Henry Ford, with dictatorial power over his business, would dare to create a mass market for automobiles by arbitrarily setting his prices low enough and his wages high enough that his workers could afford to buy his product. Both in pure science and in applied science, rule by committee discourages unfashionable and bold ventures. To bring about a real shift of priorities, scientists and entrepreneurs must assert their freedom to promote new technologies that are more friendly than the old to poor people and poor countries. The ethical standards of scientists must change as the scope of the good and evil caused by science has changed. In the long run, as Haldane and Einstein said, ethical progress is the only cure for the damage done by scientific progress.

The nuclear arms race is over, but the ethical problems raised by nonmilitary technology remain. The ethical problems arise from three "new ages" flooding over human society like tsunamis. First is the Information Age, already arrived and here to stay, driven by computers and digital memory. Second is the Biotechnology Age, due to arrive in full force early in the next century, driven by DNA sequencing and genetic engineering. Third is the Neurotechnology Age, likely to arrive later in the next century, driven by neural sensors and exposing the inner workings of human emotion and personality to manipulation. These three new technologies are profoundly disruptive. They offer liberation from ancient drudgery in factory, farm, and office. They offer healing of ancient diseases of body and mind. They offer wealth and power to the people who possess the skills to understand and control them. They destroy industries based on older technologies and make people trained in older skills useless. They are likely to bypass the poor and reward the rich. They will tend, as Hardy said eighty years ago, to accentuate the inequalities in the existing distribution of wealth, even if they do not, like nuclear technology, more directly promote the destruction of human life.

The poorer half of humanity needs cheap housing, cheap health care, and cheap education, accessible to everybody, with high quality and high aesthetic standards. The fundamental problem for human society

in the next century is the mismatch between the three new waves of technology and the three basic needs of poor people. The gap between technology and needs is wide and growing wider. If technology continues along its present course, ignoring the needs of the poor and showering benefits upon the rich, the poor will sooner or later rebel against the tyranny of technology and turn to irrational and violent remedies. In the future, as in the past, the revolt of the poor is likely to impoverish rich and poor together.

The widening gap between technology and human needs can only be filled by ethics. We have seen in the last thirty years many examples of the power of ethics. The worldwide environmental movement, basing its power on ethical persuasion, has scored many victories over industrial wealth and technological arrogance. The most spectacular victory of the environmentalists was the downfall of nuclear industry in the United States and many other countries, first in the domain of nuclear power and more recently in the domain of weapons. It was the environmental movement that closed down factories for making nuclear weapons in the United States, from plutonium-producing Hanford to warhead-producing Rocky Flats. Ethics can be a force more powerful than politics and economics.

Unfortunately, the environmental movement has so far concentrated its attention upon the evils that technology has done rather than upon the good that technology has failed to do. It is my hope that the attention of the Greens will shift in the next century from the negative to the positive. Ethical victories putting an end to technological follies are not enough. We need ethical victories of a different kind, engaging the power of technology positively in the pursuit of social justice.

If we can agree with Thomas Jefferson that these truths are self-evident, that all men are created equal, that they are endowed with certain inalienable rights, that among these are life, liberty, and the pursuit of happiness, then it should also be self-evident that the abandonment of millions of people in modern societies to unemployment and destitution is a worse defilement of the earth than nuclear power stations. If the ethical force of the environmental movement can defeat the manufacturers of nuclear power stations, the same force should also be able to foster the growth of technology that supplies the needs of impoverished humans at a price they can afford. This is the great task for technology in the coming century.

The free market will not by itself produce technology friendly to the poor. Only a technology positively guided by ethics can do it. The power of ethics must be exerted by the environmental movement and by concerned scientists, educators, and entrepreneurs working together. If we are wise, we shall also enlist in the common cause of social justice the enduring power of religion. Religion has in the past contributed mightily to many good causes, from the building of cathedrals and the education of children to the abolition of slavery.

Religion will remain in the future a force equal in strength to science and equally committed to the long-range improvement of the human condition.

In the world of religion, over the centuries, there have been prophets of doom and prophets of hope, with hope in the end predominating. Science also gives warnings of doom and promises of hope, but the warnings and the promises of science cannot be separated. Every honest scientific prophet must mix the good news with the bad. Haldane was an honest prophet, showing us the evil done by science not as inescapable fate but as a challenge to be overcome. He wrote in his book *Daedalus* in 1923, "We are at present almost completely ignorant of biology, a fact which often escapes the notice of biologists, and renders them too presumptuous in their estimates of the present condition of their science, too modest in their claims for its future." Biology has made amazing progress since 1923, but Haldane's statement is still true.

We still know little about the biological processes that affect human beings most intimately—the development of speech and social skills in infants, the interplay between moods and emotions and learning and understanding in children and adults, the onset of aging and mental deterioration at the end of life. None of these processes will be understood within the next decade, but all of them might be understood within the next century. Understanding will then lead to new technologies that offer hope of preventing tragedies and ameliorating the human condition. Few people believe any longer in the romantic dream that human beings are perfectible. But most of us still believe that human beings are capable of improvement.

In public discussions of biotechnology today, the idea of improving the human race by artificial means is widely condemned. The idea is repugnant because it conjures up visions of Nazi doctors sterilizing Jews and killing defective children. There are many good reasons for condemning enforced sterilization and euthanasia. But the artificial improvement of human beings will come, one way or another, whether we like it or not, as soon as the progress of biological understanding makes it possible. When people are offered technical means to improve themselves and their children, no matter what they conceive improvement to mean, the offer will be accepted. Improvement may mean better health, longer life, a more cheerful disposition, a stronger heart, a smarter brain, the ability to earn more money as a rock star or baseball player or business executive. The technology of improvement may be hindered or delayed by regulation, but it cannot be permanently suppressed. Human improvement, like abortion today, will be officially disapproved, legally discouraged, or forbidden, but widely practiced. It will be seen by millions of citizens as a liberation from past constraints and injustices. Their freedom to choose cannot be permanently denied.

Two hundred years ago, William Blake engraved *The Gates of Paradise*, a little book of drawings and verses. One of the drawings, with the title "Aged Ignorance," shows an old man wearing professorial eyeglasses and holding a large pair of scissors. In front of him, a winged child is running naked in the light from a rising sun. The old man sits with his back to the sun. With a self-satisfied smile he opens his scissors and clips the child's wings. With the picture goes a little poem:

> *In Time's Ocean falling drown'd,*
> *In Aged Ignorance profound,*
> *Holy and cold, I clip'd the Wings*
> *Of all Sublunary Things.*

This picture is an image of the human condition in the era that is now beginning. The rising sun is biological science, throwing light of every-increasing intensity onto the processes by which we live and feel and think. The winged child is human life, becoming for the first time aware of itself and its potentialities in the light of science. The old man is our existing human society, shaped by ages of past ignorance. Our laws, our loyalties, our fears and hatreds, our economic and social injustices, all grew slowly and are deeply rooted in the past. Inevitably the advance of biological knowledge will bring clashes between old institutions and new desires for human self-improvement. Old institutions will clip the wings of new desires. Up to a point, caution is justified and social constraints are necessary. The new technologies will be dangerous as well as liberating. But in the long run, social constraints must bend to new realities. Humanity cannot live forever with clipped wings. The vision of self-improvement, which William Blake and Samuel Gompers in their different ways proclaimed, will not vanish from the earth.

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