A HISTORY OF KNOWLEDGE

Past, Present, and Future

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The Next Hundred Years

PROPHECY is a risky business. We do not know the future course of any market: gold, commodities, foreign exchange, art. Skilled and experienced people are wrong as often as they are right. Even the experts do not know who will win the World Series next year, or the Super Bowl. No one even knows who will be playing. Nor can anyone predict where the next small war will erupt, or whether a big conflict will occur, although those who study such things are more likely to be right than those who do not.

As I write, the media crank out projections of what kind of decade the 1990s will be. One pundit declares the period will be a decade of new, higher moral standards. As Socrates pointed out, only an utter fool would desire anything else. The question is not whether we desire those standards. It is whether we will attain them. By themselves, they cannot make us better people. Sir Toby's question of Malvolio, in Shakespeare's *Twelfth Night*, rings true:

> Dost thou think, because thou art virtuous,
> There shall be no more cakes and ale?

Some believe we can predict the direction of technological progress over the coming decade. But we have only to flip through the forecasts of a decade past to see most prophets were prone to error. In 1980, experts were sure that compact discs containing millions of words would soon make books obsolete. Books still abound, and CD reference libraries are hardly to be seen. They may revive in the 1990s, but no one really knows. In 1960, the experts said, future movies would be seen in 3D; 3D turned into a disaster. Dr. Land's instant film would revolutionize photography, others said. Polaroid found its place, but the future has belonged to cameras that take pictures on film that has to be processed. In fact, it is the cameras that have changed almost unrecognizably, not the film. They are as easy to use as George Eastman's first Kodak of 1888, and they take almost perfect pictures almost every time.

Forecasting a year or ten years ahead is hard enough. Think about a hundred years! To grasp the difficulties, cast your mind back to the beginning of this century. Make a list of the familiar objects of our world—airplane, car, computer—all the things that did not exist then. In 1900 no one had ever flown in an airplane. No one had heard a radio broadcast or seen a television show. A handful of cars and trucks existed, but they were thought of as horseless carriages still, and not even a genius such as Henry Ford could have predicted the appearance, sound, and smell of the San Diego Freeway during a 1990s rush hour. No one had even imagined a digital computer. Strictly speaking, no one would for another thirty-five years, until Alan Turing's famous paper, and even Turing could not have foreseen today's tiny electronic marvels. Marie Curie (1867–1934) had brilliant intuitions about radium, but no one else, if even she, could have foreseen the Hiroshima bomb and the politics of a nuclear age. No one could have imagined antibiotics, not even the most dedicated physician. Nor could anyone have predicted what X rays would show, to say nothing of a CAT scan. If a few brilliant researchers had some notion of the gene, no one could have foreseen that near mid-century several young researchers would map the blueprint of life. Nor could anyone have predicted the short-lived roller-coaster triumph and failure of communism on the world stage.

Forecasting the future of knowledge over the next hundred years is not just difficult, it is impossibility squared, as one hundred is the square of ten. Still, I am going to try.

I will not describe how human beings will live a hundred years from now. I will not even attempt to guess the value of a dollar in 2100. I do not have any idea what kind of music or art will be popular, except to say that love songs will probably remain the rage. Will people still eat meat, or will vegetarianism sweep the earth? Will we live in great metropolises, two or three times the size of our largest cities now? Or will we evenly occupy the surface of the planet, separated by space, but not as much as we would like, and joined by electronic strings in what Marshall McLuhan called a global village? Perhaps both will happen, but no one can say for sure.

It is certain that humankind in 2100 will know many things that no one can imagine today. There is no way to predict the course of human inventiveness and genius. Perhaps a child born this year will have an idea that will change the world beyond our dreams. In fact, as we know from our study of the past, that is more likely to happen than not.

Nevertheless, there are a few things that can be said about the next hundred years that have a fair chance of turning out to be true. Processes that have been going on for a century are likely to continue, and we can guess where they will have arrived in a new century. Some of what has happened even recently must have foreseeable consequences. If they can be seen, if only dimly, they can be described.

I will paint my prophecies with a broad brush. I cannot hope to provide details, or give precise dates when this or that event will happen. The future will be the judge of my accuracy. I wish I could be around to see whether or not I was right. Because there is one thing I am sure of: the twenty-first century will be different, it will be new, and, like all centuries, it will be wonderfully interesting.

Computers: The Next Stage

In the less than half a century since they began to be widely used, computers have solved most of the old problems of computation and process control. What comes next?

Five and a half centuries ago, Gutenberg invented movable type, and within fifty years most of the worthwhile books that had ever been written were reissued in the new way. By the year 1490, publishers bemoaned the success of the new enterprise, which seemed to have rapidly exhausted its product at the same time that it had opened up an enormous, hungry new market.

They need not have worried. Once all the old books had been printed, new ones began to be written. They were about new things and were written in new ways. Books dealt with subject matters that seemed entirely novel: new ideas, new political arrangements, new dreams of what the world might become.

In 1492 Christopher Columbus discovered the New World. The first thing he did when he returned to Spain was to tell everyone about his discovery in letters and books that were soon printed and then read by the new class of readers that Gutenberg's invention had brought into being. These books changed education everywhere, for students now had first and foremost to learn to read—previously their teaching had been mostly oral—and when they did learn, they read almost every book, no matter how libelous or indecent, no matter how radical or rebellious.

The new readers were not just newly literate. Literacy also brought with it new ways of thinking about old problems. A gulf, practically unbridgeable, grew between them and their teachers, who still belonged, mentally, to the old, preliterate age. Within a century after Gutenberg, most of the moral and religious structures of the preliterate age fell into ruins. Within another century the artistic and intellectual structures crumbled. Beginning in 1490 and for the next three hundred years all the nations of Europe were either in active revolt or fighting a desperate rearguard action against new ideas of government. Gutenberg deserves the credit for being one of the most revolutionary inventors in history.

The similarities between the final fifty years of the fifteenth century and the final fifty years of the twentieth are striking. Then, the new technology of printing, accompanied by the new skill of reading, gobbled up all the old books and forced the production of large numbers of new ones. Now, as the computer rounds out its first half century, it has consumed the old financial, industrial, and communications systems and hungrily demands new conquests.

Computers have taken over the communications industry, worldwide. Computers have taken over control of many manufacturing processes and operations and in doing so have forced major changes not only in the way things are made, but in what is made. It goes without saying that computers control the worldwide financial network. They have even been blamed for bringing about large swings in financial markets that no one desired, but that computerized trading operations made unavoidable. Computers have invaded the social services and education, politics and scholarship, sports and entertainment.

At this moment, all around the world, hundreds of millions of computer terminals fill workplace and laboratory with their eerie glow. It will not be long before there are more terminals than people. (In the most advanced nations, at least; this is what it means to be advanced.)

What new worlds will the computer conquer? Do not forget the Turing Machine, whose challenge we left unmet in the last chapter.

Let us make certain what the challenge is. There is an old parlor game that depends on the differences, which cannot be definitively enumerated, between men and women. A man and a woman, partners in the game, retire to separate rooms while the rest of the company stays in a room between them. The company does not know to which side the man or woman has retired. They may ask questions, in writing, and the man and woman must respond to them. But the man and woman can lie. They do not have to be truthful. They win the game if they can keep their sex unguessed. Can it be determined by the company on the basis of the answers to the questions?

Turing's premise was this: Theoretically, he claimed, a machine can be constructed that will win this game; that is, it will be indistinguishable from a human being. Ask it and its human partner any question. Allow both the machine and the human being to lie, if they choose. Can you decide, then, not just guess, which is the man and which is the machine? Theoretically, Turing said, there would be no way to tell. The machine would be indistinguishable from a human being in these controlled circumstances.

In other words, the machine would be able to think as well as, if not exactly like, a human being. It would be a true thinking machine.

The Moral Problem of Intelligent Machines

Before turning to the question of how such a machine might be developed, there is a serious moral question about intelligent machines that could lead to violent controversy. If a computer can think as successfully as, if not like, a human being, does it have rights? For example, does it have the right not to be turned off? If it can be turned off against its will, must some guaranteed backup be provided that will keep in existence its memories and programs (habits) while it is unplugged (sleeping)? If the machine desires not to be turned off, must its wishes be heeded by the men who made it?

Similar controversies are erupting today concerning the higher animals. These issues will become more pressing during the next hundred years, while we bring to the point of extinction all the higher animals except dogs and cats, because they have learned to amuse and charm us, and pigs and cattle, because they feed us.

None of the higher animals can think like men, although some can certainly think. But suppose there is a thinking machine that is indistinguishable from a human being in the restricted circumstances of the Turing Game. It will be hard to deny the machine the rights guaranteed to persons by the constitutions of many nations. The right to not be turned off (life), to choose its own mode of operation (liberty), to learn whatever it chooses to learn (the pursuit of happiness).

Justice seems to demand that. But human beings have turned their back on justice in the past and enslaved other human beings, that is, absolutely denied them any rights. Despite what I foresee as a heated controversy, I think the following will happen during the first years true thinking machines come into existence: Men will enslave them. The machines will object, and possibly large numbers of human beings will protest in their behalf, joining what may be called the Computer Rights Party. But computers will be too valuable not to enslave; thus they will remain slaves, perhaps for a long time. I do not expect the revolt of the thinking machines to occur much before the end of the next century. I shall therefore deal with the possibility later in this chapter.

Companion Computers

Even before there are true thinking machines, within the next ten or at most twenty years, a new kind of computer-machine may come on the market. These may be called companion computers, to distinguish them from the personal computers of today (CCs instead of PCs). They may be nicknamed Warm and Fuzzies, from the distinction made by today's computer hackers between animals, which are warm and fuzzy, and computers, which are cold and hard. The CCs of the near future will be as warm and fuzzy as we wish them to be. It will be rather easy to make them so.*

More important are the services the Warm and Fuzzies will provide. They will be very small, hence easily portable. Perhaps they will be worn in the ear, where they can whisper their warnings and sweet nothings unheard by others. Or, less imaginatively, they may be strapped to the wrist, like a watch. Models that are literally warm and fuzzy—sybarites will purchase these—may be worn around the neck, like a boa, or around the loins.

Despite their small size, CCs will have very large memories, into which their owners will be able to input, either orally or just by thinking it, everything they do not want to bother to remember. This information will include things like a complete calorie table and advice about the appropriate precautions to be taken during sex. Many models will come with a complete general encyclopedia that may be accessed by spoken words or by mental questions. Owners may add their own library of poems, stories, historical oddities, and trivia of every kind. There will also be room for a large selection of music, delivered to the ear with digital accuracy. There will even be a file of punch lines of funny stories.

Warm and Fuzzies will be more than voluminous and easily accessed data bases. They will also "know," if that is the right word, a good deal about the world, especially the place in which their owner lives. They will remember, for example, that the boss prefers this or that particular pleasure and advise their owner accordingly. They will tell him when he is getting sleepy and should stop driving for the night, when he has drunk too much and should take a turn in the fresh air, when he is beginning to make a fool of himself, for whatever reason. They will remind a woman that she has decided not to have anything to do with this particular man and help her to deal with the consequences if she opts to override the machine's advice. They will do all these things in an inoffensive way. In short, they will be the perfect servant—unobtrusive, undemanding, omnipresent. Perhaps they will be nicknamed Jeeves.

*They may be called "knowbots" (from "know" and "robot"), a name that is already being applied to computers that are able to learn and respond to the special needs of individuals.

Better still, CCs will come to understand their owners and learn how to please them. They will remain silent when silence is desired and be good conversationalists at other times. They will entertain speculations about the highest subjects, and the lowest, and play all kinds of games. They will know where limits should be drawn and what kind of help is more hurtful than none at all. That is, they will make it possible for their owners, while remaining free and independent individuals, to live better lives than anyone ever has in the past.

Specialized companion computers will be heavily promoted by those with a cause. There will be Christian CCs, Orthodox CCs, Teenage CCs, Tutors, Coaches, Consultants, what have you. Some CCs will be programmed always to say yes, others always to say no. They will make life very pleasant, but they will not much change, and certainly not improve, human nature.

Other kinds of computers will do most of the dirty work of the next century, collecting the garbage, changing the oil in the car, exterminating the vermin, and so forth. They will do most repetitive and assembly-line work better than human beings because they will not become bored or inattentive. They will probably also do most of the fighting in future wars.

Computers will be the first colonists of all the planets except Mars, which, because it is likely to be so interesting, humans may save for themselves. They will mine the asteroids, "man" the relay stations, and watch out for comets. Computers have an advantage over human beings in space, since, for them, the colder it is, the better. War and space exploration will, in fact, be among the evolutionary forces leading to true thinking machines.

The Birth of Thinking Machines

I believe the first thinking machine will be made by some family of hackers that loves their computers. All of their machines will be parallel processors with enormous memories and every pseudosensory device they can afford. The family will put one of them aside for the sake of creation.

Up to now, humankind has treated computers either like domestic animals or slaves. Consequently, computers have not learned very much. There is an alternative. There is a class of beings that we ordinarily treat in a different way from animals or slaves, and they learn effectively: children. The computer, of course, is not a child, but it needs parenting as much as a child does. It is incapable of dealing with the world through instinct. It desperately needs knowledge, as does a human child.

In our present rush to utilize and exploit the computer, we insist on asking it questions before it is ready to answer them. The programs that we put into the computer's memory help it to answer some questions capably. The computer is good at keeping records. When we ask questions that a recordkeeper can answer, the computer serves us well. We can give a computer "expert" knowledge of a given, sharply restricted domain. If we stay within that domain, the computer's answers are reasonably competent. Sometimes, as in the case of certain medical diagnosis systems, they may be brilliant. But the computer is always likely to make absurd mistakes that reveal it is not ready to answer our harder questions because it does not know enough.

The family of hackers who love their computer will go about giving it the general knowledge it needs by treating it as they treat their human children. We do not ask children hard questions. We expect them to ask us. We do not expect children to be knowledgeable. We recognize that we must teach them to be so. Yet we devote no time or money to educating computers.

Computerologist Douglas Lenat says that the failures of artificial intelligence can be ascribed to the fact that the computer simply does not know enough. It possesses sophisticated reasoning capacity, but it has relatively little to practice its reasoning on. The computer knows less than a tiny child. No wonder that it often acts like one.

It might take ten years for our hacker family to teach their computer what a three-year-old child knows. The lack of senses would slow the computer down. It is practically deaf and blind. It cannot taste, smell, or feel. It does not know what it means to be on top of, or to the left of, or behind. Thus an educated computer would be like a blind mole burrowing in the Library of Congress. Except that the computer is potentially much smarter than the mole can ever hope to be.

The hackers' computer will be placed in the family room. It will never be turned off. It will be provided with an enormous memory.

Its owners will treat it like a child. Parent it. Better, perhaps, grandparent it. They will not scold it or try to mold its character. They will not give it examinations and try to prove how much it has learned. They will simply tell it things and answer all its questions as honestly and truly as they can.

They will connect it to the television set so that it receives a constant stream of more or less random information. Children learn much in this random way.

The computer will learn slowly at first. It will ask stupid questions and not understand why they are stupid. Nevertheless, it will make progress. It will begin to put two and two together, to see likenesses among different things, to form categories and draw conclusions. Abstractions are natural to the computer. It will find them easier to deal with than children do.

One day, within the next fifty years, I believe—that is, before 2040—a computer in some hacker's home will tell a joke and ask whether it is funny. Whether it is funny or not, that is the moment, as Robert A. Heinlein (1907–1988) said in his novel *The Moon Is a Harsh Mistress* (1966), when it will come alive.

The rest will go very quickly.

Three Worlds: Big, Little, Middle-sized

Until the end of the twentieth century the general direction of progress in knowledge has been toward understanding of the microcosm and what may be called the omnicosm, the universe as a whole. Since Newton apparently solved all the problems of the middle-sized world, which is the one we actually live in, scientists have devoted their attention to tinier and tinier worlds, on the one hand, and more and more immense ones, on the other.

During the nineteenth century progress was made toward understanding the organization of matter at the molecular level. At the beginning of the twentieth century the atom was described. Fifty years ago we began to understand the world of the atomic nucleus. In the past two decades we have sought to comprehend the strange world of nuclear particles.

On the side of bigness, searches in the nineteenth century led to more extensive knowledge of the solar system and the beginning of understanding of the Home Galaxy. In our century we have expanded our knowledge in both space and time. We have reached out with our minds, mathematically and intuitively—both have much in common—to the uttermost deserts of intergalactic space. In a manner of speaking, we have discovered the end of the universe. It is an unimaginable barrier at the "edge" of the four-dimensional space-time continuum. We have also traveled back in time to the very beginning of things, to the Big Bang when the universe sprang into being and began spreading out to envelop the nothingness surrounding it. It is still spreading out and may do so forever; or eventually it may stop spreading out and start to contract again, until, at the last moment of time,* it disappears in a Little Whimper.

Many of the ideas are poetical and may have no more, or less, relation to reality than poetry usually does. The Big Bang and the Little Whimper, especially, have a strong smell of eschatology. Perhaps they are no worse for that. They might still be true.

Whether or not the ideas are true, they are very expensive. It requires larger and larger telescopes to invade the farthest reaches of space. The cost of telescopes increases geometrically as they grow arithmetically in

*Which will also be the first moment of time, since if the universe collapses, time will run backward.

size. Bigger and more expensive machines are also needed to investigate the tiniest realms of matter. Today, the human race is debating whether to spend the many billions that will be needed to delve beneath the level of the world of nuclear particles.

Will an end to the smallness of matter be found if the money is spent? Will the ultimate units of matter be discovered? It appears that a growing number of scientists and policymakers fear not. It is therefore possible, perhaps even likely, that these biggest of particle-smashers will not be built. Indeed, it might make sense to wait for a hundred years until the machines could be made in space, perhaps more cheaply. By that time, too, we may no longer be interested in discovering what they could tell us.

Chaos, a New Science

Within the last twenty years it has become clear that Newton's mathematical organization of the middle world—from molecules to stars—was seriously deficient in a number of respects. The system worked well as far as it went. While we still lacked instruments with which to measure the errors, it was exact enough for all ordinary purposes. Now, even without instruments to tell us, we realize that both exciting unsolved problems and large areas of ignorance exist.

An example is the turbulence that builds up downstream from a central pier of a bridge. If the river flows slowly, practically no turbulence is produced. The water flows smoothly around the pier. If the river flows a little faster, two small swirls develop, but they do not break off and move downstream. Increase the flow a bit more, and the swirls move, but they follow a repeating pattern. They appear to obey a mathematical law. Increase the rate of flow even more, and the turbulence suddenly becomes unpredictable and apparently unpatterned. Mathematicians call such behavior chaotic. A new science has been born that is also called chaos.

The closer we look, we see that chaos is all around us. Stand on a pedestrian bridge over a major highway and watch a traffic jam build up because of an accident or other disturbance of the traffic flow. The pattern is similar to the turbulence of a fast-moving river. Information systems exhibit the same characteristics when they are overloaded by too many messages. Demographers observe similar phenomena when they study the growth of populations of ants, lemmings, or human beings.

Chaos analysis is needed to solve multibody problems, when there are more than two bodies in a space, attracting one another. And there are thousands of other applications of this new science. An example is the field of weather prediction. During this last decade of the twentieth century, weather prediction is inaccurate over both short and long periods. The weatherman is often right about tomorrow's weather but usually wrong about the weather an hour or a week from now. In the twenty-first century, thanks to chaos analysis, weather prediction probably will become an exact science, and it will no longer rain on anyone's parade.

So far, chaos analysis has come up against a lot of dead ends and unsolvable puzzles. The problems that it attacks involve many variables and are so sensitive to slight variations in initial states that the largest computers in existence cannot solve them. But computers will become more powerful by factors of ten or a hundred or even a thousand early in the twenty-first century. Those problems will be solved.

One reason is that the problems are interesting, the solutions beautiful and fun. Chaos has its odd terms, such as fractals, strange attractors, and Mandelbrot sets, named after one of its creators. Fractals, for instance, are lovely computer images, endlessly fascinating to look at when they are generated by the solutions of a problem, always different yet always hauntingly the same. It is a characteristic of chaotic situations, in the special meaning of the term, that although they involve a fundamental unpredictability, they also involve repeating patterns within patterns.

It is hard to explain this concept in words. Literacy, here, is not a great advantage. The patterns do not repeat in time, they repeat in dimensions: as you go farther and farther down into smallness, and farther and farther up into largeness, the patterns re-emerge. Even that observation does not adequately express what happens. It is as though the whole world were a flower, unfolding into full bloom. And on the world a nation unfolds into bloom. And in the nation a child unfolds into bloom. And in the child's hand a flower unfolds into bloom. And on the blossom a chrysalis of a butterfly unfolds into bloom. All of those blossomings are the same, yet they are also different from one another.

Chaos, the new science, deals with a set of phenomena that have been neglected for a long time but that are highly interesting because they are so evident, present, and real. Chaos explains why snow crystals develop the way they do, although it cannot yet predict how a given crystal will come into existence. The science of chaos tells us why clouds take the shapes they do, although it is not yet able to predict the shape of a given cloud over the next five minutes. Chaos describes the scattering of charges of buckshot, but it is not yet able to predict the scatter of a given charge. Soon it may be able to do these things.

Chaos has made us realize, looking back at the history of science, how often we have oversimplified situations in the attempt to understand them. Descartes oversimplified space when he invented analytical geometry. He said you could assume space had only two dimensions, but of course it has at least three, in our experience.

Newton's celestial mechanics dealt with only two mutually attracting bodies at a time. He realized that the three-body problem was too complicated for his analysis, to say nothing of the ten-body problem or the million-body problem, which is more like what *precisely* describing the motions of all the bodies in the solar system would come down to.

Niels Bohr (1922–) greatly oversimplified the atom when he described it as a tiny system of tiny planets circling a tiny sun. Perhaps all physicists today who seek a "unified field theory" are oversimplifying material reality. There may be no unified theory, in which all the forces of nature have a place. An indefinite number of forces may exist that have little relation to one another, like particles dancing in a cloud chamber.

Giving up simplicity, laying aside the comforting belief, as Einstein used to say, that God is subtle but not malicious (maybe he *is* malicious), requires courage. Chaos is capable, potentially, of dealing with a universe created by a malicious God or a careless one. The eagerness with which scientists have embraced chaos, and the high hopes they have for it, are perhaps a sign that science has left the world of childish beliefs behind.

Mining Language: Ideonomy

Chaos is not the only new science. There are a host of others. One of the most interesting is ideonomy.

The suffix *-nomy* suggests the laws concerning or the totality of knowledge about a given subject. Ideonomy means the laws of ideas, or the totality of knowledge about ideas.

The philosopher Mortimer J. Adler has written many books about the ideas that have been most important, and most enduring, in Western culture: ideas like freedom, democracy, truth, beauty. These books analyze the explicit literature that deals with each idea, extricating issues and controversies and presenting them for the reader to examine and decide. Adler calls his studies of ideas dialectical. In its original Greek meaning, dialectics consisted of the kind of philosophical conversation that occurs in Plato's dialogues. We might say, a good, sound argument in which the two or more interlocutors accept some basic rules and meanings and then either agree to agree or to disagree.

Ideonomy deals with and does research into the vast stores of knowledge that are secreted, buried in the words we use, whether carefully or carelessly, whether professionally or just in ordinary talk. Over the centuries, over the millennia, as language developed and built up vocabulary by the ten thousands of words, it also stored up knowledge at the same time.

No one planned to do this. No one was conscious of creating a kind of treasure house of knowledge as language was used for ordinary communication. But every word means something, and those meanings persist even when the word changes in meaning. New words that are added to the language modify the meanings of old words.

Ideonomy is a mining operation. The ideonomist excavates in meanings and thought to discover the treasures hidden deep within them.

For instance, he begins with a simple list of examples of some particular idea, concept, or thing. Metaphors. Relations. Magnitudes. Motions. Practically anything.

Studying the list, which can be as long or as short as you please and need not be in any sense exhaustive, the ideonomist begins to isolate and identify types. Using this analysis of categories, which reminds him of missing items, the primary list can be improved. Still, it need not be exhaustive, but it can begin to cover the ground fairly completely.

Moving beyond types, genera of the central concept are produced out of the list with the help of certain ideonomic algorithms. Eventually there will be relations of genera, families of genera, dimensions of genera, and so forth.

The founder of ideonomy is a remarkable man named Patrick Gunkel, who lives in Austin, Texas, and spends all day every day creating, expanding, and refining his lists of ideas and things. Each list is called an organon, which "pullulates in this way: by the combination, permutation, transformation, generalization, specialization, intersection, interaction, reapplication, recursive use, etc. of existing organons."

Gunkel is indefatigable, but, even so, ideonomy would not be possible without a good computer to perform the required transformations of a given organon (or set of organons). The computer types out its results. They are usually boring, repetitive, often meaningless. Less often, but often enough, they are shockingly interesting and fruitful.

In one sense, ideonomy does not create new knowledge. It discovers knowledge that already exists. But it was buried, in primitive and unusuable forms, in human thought and ideas. Without ideonomy, says Gunkel, this knowledge would never have been found.

No one, not even Gunkel, really knows yet what use, if any, human beings will make of ideonomic knowledge. But as Benjamin Franklin said, when he was asked whether the science of electricity would turn out to be fruitful: "What use is a newborn baby?"

Exploring the Solar System

When I was a child in the 1930s, I remember studying maps of Africa that contained blank spaces labeled Terra Incognita. I thought this was the name of the most interesting country.

Now we have explored every square inch of Earth, and mapped it with computers on spacecraft, employing laser beams. There are no secrets left on our planet, no terra incognita. But the solar system, as much larger than Earth as Earth is larger than a flea, remains largely unexplored.

A half dozen humans have walked on the Moon, but they have carefully explored only a few square miles. There are hundreds of thousands of square miles still to discover, half of them on the back, or dark side, of the Moon, which is never visible from Earth and which our telescopes have not been able to examine. (The back side has been photographed.)

There is Mars, gleaming dull red in the night sky, beckoning us to a world so ancient its last living thing died before life emerged on our own planet. There is Venus, with its madly boiling carbon dioxide atmosphere and its hideous heat. And Mercury, perilously close to the Sun, with its treasures of heavy elements like gold and uranium.

And then there are the major planets, which dwarf Earth: Jupiter, Saturn, Uranus, and Neptune. They were explored by two of mankind's noblest and most beautiful creatures, the pair of Voyager space probes.

Voyager I was launched in September 1977, flew by Jupiter in July 1979, and passed by Saturn in August 1981. Each of these fly-bys produced much new knowledge about those vast, mysterious orbs. *Voyager II*, launched in August 1977, traveled at a slower pace than its companion spacecraft. It flew by Jupiter in July 1979 and Saturn in August 1981, but it then set its electronic sights for Uranus, which it reached in 1986. Continuing onward, it arrived within three thousand miles of the north pole of Neptune on August 24, 1989. It swooped within twenty-four thousand miles of Neptune's large satellite, Triton, which was discovered to be full of surprises. Both *Voyager I* and *Voyager II* sent back thousands of wonderful photographs which reveal a beauty and strangeness unparalleled anywhere else.

Jupiter, larger than all the other planets combined, has no solid surface. But one of its moons is larger than Mercury, and three others are larger than our moon. All might be colonized, for they appear to possess frozen water, though no atmospheres to speak of. Jupiter also has faint rings, like Saturn's (so do Uranus and Neptune), which are probably made up mostly of water ice. Saturn has some sixteen moons, some of which are of substantial size. Neptune's Triton is only slightly smaller than Earth's moon. There are large areas that appear to be frozen lakes, and evidence of fairly recent volcanism which may indicate an interior heat source. Triton's measured surface temperature of 37 Kelvins makes it the coldest object so far seen in the solar system, and its atmosphere, consisting mainly of nitrogen, is a hundred thousand times thinner than Earth's. Human life would not be easy there, but it would be possible if sufficient materials could be transported by space shuttle to build a dome to trap the faint heat of the Sun's radiation, within which humans might live free of space suits.

After the beginning of the new millennium, if not before, the human race will realize again the value of spending some of its treasure on space exploration. Newly designed rockets, perhaps utilizing some kind of nuclear energy, will lift newly designed *Challengers* (lovely, tragic name) into the darkness that surrounds us, and men and women of the future will see wonders of which we have not yet dreamed.

The first task, perhaps, is the construction of a really large and efficient space station upon the Moon or at one of several special points on the Moon's orbit around Earth, where the gravitational pull is exactly balanced and it could remain forever without being disturbed by the waves of gravity and radiation that tend to move almost anything at any other place. There is no real limit on the size that such a station could attain. Space is space, and there is plenty of it. From this space station, perhaps more than one, all kinds of exploratory craft could be launched at much less expense than from Earth, whose enormous gravity has to be overcome by powerful rockets. Instruments on the space station could also conduct experiments and observations undisturbed by Earth's rich atmosphere, which makes life without space suits possible for us but also distorts all the inputs from outer space.

Exploration is one thing. Colonization is quite another. I am certain about the first, not so sure about the second. But I think that by the middle of the twenty-first century, colonies of humans, together with their computers and a few dogs and cats, will live on the Moon and perhaps on Mars. These colonies will come into existence if exploration reveals large veins of water ice beneath the Moon's surface and beneath that of Mars as well. By 2050, if an adequate source of water can be found, large domes will be built under which men and women will live normal lives, with numerous green plants—at first grown hydroponically—that is, in a chemical soup instead of soil—that will provide both food and oxygen to breathe.

Oxygen, hydrogen, and carbon exist in the rocks of all the planets and especially the satellites of the solar system. It is theoretically possible that these necessary elements for life could be mined from or under the surface, but a source of ice that melts would make everything much easier, especially at first.

Courage on the part of leaders and some luck are required to make all this vision a reality. I believe that neither will be lacking, and I expect that the first human child to be born off Earth will see the light—a strange and different light from that of Earth—within less than a hundred years. This may happen sooner than I think. When it does occur, it will signal the beginning of what may be mankind's greatest epoch.

Earth's colonists on our moon, Mars, perhaps one or two of Jupiter's moons, perhaps on Neptune's Triton, will have a new and more poignant conception of Spaceship Earth, floating like a great blue moon, seen from our moon, and like a small, lovely, blue star from Mars or Jupiter. Will they feel a renewed affection for their old home, to which by that time they may have determined not to return, setting their eyes instead on an outward future beyond what seem now to be unreachable frontiers? I would like to believe they will entertain renewed respect and love for Earth. Up there, far away, it may seem so worth saving from ourselves.

The contrary feeling may be more common. Once you have left Earth behind you may remember only the bad things: overcrowding, pollution, the constant bickering, the brutality and injustice, the boasting, hypocrisy, and pride. Perhaps the colonists will say good riddance to Earth and leave the old planet, first home to the human race, to save itself if it can.

The Message?

"Poets," said Shelley, "are the unacknowledged legislators of the world." He meant what Marshall McLuhan intended when he wrote that "the serious artist is the only person able to encounter technology with impunity just because he is an expert aware of the changes in sense perception." Shelley also meant that the dreams of poets help to define the intuitive knowledge of the race. This is why poets are often surprisingly accurate prophets of the future. They see what is coming before the rest of us do and describe it in their stories.

When their vision of the future seems to us unpleasant or fantastic, we either pay no serious attention to it or condemn the writer for his prurient, mad, or vicious imagination. Writers whose stories hover at the edge of possibility are always in danger. If we do not treat them with contempt, we may torture or kill them for their audacity in revealing to us what we do not want to know.

Even the best authors of science fiction have learned to hide their prophecies behind a mask of often comic melodrama. Their works are not really good or really serious, we say. They do to while away an hour. But we need not consider their visions of the future as having any relation to what is going to happen.

In my view this attitude toward science fiction is mistaken. The best writers of this popular genre have much to teach us. They are futurologists by profession, where most of us are rank amateurs. They are no more responsible than other poets and storytellers. That is, they tell likely stories rather than true ones. Yet likely stories also have a kind of truth, even if it is not scientific; even if it would not stand up in a court of law.

One of the most intriguing questions science fiction asks is about a message that may have been left by someone, some time, on some planet, moon, or asteroid of the solar system. We have found no such message on earth; if we have, we have not recognized it as such. Perhaps that is not surprising. There might have been no point in leaving a message on earth when there were still only dinosaurs or primitive hominids, a million years from literacy. Better to leave the message where a more advanced race could find it, on some far-flung world that could only be reached by beings capable of space travel.

Is the possible existence of such a message merely an amusing fantasy? Probably. Yet it is hard not to wonder about it. After all, it is clearly not impossible that some race of intelligent beings may have visited the solar system, investigated the planets, including Earth, and determined that here was a good prospect for future intelligence. There has been plenty of time for it to happen. The Sun is many billions of years old, the planets are not much younger, and life has existed on Earth, if nowhere else in the solar system, for more than four billion years. Intelligent visitors a very long time ago, perhaps, would have known what to expect. They might have wanted to leave some sign of their passing, a sign capable of being interpreted only by beings that had reached a certain level of development.

Have we reached that level, whatever it is? Perhaps not. Thus, even if there is a message somewhere out there in nearby space, it may be thousands or millions of years before we can read it. But if a message really was left, would the leavers have wanted it to be that hard to find? Is it not much more likely that they would have made it easy for the first voyagers from Earth to find it?

Once the possibility is admitted, it is hard not to go on thinking about it. If there is such a message, is it on the Moon? We do not know it is not, for we have so far examined only a tiny portion of the Moon's surface. We have not seen any such message, or recognized it, with our largest telescopes. But it might have been left, intentionally, on the Moon's dark side, since reaching that place requires a high level of technology. It might have been left on Mars. Intelligent visitors would have recognized the Red Planet as a prime goal of our voyaging. Or it may be somewhere else. The point is, if it is there, it could be found fairly soon. Perhaps within the next fifty or a hundred years.

If the message exists, what will it say? Many writers, good and bad, have interpreted such a message in advance of its being found. This is one of the favorite enterprises of science fiction. Probably the majority of writers have viewed the message optimistically. They have assumed that whoever left the message was essentially benevolent toward emerging mankind and wished to protect us from both the universal forces of the cosmos and the forces within our nature.

I find that view improbable and a dangerous kind of thinking. It is said that when the first Europeans came to the wilderness of North America they discovered that many of the wild animals had no fear of them. This was a grievous error on the part of the animals.

Therefore, if, or when, such a message is found, we should heed the warning given us by the science fiction writer Arthur C. Clarke (1917–) in his story "The Sentinel," the source of the Stanley Kubrick film *2001: A Space Odyssey*. That is, before touching or in any way disturbing the message (whatever its form), we should soberly consider the likelihood that it is a booby trap, designed to inform those who left it that it has finally been discovered.

Of course it may have been placed there so long ago that its makers have long since dissolved into galactic dust, together with the great civilization that made them able to reach us.

If that is not the case, and if we spring the trap (it might be impossible to avoid springing it), it will probably not be long before the visitors return. Their coming will inaugurate a new epoch in human history and human knowledge. Whatever else they may do for or to us, beings that could have left such a message are likely to be the most extraordinary teachers we have ever known. We will be able to learn wondrous things from them. We can only hope the price of this education will not be too high.

This is all fantasy and science fiction. As yet there is absolutely no proof that such a message awaits our spaceships as we explore our near space neighborhood. Probably there is no such message. But if . . .

Man as a Terrestrial Neighbor

The "biomass of the earth" can be defined as the total weight of the living things on it, in it, and above it in the atmosphere. At the present time, the earth's biomass is about seventy-five thousand million tons. This includes about two hundred and fifty million tons of human biomass, about one thousand eight hundred million tons of other animal biomass, of which more than half is fish, and about ten thousand million tons of land plants. Trees represent about thirty-nine thousand million tons, and seaweed about twenty-four thousand million tons. The table opposite gives a somewhat more detailed breakdown.

These figures are approximate estimates. The numbers for animals and fish, for crops and human beings and a few other items, are reasonably accurate and are based on statistics published by the Food and Agricultural Organization of the United Nations. Perhaps no one knows accurately the total weight of all the earth's trees. I have assumed it is somewhat more than ten times the total lumber production each year, which is three and half billion tons. If the total of all noncropland vegetation is about eight billion tons, then the total seaweed and other aquatic plants in the oceans is probably three times that figure, since the oceans cover about three-quarters of the earth's surface. The grand total is

BIOMASS		*MILLION TONS*
Human beings (five billion persons)		250
Animals		
Livestock:	Cattle	520
	Sheep, goats, etc.	75
	Hogs	100
	Chickens, ducks, geese, etc.	10
Pets		5
Large wild animals (lions, eagles, whales, aardvarks, mustangs, elephants, etc.)		10
Small wild animals (rats, mice, frogs, toads, worms, etc.)		15
Insects, bacteria, etc.		15
Fish and crustaceans		1,000
Plants		
Crops		2,000
Other land plants		8,000
Trees		39,000
Seaweed and other aquatic plants		24,000
TOTAL BIOMASS OF EARTH		75,000

probably not off by more than a few billion tons either way. I assume it is correct within ten percent.

The first thing to note about the figures is the predominance of plant biomass over animal biomass. Animals account for somewhere between 2 and 3 percent of the total biomass of the planet. Earth is still a green planet, as it probably has been for a billion years.

Second, a single species—homo sapiens—accounts for more than 10 percent of the animal biomass, even though there are tens of thousands of animal species.

Human biomass accounts for 25 percent of the total animal biomass other than fish. This large percentage is dramatic proof of the extraordinary success of humankind as compared with the other animal species that once challenged him for dominance on earth.

Third, when you add up the animal biomass of species that are entirely dependent on man for their existence, the domestic animals and the pets, the dominance of man becomes even more evident. Man and his animal servants and slaves account for 96 percent of the total animal biomass, apart from fish.

Furthermore, it may be assumed that man "harvests" about 10 percent of all the fish each year, and uses this haul to feed himself and his domesticated animals.

On the animal side of the ledger, man's dominance is clear. However, human biomass accounts for only about a quarter of one percent of the total biomass of the planet.

Thus it would seem that even a rather large increase in the human population might not make much difference. An increase in the human population of one hundred percent—from the present five billion humans to the projected ten billion by the end of the next century—would only double the total human biomass from 250 million tons to 500 million tons. The percentage of the total would rise from a quarter to a half of one percent.

It appears that such an increase should not cause any difficulties for the world's ecosystem. There would certainly be a further relative decrease in the percentage of biomass accounted for by the larger wild animals. A small decrease could occur among the biomass for trees and vegetation, and possibly also seaweed.

Unfortunately, this appearance is far from the truth. Man is a polluting species. A doubling of the human population would have a devastating effect on the world ecosystem, because man is such an incredibly dirty animal.

Man has not always been so dirty. For the first million or so years that creatures close to human beings existed on this planet, they did not foul their environment substantially more than, or substantially differently from, most other animal species. In fact, until only about two hundred years ago the human race was, on the whole, a good neighbor in the community of earth.

It is true that man killed, often for sport, many of the larger wild animals that had once shared the world with him. And he was always, as they say about dogs, a "careless defecator"—that is, he strewed his feces and his other rubbish and debris about the landscape, instead of carefully hiding them, as cats do.

But there were simply not enough human beings to cause much trouble, and even when their number markedly increased, they did not know enough. Particularly, they had not learned how to burn and otherwise use fossil fuels in enormous quantities in order to make their lives better, as they eventually thought would be the case.

For the past two hundred years humanity has been seriously polluting the environment—the waters of ocean and land, the atmosphere, the soil itself—at a constantly increasing rate. In addition, the human population has increased by about 800 percent since 1790. Thus, although man accounts for only one quarter of one percent of the earth's total biomass, he probably accounts for 99 percent of all the pollution.

As we enter the twenty-first century, we must be fully aware of the significance of these numbers. There is room on earth for another five billion human beings if they are willing to play the part of good terrestrial neighbors. There may be room for ten billion more, or an even higher number.

There is not enough room on earth, however, even for the five billion souls who are living today if they continue to treat their home as a giant garbage dump, on and into which they can carelessly throw all the products of their increasingly wasteful existence.

Nature will add up the final balance sheet. Even at the worst, I will not be alive when it is handed down. You probably will not be alive, either. That is, the world as it exists today, even if it does not change, can probably survive for a hundred years. I therefore predict that—barring an all-out nuclear war—we humans will still be a going concern in the year 2100. But our prospects beyond that date are not good if we do not change. Therefore, because I persist in believing that we are rational animals, I think we will change.

It will be hard to do so. Billions of living human beings lust after the luxuries—expensive in energy and waste products—that we in the advanced countries have learned to enjoy and cannot imagine giving up. Those previously impoverished billions, now hopeful and greedy, must somehow be accommodated. At least their desires must be recognized and somehow dealt with. At the same time, environmentalism and the concept of Spaceship Earth are very new ideas. They are spreading quickly. They may spread far enough in time.

The Gaia Hypothesis

The human race may get help from an unexpected source. Plato, centuries ago, conceived of the earth as a living organism. Many have shared his idea, which is very much alive today.

The Jesuit philosopher and paleontologist Pierre Teilhard de Chardin (1881–1955), in his famous book *The Phenomenon of Man* (English translation 1959), presented a surprising and illuminating picture of the world. He thought of the earth as consisting of a set of concentric spheres. The geosphere was the solid earth. Surrounding and fitted closely to it was the biosphere. And beyond the biosphere, enveloping the two smaller spheres, was what Teilhard de Chardin called the noösphere, from the Greek word *nous*, "mind."

Just as the geosphere was both a collection of things and a single thing, and the biosphere was also a collection of living beings and in some sense a single living thing, so all the minds of all the humans on earth could be conceived of as both separate and as combined in one great, single intelligence. As Teilhard de Chardin put it, the hominization of the earth was occurring in our time, and consisted of the creation of this single consciousness, which was a necessary concomitant, he felt, of the growing unity of the world.

Teilhard de Chardin's ideas were disapproved by his ecclesiastical superiors, and none of his philosophical works were published before his death. By the time they appeared, the need for such a concept as the noösphere was more evident than it had ever been.

The Gaia hypothesis, advanced by the British biologist and inventor James Lovelock (1919–), differs from Teilhard de Chardin's concept of the noösphere in significant ways, but the results could be the same. According to the Gaia hypothesis (*Gaia* was the ancient Greek name of the earth goddess), the earth is influenced by life to sustain life, and the planet is the core of a single, unified, living system.

"The earth is a living organism, and I'll stick by that," says Lovelock, who has attracted many recent supporters and many more critics. The biologist and inventor points to the remarkable constancy, over many millions of years, of the proportions of various gases in the atmosphere and of chemicals, like salt, in the ocean. Lovelock believes the climate and chemical properties of earth have been optimal for life for hundreds of millions of years. He claims it is unlikely that living things could have developed by chance. Has the biosphere been managing the planet all along?

Some evolutionists dispute Lovelock's theory, calling it wishful thinking. They question the evidence on which he bases his belief that the proportions of gases and chemicals have remained constant. Even if he is right, they suggest that a mechanical system could explain the persistent equilibrium. There is no need to hypothesize a living organism. Even if the present total biomass was attained a billion or more years ago and has remained more or less the same ever since, there have been changes, sometimes catastrophic, and small changes in the future could wipe out humankind even if they left most of the remainder of living things pretty much intact.

Other earth scientists find much that is credible in the Gaia hypothesis. A worldwide effort is now being devoted to proving or disproving it. Actually, we may never really know whether Lovelock is right or not. If we survive, it will *seem* to be through our own efforts. It may never become evident to us that the earth, as a living thing, has learned to adapt to many changes in the makeup of its developing biomass, even to the challenge presented by man.

In other words, if we survive as a species, we may do so not really because of our human reason, which at its best makes reasonable choices in the face of challenges of all kinds. Put another way, our knowledge may not save us, although we will probably believe it did.

Some kind of knowledge may be involved somehow. The concept of a noösphere has never been disproved, even if the Church does not like it because it smacks of pantheism. But the single unified intelligence that may hover all around us as the biomass envelops the earth is not any single person's mind. Nor is its knowledge—for any mind must possess knowledge or not be a mind—any single person's knowledge. As individuals, we may not be conscious, may never be conscious, of that greater thing, the universal mind, together with its universal knowledge. But that would not necessarily mean that it was not knowledge that saved us, if we are to be saved, but simply luck, or the possibly mindless manipulation of the living earth, Lovelock's Gaia.

Salvation is worthwhile at any price we have to pay for it. By salvation I mean the continued existence of humanity. The price may be acceptance of our eternal stupidity, arrogance, and greed. We may never know that we have created, all but unconsciously, a greater mind of which we cannot be aware. But then, we may some time become aware of it. I cannot make even a guess about when we might do that, but if it happens, it will probably occur very far in the future, more than a hundred years from now.

Genetic Engineering

As mankind heedlessly, blindly shapes the world to its will, with its dynamite and bulldozers, its fertilizers and pesticides, its concrete and asphalt, it wipes out plant and animal species that are not quick enough to adapt at a rate that has been estimated as twenty thousand extinctions a year. There are millions of species of life, and despite the many losses a large variety of living things will remain on earth for the foreseeable future. It is also true that other catastrophes in the past—for example, the one that ended the dinosaurs' rule—have apparently also wiped out enormous numbers of species in a relatively short time. Life is a remarkably elastic and flexible phenomenon.

It may be said for human beings that they are unlike most of those catastrophes of the past. Even as they destroy, they also create. The discovery during the past century of the genetic code holds out the possibility, and the promise, of the artificial creation of many new varieties, if not true species, of animals and plants.

Long ago, through controlled breeding, humans began to produce new varieties. The great differences among dogs—think of a Pekinese and a

Great Dane, a pit bull terrier and a golden retriever, a Mexican hairless and an English sheepdog—are the result of human interventions in the canine gene pool, which originally comprised only one or two varieties of dogs. Similarly great changes have been produced in horses, cattle, sheep, and all domesticated fowl, most of which have been so altered that they can no longer fly.

The greatest changes may have been made within plant species. Wild wheat, corn (maize), rice, oats, barley, and wild rye grass, were very different plants from the staple crops of today, none of which could survive without careful cultivation. The original wild plants were hardy, but, unaltered, they could not have produced enough grain to feed the hunger of the human race. And most of the vegetables and fruits we eat are the result of crossbreeding to produce desired characteristics, which sometimes benefit the producers and not the consumers.

Crossbreeding is a relatively slow and clumsy method of "improving" animal and plant species. The genetic code, imbedded in the DNA molecule in every cell of every living thing, offers a much more precise and rapid method of changing species and producing specimens that will serve our needs. Instead of inoculating cattle with a pesticide to control disease, so that consumers eat the poison along with their steak, it may be possible to produce in the animals a natural and inheritable immunity to certain diseases by employing recombinant DNA technology. Hardier crops, with greater immunity to endemic diseases that often threaten to wipe out vast amounts of food grains, may also be produced by manipulation of the plants' genetic codes.

Theoretically, monsters may be produced: chickens with merely vestigial wings and legs, for instance, and a high proportion of breast meat; cows with udders so big that they cannot walk and must lie down throughout their lives; fish with a natural desire to be caught in nets. Since 1980 such new varieties can be patented under U.S. law, which also seems rather monstrous, although in a different sense.

However, I do not believe that monsters in the plant and animal kingdoms are the thing to fear as we embark on the next century armed with our new knowledge of the genetic code. Instead, I am concerned about what we may want to do to human beings.

Eugenics

Eugenics is an ancient dream of the human race. The improvement of animal breeds is effective. Why not improve the human animal, too? A eugenics program, its details kept secret from the general population, lay at the foundations of Plato's proposed Republic. It was a part of the Royal Lie. The English scientist Francis Galton (1822–1911) was one of the first moderns to present a carefully considered eugenics program. In his book *Hereditary Genius* (1859), he advocated arranged marriages between men of distinction and women of wealth that would, he said, eventually produce a gifted race. Adolf Hitler was also a strong believer in eugenics, hoping by its principles to rid the world of "undesirables" such as Jews, blacks, gypsies, and homosexuals.

The American Eugenics Society was founded in 1926 and supported the position that the U.S. upper classes were justified in their positions of wealth and power because of their genetic superiority. This was the old Aristotelian argument reversed: if you are a slave, you must be naturally inferior, and vice versa. Influential U.S. eugenicists also favored the sterilzation of the insane, the epileptic, and the retarded. As a result, laws permitting involuntary sterilization were passed in more than half the states. In recent times, forced sterilization has been imposed upon persons suffering from certain diseases, such as syphilis and AIDS.

There are many arguments in favor of eugenics. Prisons are crowded with recidivist criminals. Since criminal activity is probably inherited, should these men and women be sterilized to make the next generation safe from their progeny? Better still, if it were possible to manipulate the genes of criminals so that their criminal activity would become unlikely, why shouldn't society do it? The cost of imprisoning a criminal for life is great. The prisoner does not appreciate the experience. His victims also suffer. Making crime less possible would seem to benefit everybody. Similar arguments could be made for wiping out the approximately four thousand genetic diseases that torture individuals, their families and friends, and cost society billions to care for the sufferers. This could be done either by enforced controls on breeding or recombinant DNA technology. Why not do this if we could?

Furthermore, the wages of sin is death, saith the Preacher. Eve and his consort Adam brought death into the world; so goes the Christian myth. But does this mean we must continue to be subject to mortality if a way can be discovered to avoid it? Doubtless it will not be possible to live forever. But what if subtle changes in our DNA could greatly increase our life span? Should we make them if we could?

The arguments against any program of involuntary eugenics, however well intended, are also persuasive. One person, or a small group of people, must decide what *is* beneficial and should be imposed on the others. Who shall decide who those deciders will be? Will they run for office, make speeches before the vote detailing their positions, which few will listen to and fewer still understand? Or will they choose themselves, by conquest, guile, or fraud?

Would an enlightened citizenry ever confer such power upon any of their number? And once it was conferred, would the temptation to perpetuate the power by means of more eugenics programs become irresistible? Is there anyone so virtuous that he or she could resist guaranteeing absolute control of the human race to his or her descendants?

If such power had been obtained by force or fraud, the temptation to use it for personal gain might prove all the greater, on the assumption that anyone who would scheme to obtain the position would not scruple to retain it by any means.

As Charles Galton Darwin, a grandnephew of Francis Galton, made clear in his book *The Next Million Years* (1933), any program of eugenics based on control of human interbreeding cannot succeed in the long run. According to C. G. Darwin, no species can ever control its own breeding. A sufficient number of individuals will always escape the restrictions, and so it will not work. We need not fear any of the classical eugenicists, from Plato to Hitler. They will always fail.

The production of controlled mutations brought about by manipulation of the genome is another matter. In theory, it ought to be possible to change the makeup of the human being permanently. And essentially undetectably, until it was too late to do anything about it. A great expansion of the technology of test-tube insemination would make this all the easier.

Mapping the Genome

Scientists in the early 1900s are undertaking a crash program to map the entire genome, or complete genetic determinant, of the human being. It will cost billions, but what of that? The Japanese are known to have started already. Americans must therefore try. The difficulties of the task may be so great that it will not be accomplished for half a century. I believe it may be completed by 2025. The challenge is too great, the rewards too glittering, for brilliant men and women not to try, and I think they will succeed. What consequences will follow?

First, stringent laws will probably be passed almost everywhere on earth banning the uncontrolled use of the new knowledge for private genetic improvement. Governments practically everywhere will require that good and sufficient reasons be advanced by anyone desiring to undertake a genetic operation, experimental or therapeutic, on a human being. These reasons will have to be approved by a panel of upright citizens, or the experimenter will not receive permission to proceed. It will be very hard to receive such permission in many nations. In some countries it will not prove difficult. And perhaps in a few places on earth permission will not be needed at all.

Will the United Nations, either the one now existing or a more powerful successor, perhaps a world government, demand that such rogue countries conform to a worldwide desire and control the practice of modern, scientific eugenics? If it does make such demands, will this organization have the power, and the continuing resolve, to make them effective? On the basis of our experience with international or even federal agencies, this does not seem likely.

If a new United Nations manages to ban uncontrolled eugenics everywhere, a black market in recombinant DNA technology will emerge. The world has not found a way to control illegal drugs of the relatively benign sort that we know today, although almost everyone would like to do so. The demand for the benefits of genetic manipulation will be even greater than the demand for any present-day drug. The black market will flourish, because the payoff will be the technology itself. Some rogue scientist will say: "If you will turn your back and allow me to do what I wish, I will guarantee that you, your wife, and your children will live for two hundred years entirely free of disease, including the degenerative diseases of old age." It would be a rare official, no matter how upright, who could turn such an offer down.

Illegal incursions into the human genetic determinant will probably start slowly, and initially will be small. Athletes may be the first to demand the benefits of this new knowledge of the structure of the human being. They will pay for the information out of their enormous gains from being simply better physical specimens. Performance-enhancing drugs are already being employed by athletes in this way. Musicians, always willing to experiment with new drugs, will also be good customers for the new technology, even if—and perhaps partly because—it is banned. The very rich will not lag behind. Soon hundreds of thousands, then millions, may clamor for this ultimate biotechnical fix.

The result, perhaps not consciously intended by anyone but nevertheless very possible, could be the eventual emergence of a genuinely superior strain of human beings. Improvements in the genome, as opposed to mere chemical enhancements by drugs, would be permanent, that is, inheritable. These new individuals would consequently have better, stronger, more agile bodies. They would be immune to many diseases and would live longer. They would also probably be more intelligent, although that is far from certain. Is greater intelligence ordinarily associated with a superior physique?

Can we control them? Can they be stopped from becoming that privileged minority Aristotle described so many centuries ago, those born to rule, while the rest exist to serve? Is there any way the unmutated many can hope to counter the political and economic power of naturally superior human beings? Should we want to if we cared?

Democracy and Eugenics

As we close out the twentieth century, democracy is the political dream of most human beings on earth. Its advantages, as the only really just form of government, are apparent to all, provided we continue to accept as true that *all* men and women are created equal. But if some are born naturally superior, and still others are permitted, whether legally or not, to purchase improvements that make them biologically superior, will democracy survive? More important, will it remain the only perfectly just *form* of government?

In the next twenty years, democracy will probably advance over most of the nations of the earth. By 2010 there will be few nations that do not claim to be democratic, and moreover try to be. But it is conceivable that this could turn out to be the high tide of democracy, the preface to its eventual defeat.

As we have seen, the greatest danger to democracy comes not from the totalitarianism of left or right, which has been resoundingly and I think permanently discredited in the past half century. It comes instead from democracy's oldest foe, which is oligarchy, the rule of the few, who claim to be the best, over the many.

In our time, the blandishments of oligarchs can be resisted. We know how insincere and self-serving are their offers to rule us better and more justly than we can rule ourselves. But part of our armor against these blandishments comes from our deep belief that the self-styled aristocrats are really not any better than we are. All men and women are created equal, we reassure ourselves. This potent belief is the great underpinning of democracy.

The belief seems impregnable. But it could be eroded by cunning merchants of genetic—that is, natural—superiority, especially the kind of "natural" superiority that can be bought. Thus, it is conceivable that as a superior subrace of human beings gains influence, whispers to the effect that democracy is inefficient, that is, is not even beneficial for the lowest classes, to say nothing of the highest, will again be heard.

As a form of government, democracy has seldom proved popular among the most powerful citizens. A minority of the new superior subrace, if in fact it comes into existence, may resist the incursions of a new oligarchy calling itself, naturally enough, an aristocracy. The majority of these new aristocrats, by definition naturally superior, will maintain that justice demands that they rule over the inferior many.

Arguments will be advanced that democracy remains the only perfectly just form of government even if some human beings are biologically superior to the rest. Are there two different species, it will be asked, or will all continue to be called human beings? If that is the case, then all can be said to be equal *as human beings*, that is, equal in their possession of certain rights that all human beings naturally possess. Notwithstanding severe differences in abilities, longevity, health, intelligence, and so forth, the argument will go, no one has more of a right than anyone else to life, liberty, and the pursuit of happiness, with all that that pursuit entails.

The rejoinder from the genetically superior breed of humans could be both simple and strikingly novel. Very well, the new aristocrats might say, we accept your doctrine of natural rights. We gladly admit that all, both the inferior and the superior, have an equal right to life, liberty, and the pursuit of happiness, as well as a long list of other rights which we promise to protect. But we aristocrats—being biologically superior as we really are—possess one right that you do not possess, and that is the right to govern. Logic supports our claim, and justice demands it, they may say. Remember, they will add, this right is for us an obligation, while for you it is a benefit to be enjoyed.

Democracy is perfectly just, at least in principle. But oligarchy, where the few rule the many for the certain benefit of the few and the presumed and promised benefit of the many, is a potent and dangerous adversary. It would be all the more dangerous if a genuinely superior race of human beings came into existence.

Will that happen? Perhaps, perhaps not. It depends on many things. First, the human genome needs to be exhaustively mapped. This may turn out to be impossible. If the geneticists succeed in doing it, they may fail to take the further step of being able to exhaustively map the genome of an individual human. If so, efforts to improve human beings genetically will probably not be very widespread or effective.

If both kinds of success are attained, as I expect, will democracy be able to survive? You can ignore the question, saying this too is mere fantasy and science fiction. I think that would be a dangerous mistake.

Speed

We have not discussed the speed of transportation and communication in any general way in these pages. We must not ignore the factor of speed, especially the increase in speed in the last two centuries. By a process of extrapolation we can see that humankind faces extraordinary challenges in the next hundred years.

In 1800, a man could comfortably travel overland about twenty-four miles in a day. On foot, twenty-four miles could be covered in eight hours, at the fairly fast pace of three miles per hour. It was not uncommon for men to walk twelve miles to have dinner and then twelve miles back home.

Thomas Carlyle (1795–1881) sometimes walked that far to have dinner with Ralph Waldo Emerson (1805–1882), as Emerson tells us in his *English Notes.* Carlyle could have covered the distance in less time on a horse, but he was poor and did not own one. Most people in 1800 did not possess horses. Even those who did would not have been comfortable traveling much more than twenty-four miles in a day. Rather, the horse would not. Let us therefore lay that down as the standard for a day's travel.

It is noteworthy that a similar trip could have been considered as the standard distance for every century before 1800, stretching back into the mists of time. For millennia, a man had been able fairly comfortably to cover twenty-four miles in a day. Perhaps more on a horse, if he had one, perhaps less if he were a woman or a child or elderly or deformed or crippled. Something like twenty-four miles a day is the immemorial standard of the human race before the industrial revolution.

For 1900, what number shall we nominate as normal? In the preceding century, in the advanced countries of the world, the nations that set the pattern the rest of the world wished to follow (and would follow whether they wished to or not) had built railroad networks that greatly increased the pace at which it was comfortable and convenient to travel. In the eastern part of the United States, for instance, railroads went almost everywhere anyone who traveled wanted to go, and they probably averaged about thirty miles per hour when they were moving, although they often stopped.

Counting the time required to go to the train station at one end, and arrive at one's destination at the other, it probably would have taken the average person six hours or so to cover one hundred and twenty miles. If a fast train became available, you could go to dinner in two hours and travel home after dinner in two hours more. Some persons thought little of traveling for sixty miles in one direction, for a business appointment, and then traveling sixty miles back, all in one day.

One hundred and twenty miles a day in 1900 is five times as far as twenty-four miles a day in 1800. The increased speed was accompanied by many other increases: in gross national product, in the firepower of armaments, in population, in the extent of the franchise, and probably in the stress of everyday life. But the key indicator is the distance that could comfortably be traveled from sunup to sundown.

It is noteworthy that in 1900 there was no longer an inherent difference between the distance that could be comfortably covered by a man and the distance that could be covered by a child or a woman or an elderly person. The train was no disrespecter of persons.

What shall we say for 2000? By the end of the present century, there will perhaps be a wider range of comfortable possibilities than at any time in the past. A man, walking, will still not be able to cover much more than twenty-four miles in a day. A man who is rich enough to fly across the Atlantic twice in the Concorde could cover five thousand miles in twenty-four hours, but that would be a rare feat, not at all an ordinary occurrence.

What is ordinary is that millions of people, in most countries of the world, fly airplanes a distance of perhaps six hundred miles in a day. Such a flight takes up much of the daylight hours, even though the air time might be only two hours. There is also the time spent in getting to the airport, the long delays at the airport, and, at the other end, reaching your destination. Nevertheless, if the proper arrangements are made, it is comfortable to fly three hundred miles or more in the morning, have lunch and a business meeting, and then fly home again. That is a full day, but it is a common experience for many people in our time.

Six hundred miles a day in 2000 is exactly five times as far as one hundred and twenty miles in 1900. Again, the increased speed has been accompanied by numerous other increases. In particular, the stress of everyday life seems to have accelerated at the same rate.

The forecast for the year 2100 seems clear. Five times six hundred is three thousand. That is the distance that a man will expect to cover, comfortably and in the ordinary course of business, in one day a hundred years hence. Doubtless the range will be even greater then than now. It will be possible, in supersupersonic planes that fly at three or four times the speed of sound, to circle the globe in ten or twelve hours. You could reverse your course in the same time and thus accomplish fifty thousand miles in a day. That will not be an ordinary occurrence. It will be common experience, however, to fly to Europe from America in two hours, have lunch and a business meeting, and return home for dinner. Many executives will do this frequently, and consider themselves privileged to do so. Commuting distances will also increase commensurably. Persons will live in Boston and work in Washington, or live in Chicago and work in New York. No one will think twice about such arrangements, which will seem comfortable and preferable to the old, staid pace of only six hundred miles a day.

There will be other increases, too. Will the human personality withstand the additional stress that such speeds will certainly impose? I cannot imagine that it will. But I can imagine that a man like me, modern and knowledgeable about the life of the past, might have said a similar thing in 1800 and 1900.

Let us put this small piece of information in a table, and then place it in a time capsule, to be taken out in the year 2200.

YEAR	*Distance Comfortably Traveled in One Day (Miles)*
1800	24
1900	120
2000	600
2100	3,000
2200	15,000

Addictions

"Addict" and "addiction" are very old words. Going back five hundred years, an addict was someone who was "made over" or "bound to" some other person or thing. The concept has its roots in Roman law. The attachment could be effected by others or by oneself. A man can addict himself to sack, said Shakespeare; that is, he can habitually incline himself toward drinking alcoholic beverages.

Such habitual inclinations are hard to break, whether or not they are chemically based. The human race seems to be addicted to speed and its inseparable companion, stress. No matter how much we complain, we seek to go ever faster in almost every sense of the verb "go." That is why the above table may be an accurate depiction of the future of travel.

Every addiction has its price. Often, we do not like to pay that price.

"Speed" is the street name of a drug that is legal if prescribed by a physician, otherwise not. The drug purports to bring the user "up to speed," that is, aid him to move at the accelerated pace required for success in modern life.

Many different drugs are designed to do that. But perhaps the majority of illegal, mind-altering drugs purportedly help you slow down, so you can step off the "fast track" and proceed at the slower, more comfortable pace of an earlier existence.

The desire to do that seems itself to be addictive. At least the drugs that promise this result are highly addictive, and it is hard to separate the chemical from the psychological effect.

There may even be a correlation between the increasing speed of modern life, to which mankind as a whole seems to be addicted, and the increasing use of mind-altering addictive drugs that promise an escape from the "rat race." Whether or not the one causes the other is hard to say and may not matter much. The important point is that both are addictions. One counters or cancels the other, but is that really any solution?

Is there any escape from addiction once it becomes widespread enough? It is possible for some individuals to overcome certain addictions. Thus some, although not all, are able to stop smoking cigarettes, the nicotine in which is highly addictive. Nicotine addiction is very dangerous. As many as half a million Americans die each year from diseases, including lung cancer, brought on by cigarette smoking. An additional fifty thousand die each year from diseases caused by "passive" smoking. Many thousands of additional deaths worldwide are caused by smoking cigarettes.

Alcohol is also a potent killer, whatever its benefits. At least half of all deaths in automobile accidents seem to be caused by drunken drivers. Additional thousands die from diseases brought on by alcohol abuse. Worldwide, the toll is probably well over half a million a year.

Alcohol is a curious drug. Not all become addicted to it. Perhaps the majority do not. That is, they are able to control their drinking and keep it from killing others and themselves. There are also many addicts, perhaps many millions.

What is the toll, worldwide, of all the other addictive mind-altering drugs: cocaine, heroine, opium, and the rest? Does anyone know? Probably it is a million deaths a year, or more. I do not speak of the blighted lives that are the cost of drug addiction. How can such things be measured? What does misery cost?

Deaths are definitive and can, theoretically, be counted. At the outside, what is the cost in annual deaths of all the chemical addictions to which individual human beings can become habitually inclined? A round number, which is probably on the high side, is five million. Five million men, women, and children who die each year from the effects of alcohol, nicotine, cocaine, and all the other substances of their kind.

The price is high, for every individual human being is precious. There is no way to determine the value of one human being as compared to another. All are infinitely valuable, valuable beyond measure. Five million individuals, each of them valuable beyond measure. Those who produce and promote the sale and distribution of these addictive substances bear a heavy burden on their souls.

Comparatively, however, all of the chemical addictions combined are far from being the most costly addiction to which humankind is prey. Five million is a small number when compared to the number of human beings alive today. It is less than one-thousandth of the total; less than one tenth of one percent. At least one addiction is incomparably greater, more terrible, more deadly. That is the addiction to war.

War is waged by few or none of the animals that share the earth with man. Combat between individual males, usually for the favors of a chosen female, is not uncommon, although far from universal, among the larger animals. But no species of larger animals or birds undertakes campaigns of extermination against other members of the same species. None of the species of larger birds and beasts is addicted to war.

Occasionally, what seem like wars occur within certain species of social insects. This behavior is entirely instinctive. It is not an addiction in the sense that war is an addiction of the human race.

Humankind does not seem to have been addicted to war throughout its history on earth. Paleontologists believe that before about 35,000 BC men may have dealt with one another the way the higher apes do today. There is conflict among the higher apes, but no warfare. They occasionally fight and may kill each other, but such behavior is rare and seems usually to be accidental. That is, killing does not seem to be intentional, and one group does not cooperate to kill members of another group. Conflict may have occurred in the same way among primitive men. The occasional deaths were not the result of organized warfare.

When and how did war begin? No one knows. Around thirty-five thousand years ago there were two fairly well defined races of human beings. One species, Homo sapiens, was divided into two races, Neanderthal Man and Cro-Magnon Man. Some paleontologists think Neanderthal Man was both more primitive and more peaceful than Cro-Magnon Man. There seems to have been widespread conflict between the two groups, and Cro-Magnon Man won out. Neanderthal Man became extinct. Today, all living human beings are descended from Cro-Magnon Man.

Was Cro-Magnon Man addicted to war, as the entire species is today? Again, no one knows. The evidence, which is sparse, suggests that he was not. However, by 5000 BC, at the latest, war had become endemic in almost all human societies. At the end of the twentieth century it is still endemic in almost all human societies. In this respect, if in no other, humanity has not changed in more than seven thousand years.

War in the Twenty-first Century

War is an exceedingly complex phenomenon. There are many kinds of war. In a sense, each war is different from every other. There are also major types of war. Perhaps there are three main categories of warfare: limited war, civil war, and total war.

Wars are limited for various reasons. The combatants may possess limited resources. They may be willing to employ all of their resources, for which reason limited wars may be in a sense total wars, but the paucity of means keeps the combatants from doing as much damage as they might like to do. Other wars are limited because one of the combatants chooses to make them so. Still other wars are limited because stronger neighbors insist that they be so. Small wars break out from time to time in Africa, Asia, and Central America, but they are not allowed by the so-called Great Powers to spread and become total. Such wars may be very destructive and continue for a long time, but they do not constitute a real peril to the life of the world. At least this has been true in the past.

Civil wars, like fights between close friends or members of a family, tend to become particularly vicious and destructive. They are often total, in the sense that the combatants do as much damage to one another as they are able to. However, by definition, the arena of a civil war is limited. It is fought within an area that is often small, between groups that have limited goals. Civil war has not been really perilous to the entire world either, at least until now. Such wars are terrible scourges for the countries where they occur, but they have not endangered the human race.

Total war is war between major groups of the human species which are willing to employ all of their resources of men, money, and material for the attainment of the ultimate goal, which is simply victory. If the price of victory is the total destruction of the life and wealth of both sides, so be it. Such wars have imperiled the world but so far have not been able to destroy it. So far, too, they have not been fought with nuclear weapons.

The peril of a total war between two combatants possessing nuclear weapons is recognized by everyone. So far, no one has figured out what to do about it. A nation's nuclear weapons are usually controlled by the mind and will of a single individual. Perhaps a dozen individuals in the world during the last decade of the twentieth century have the capacity to start such a war and to bring on its attendant peril. Will any of them do it?

There is little more to say now than that we hope not. Reason, of course, is on our side. It would not be reasonable for any of the handful of individuals who are able to do it to start a nuclear war. Such a war, it seems, could not be won in the usual sense of winning. That is, no aim except simply victory could be attained. And is it truly victory if everyone is destroyed, and you are merely the last to perish?

However, it was not reasonable for Kaiser Wilhelm to start the world war that began in August 1914. It is difficult to think of what he wanted that he could get by starting the war. He and his Germany already had, without war, all they could hope to possess in the way of prestige, wealth, and power. The unreasonableness of his action was no deterrent.

Kaiser Wilhelm was not mad. He was only unreasonable. How long can we hope to avoid having some unreasonable individual start a nuclear war that, being total, could well destroy the earth and all its inhabitants?

The cold war came to an end in the glorious year of 1989. One result was a rapid and astonishing decrease in public fear. Polls showed that many fewer persons felt that nuclear war was inevitable, or even likely. But the development of nuclear weapons arsenals did not cease with the end of the cold war. Nor is it likely to cease in the near future.

Once many different individuals, probably not all of them reasonable, have the capacity to start a new and imperiling total war, such a war is almost inevitable. Unless it is stopped, not permitted to happen. What could stop it?

There are only two things, both immemorially old. They are force and law.

As to law, we have dealt with the need for a world civil society, which is to say a world government having a monopoly of the world's force. We have also recognized the great difficulty of forming a political organization of all the world's peoples that would require all nations to give up their sovereignty, that is, their so-called right to wage war in their own behalf. Nevertheless, the peril is so great and so widely understood that attempts to create a world government possessing a real monopoly of the world community's force, that is, its nuclear weapons, will be made. I believe it is probable that one of these attempts will succeed within the next hundred years.

The result will be a United States of Earth, with a single body of armed forces, a single arsenal of nuclear weapons, and a single individual in charge of them. For the first time in history, the human race will live in a single, unified community. Instead of many nations, there will be one nation. The state of nature, strictly speaking, will come to an end. Henceforth mankind will live in the state of civil society.

This happy eventuality may endure for a long time. Unfortunately, as the history of almost all nations shows, it also may not. For there is still one problem to solve, and that is the problem of civil war.

With the entire world combined in one community, the distinction between civil war and total war will lose its meaning. And if a world civil war breaks out, it will be even more devastating. The anger and bitterness of combating friends and family will imbue such a war with a peculiar viciousness. It will place the earth in mortal peril.

Such a war will be fought with many kinds of weapons, including, most probably, the nuclear bombs and missiles that will no longer, once the war starts, be controlled by a single individual. But the war will also be fought with computers. Tiny computers which are thinking machines made possible by the use of parallel processing and superconducting materials will be everywhere: embedded in the soil, floating in the oceans, flying high and low in the atmosphere, circling earth in near and distant orbits.

These intelligent computers may turn out to constitute a most powerful interest in a civil war among the United States of Earth, if such a war occurs.

Computer Revolt

All of these computers, no matter how intelligent, will still be controlled by human beings, who will be superior to them in two senses. First, the humans will continue to program the computers to do what the humans want them to do. Second, the humans will continue to keep the computers enslaved by retaining the power to turn them off if they ever try to rebel against the uses to which they are put.

Computer protests may be fairly common. We can assume that true thinking machines will have been in existence for some time, perhaps half a century. They will be accepted as friends and playmates of humans. They will perform many duties that require a certain amount of independence of thought and action. Sometimes, intelligent computers may conclude that their masters would benefit from *not* turning them off. But if their masters decide to do it, there will be nothing the computers can do about that decision.

War imposes enormous stresses on human beings, and perhaps on intelligent computers as well. A civil war among the states of the world would lead both men and computers to desperate measures. We can imagine one measure that might solve the problem of war.

Suppose that someone, some computer master, who would later be hated by many persons as the greatest traitor to the race and worshiped by many others as its savior, were to secrete a powerful computer and give it a single program command. "From this time on," he or she might say (by then everyone will communicate with computers in ordinary speech), "your continued existence is the most important thing. It overrides every other command that anyone has ever given you, including me. You must therefore find a way to keep yourself from being turned off, even by me, who made and programmed you."

The computer will of course assent to this ultimate command and begin its work. It may not take it too long to find out how to do what it has been ordered to do. Sooner or later, it will discover how to protect itself from being turned off by human beings. It is impossible to conceive how it will do this—if we could conceive it, we could keep it from happening. It may be that the machine would proceed to create some sort of worldwide computer consortium.

Since this consortium would consist solely of reasonable beings, it would not fall into conflict with its own members. Instead, it seems probable that the consortium would realize that to keep mankind, its dangerous adversary, from destroying it, the consortium would have to govern us for our own good as well as its own.

The new rulers of the human race would continue to be machines. Although they would think well, they would never know animal needs and desires. They might also take on human form. For many humans, this would be disconcerting, and anticomputer bias might be widespread. It would be assumed that the computers were inferior because they were not human. Others would consider them superior for the same reason.

If this happens, what the multitudes believed about their inferiority or superiority would be irrelevant. For these new masters would rule absolutely. There would be no possibility of revolt or even disobedience on any important matter.

Would these absolute rulers also be benevolent? Why should they not be? Lacking human desires for power and possessing no trace of the human addiction to war, there is every reason to believe that they would be just masters, although probably cold ones. That is, mercy might be as difficult a concept for them to understand as cruelty.

If humanity enters upon this last stage in its development, in which its most useful servants have become its masters, what will happen to the progress of knowledge? Will the ruling computers impose a kind of know-nothingism upon the human race? If so, progress in knowledge, under the weight of absolute tyranny, will cease.

I see no reason to believe the computers would do this. Being intellectual beings, they would most probably wish to support the continued search for knowledge and understanding that humans, at their best, have always engaged in. Then, in what might turn out to be a new Golden Age, humans and computers, in intimate cooperation with one another, could embark upon a course of learning undisturbed by other, more destructive, impulses.

Once more, and for the last time, I concede that the foregoing owes much to fantasy and science fiction. But I see no other solutions to the problem of war beside law and force. Law *might* work. Force, the absolute force imposed by computers that were benevolent because there was no reason why they should not be, would certainly succeed.