"Social Impacts of the Future Technologies"

Ted Gordon

Lutheran Brotherhood Colloquium on the Church in Future Society

The Woodlands Inn, Houston Texas • January 29 - February 2, 1979

LUTHERAN BROTHERHOOD

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The Lutheran Brotherhood Colloquium on the Church in Future Society was a conference of 250 Lutheran leaders and ten nationally-known futurists. It was the first such event ever held by Lutheran Brotherhood, a fraternal benefit society serving Lutherans nationally, and was the result of consultations with several U.S. Lutheran church bodies. Among the concerns which were expressed by the church bodies in these consultations was the need for more disciplined emphasis on anticipated future changes as they influence congregational life.

The purpose of the Colloquium was to increase awareness of anticipated future change so that appropriate planning can be effected to strengthen the Lutheran church, especially at the congregational level.

All U.S. Lutheran church bodies were invited to take part in the planning, and nine participated by sending representatives, including six national presidents. Ten Lutheran church bodies were represented among the participants in the Colloquium.

The Colloquium was organized around five themes:

	Theme	Presentors
Monday	**The Reality of Change**	**Alvin Toffler**
Tuesday	**Problems of the Future**	**John Platt** **Theodore Gordon** **Jürgen Moltmann**
Wednesday	**Human Values & Potential**	**Willis Harman** **Jean Houston**
Thursday	**Defining the Task**	**Warren Bennis** **Hazel Henderson** **Robert Jungk**
Friday	**The Role of Leadership**	**Harlan Cleveland**

Theodore J. Gordon

President, The Futures Group; formerly vice president and senior research fellow, Institute for the Future.

Mr. Gordon founded The Futures Group in 1971. Associated with futures research and policy analysis for many years, he has made both substantive and methodological contributions to both fields. He is noted as one of the innovators of several methods of forecasting, including cross-impact analysis, trend impact analysis and probabilistic system dynamics. Mr. Gordon regularly contributes to research projects, some of which include projects for the Office of Technology Assessment and National Science Foundation. He has also contributed to research on U.S. power needs and power-generating capabilities, forces for change in the insurance industry, perspectives on American social change, life-styles of the future, future computer developments and applications, case studies in institutional innovation, and new business strategies. His consulting work has also included efforts concerned with the design and conduct of corporate and governmental forecasting activities, the development of forecasting capabilities within particular companies, and the social responsibility of business.

Mr. Gordon helped establish the Institute for the Future where he served as Vice President and senior research fellow. There he contributed to studies on the future of employee benefits, computer risk, relationships between business and society, problems of technology assessment, and the development of cross-impact analysis. Before joining the Institute, Mr. Gordon directed major engineering programs at the McDonnell-Douglas Astronautics Company, serving variously over 16 years as chief engineer of the Saturn Program, test conductor for the Thor and Thor-Launch Systems, and director of Advanced Space Systems and Launch Vehicles. He was responsible for defining, executing and supervising the design and conceptual work of Douglas' space station, boost vehicle, and interplanetary programs.

He has served as consultant to many large organizations including Northeast Utilities and the American Council of Life Insurance. He has lectured frequently for the executive programs at Arden House for Columbia University, the Young President's Organization, the Canadian Management Development School, and other academic and industry-related associations. He has also served as Regents Professor at the UCLA Graduate School of Business. Mr. Gordon has published a number of books which include: *First Into Outer Space* with Julian Scheer; *The Future; Ideas in Conflict;* and *Ahead of Time* with Harry Harrison. *A Technology Assessment of Life-Extending Technologies,* with Herbert Gerjuoy, is currently in the process of being published. He has contributed to numerous multi-author books, holds several patents and has authored more than 100 reports at The Futures Group.

Theodore J. Gordon: "Social Impacts of the Future Technologies"

President, The Futures Group
Glastonbury, Connecticut

Delivered on January 30, 1979 at the Lutheran Brotherhood Colloquium on the Church in Future Society

My charge this morning is to discuss technology and social change, and we will do so over the next hour. That discussion will be threatening. As we poke at the corners of this tapestry of change we'll cover topics that range from the molecule to the universe, whose impacts on us all are instantaneous or near infinite in duration. These technologies promise to raise fundamental questions about who we are, about what we are to become, about the way we live and the reasons for being. We will touch in this exploration on food, longevity, immortality, robots, energy, resources, the mind, life in space, automated vacuum cleaners, weather control. In short, the canvas in front of us for the next hour is very broad indeed. I've kept this discussion to the near-term. This is the knife edge of the knife edge, of Dr. Platt's. I've dealt only with the probable. These are almost tangible. These are changes that are literally here. The speculation about what lies in the middle of the next century is not part of the talk this morning. This is the next 15 years that we concentrate on, and primarily the next 15 years in our country, our time.

Here is the road map. I intend first to deal with four basic technologies. These are technologies which, it seems to me, are fundamental, and will make life different for all of us and for those who come after. These technologies are biomedicine (longer lives are coming), electronics (robots and automated intelligence are coming), resources (cheap energy is not around the corner), and genetics (the design of living organisms is at hand). Having discussed these four technologies, I will then talk about long shots, those lower-probability but high-impact developments, which if they were to occur would be profound. And finally, toward the end of the hour, I want to recapitulate and reflect on the meaning of these changes, at least in my view, for our thinking, for our organizations, for our institutions, for our planning. What difference does it all make?

With respect to biomedicine now, the first of these technologies. If we look at tables of life expectancy only since the turn of the century in our country, we find that newborn children in 1900 had a life expectancy of about 48 years. By 1977, this had increased to 72 years; in other words, a newborn child in 1977 could expect to live to about that age, 72 years. Women, newborn girl babies in 1977, could expect to live to 77 years, and men, boy babies, 68 years. It doesn't sound quite fair, but that is indeed the statistic. Women live longer than men and appreciably so, 68 to 77 years. This gap between men and women in terms of life expectancy is real, although the cause for that gap is not well-understood. Some people believe that as women enter the labor force and smoke and drink and feel the same kinds of stresses as the rest of us, those curves will tend to come together. Other people argue that there is a biological difference that explains the longer longevity of women and that those curves will not come together. But one thing is clear, that as long as that difference exists, and it will certainly for the period of time that we are dealing with here, the older society in America will be largely female, and the older we look at the strata, the older that we cut it, 80 years and above for example, the more female it is likely to be. So that when we talk about the aged in America, we're talking largely about old women. It's true, it's not meant to be funny or clever. And it looks likely to remain true.

If we look at these same life expectancy curves, not life expectancy at birth, but life expectancy at middle age and advanced age, we find a different phenomenon entirely. There has not been much progress here. Life expectancy at age 40 in the year 1900 was 28 more years. Life expectancy at age 40 in 1977 was 32 years. In other words, in that same century, the same 77 years when such great progress had been made in terms of life expectancy at birth, only four years' improvement in life expectancy at age 40 have occurred.

There are several reasons for this disparity between growth in life expectancy at birth and life expectancy at age 40. First of all, the curing of the diseases of childhood largely explains this great increase in life expectancy at birth, and the diseases of middle age and advanced age have proven very difficult to conquer. These are heart disease, cardiovascular disease of various sorts, and cancer. A second reason for the lack of progress in life expectancy at middle age has been simply that as one moves closer and closer to some absolute age, it's not very likely that we'll see much improvement. For example, if I had described to you improvements in life expectancy at age 100, we wouldn't expect to see ever, at least under our present circumstances, much improvement in that life expectancy. So the further one cuts that curve, the further one moves toward some ultimate age, the less improvement one can expect. Now the forecast is that that situation is going to change. Life expectancy at middle age and advanced age will improve, and immediately, and it's doing so now. Life expectancy at age 40 has improved two years over the last two years. And all that has to happen is for that to keep up for a while and we'll all be in good shape. A year improvement per year gives us all a very good chance at old age, Godspeed.

We looked with some seriousness at the technologies involved in biomedicine. We talked with people who were doing bench research, we talked with people who were funding these programs, and as we surveyed this field of biomedicine, we found that we could divide the research into two general classes. There was the class of technology that we might call, at least at this point, conventional. These are technologies that are directed at early diagnosis, disease-curing technologies, and extension of current medical ethics. These technologies, if they come to be, and it appears that they are coming to be, have the effect of allowing more people of middle age to live to old age. And old age itself, the maximum age to which people live, let's say, does not increase very much, it's just that more people of middle age can live and experience an old age.

If you will imagine with me for a moment a survival curve in which we take a sample of 100,000 people at birth and track them over their life span, we find that as age increases, fewer and fewer people remain until finally when we get out to about 100, almost nobody is left. The effect of this first class of technologies is to square that curve, to make it rectangular, to move it out. In the limit everyone would live to 100 years, and then on their 101st birthday everybody would die. That would be a perfectly rectangular curve. For this reason we called this class of technologies curve-squaring. It is a very certain world that a curve-squared world raises to imagination. In this world one knows when death is to be expected, the actuarial tables have to change, insurance rates are very different, inheritance is very different. What man at 95 would leave his fortune to his 75-year-old son, for example? So this world becomes more certain and the mores of that world change from what we know today. Now mind you, I'm not projecting that in this time period we go to the curve-squared world, only that progress in medical science is moving us in that direction and is doing so now and rapidly. We expect to see the take-off of the curve of life expectancy at age 40 duplicate roughly the take-off in life expectancy at birth that happened at the turn of this century.

Now I told you that there were two classes of technology that we discovered, one the curve-squaring sort. The second had the effect not of curve-squaring, but of moving out the intersection, that is, the oldest age to which people could expect to live. This is much more problematic, much less certain. There is a group of scientists in this country and elsewhere who are beginning to treat aging itself as a disease. There is no one who understands precisely what aging is, why cells die in an organism. The symptoms are clear enough, certainly. We're all too familiar with them ourselves. But why do cells die? This is at the pre-theory level, actually, this science that I am now describing. There are a dozen theories, all contradicting or reinforcing in some way not yet discovered, that have to do with the explanation for aging, the treatment of aging as a disease. The immune mechanism, for example, is one theory. Some scientists believe that because of mutations caused by cosmic rays or chemical irritants, cells in the body are recognized by the immune mechanism in the body as invaders, and the immune mechanism sets up and kills them. Others believe that abnormal oxidation takes place at the cellular level. Others believe that we are self-poisoning through some kind of timing mechanism in the pituitary. One scientist believes that the pituitary, for example, excretes a poison which he has named thanatin, and the body accumulates thanatin over time, it can't pass it out and it is a self-poisoning mechanism, and that is aging. The list is much longer than this, but you get the point.

Almost all of these scientists can point to laboratory animals with which they've experimented, and show you that these animals have lived longer than their allotted time, in some instances by a factor of 2 or so. One famous set of experiments that is now 2-1/2 decades old or so, relates to some pre-adolescent laboratory rats. A particular protein was withheld from their diet. These animals did not go through puberty as long as that protein was withheld. They stayed pre-adolescent. They were very sick rats, I might add, but they didn't go through puberty. They bled easily and they caught colds and things like that. Once the protein was reintroduced into their diet, they went through the transition to mature rats, and lived the rest of their life rather normally.

There is much to be learned here. The effect of these technologies will not be felt for decades and decades. If one were to imagine a cure for aging (that's really what I'm talking about here) or some means of modulating the rate of aging, the effects of that demographically would not be felt until the middle of the next century. These kinds of technologies we call life-extending. And if we imagine again that survival curve, the effect here is not to change the shape so much as to move that intersection out, so that maximum age moves from 100 to 120 to 150, and where that ultimately leads no one is sure.

Let me deal only with the curve-squaring technologies, to keep my promise to you that I was going to stay near-term. What are the effects of these technologies? Less than you might think with respect to demographics, with respect to the number of people over age 65, for example. The effect on demographics will be real, but not felt significantly until after the 1990s or the year 2000. Where then is the effect? It is in the level of health and vigor felt by most people. A 65-year-old in this 15-year time period becomes more like a 55-year-old, a 70-year-old more like a 60-year-old, and an 80-year-old more like a 70-year-old.

This leads immediately to questioning of retirement, retirement practices, the nature of retirement, the nature of work, because these older people will have to be redefined in terms of our thinking about their capability. We projected, when this work was being done about two years ago, that retirement age would increase, and gave testimony for the recent legislation associated with that topic. We thought that retirement age would increase because social security and pension funds would fail without that change. We felt that it would increase because older people in retirement, when interviewed, often say they would rather be working if they could, but the economic system that we've invented for older people prevents them from doing so. They cannot get their social security if they have income. And we found, finally, and poignantly, that when people feel useless, they tend to die. Their life expectancy shortens. So for all of these reasons we felt retirement age would be likely to increase. And we think it will. By retirement age, I don't mean age of first pensions. I think age of first pensions will continue to diminish. What I mean when I say age of retirement is the age at which people choose voluntarily to leave the labor force. The pattern that we see emerging is the age of first pensions continuing to drop or remain constant, people taking those pensions and then going on to do something that they really want to do with that economic underpinning, and continuing to do it either as part of the recognized economy or as part of the underground economy, getting their income in cash, unmeasured, into what we would consider today to be old age.

This raises some very significant questions about the nature of the labor force in this 15-year period. Women continue to enter the labor force. The age of retirement continues to grow, in the way that I just defined it. And I will tell you before we are done this morning that robots will also be entering the labor force, and replacing people. Those are three competitive forces for jobs: women, increased retirement age and robots. There is one force that tends to minimize the competition for jobs, and that has to do with the reduced rate of entry into the labor force of 18-year-olds. If you look at the demographic curves, you find that the peak of the World War II baby boom, which occurred in 1960, means that those born in 1960 are now 18 years old. From now on the number of people reaching 18 years of age diminishes year after year after year. That suggests that everything associated with 18-year-olds starts diminishing in our society, as of now. That includes automobile theft, for example. We can expect to see the rate go down. It includes pressures of entry into the labor force, which is the point that I'm making now. So out of this biomedical technology comes this whole re-thinking about what work means, and the competition for jobs between young and old, men and women, machine and man. The political clout of the aged begins to increase. Changes in values associated with suicide, the nuclear family changes. Let me talk about that for a moment.

In one of the scenerios, where we included not only curve-squaring, but life-extending assumptions, and we let our computers run out into the next century, we found that (and this is not a forecast, this is just the result of a set of assumptions about those technologies) toward the end of the next century, if a family patriarch called a picnic, to which he invited all of his living relatives, he would need a room larger than this. He would be inviting some 2,000 people to his picnic. The extended family in that time period is really something. Think of the problems of drawing his family tree.

Within biomedicine we reach this observation about a particular sub-technology: nutrition is an emerging science. Nutrition, that is what we eat, relates to both classes of technologies. It relates to both the curve-squaring and the life-extending. We found examples of nutrition affecting both classes. I gave you the protein experiment where transition to mature animals was controlled by nutrition. There also seems to be, on the curve-squaring side, a relationship between what we eat and diseases that we get. Some foods are poisonous, not in the sense of immediately causing death. We discovered those kinds of foods 50,000 years ago. You ate the mushroom and you died so people didn't eat the mushroom anymore. But there is a second class of poisons, apparently. You eat the food and your chances of getting a disease some years later change statistically. People who smoke know the kinds of risks they are taking as a result of smoking, that's true, absolutely true. Less certain from the statistics is the relationship between ingestion and fatty foods, for example, and later heart disease. Those kinds of relationships between what we eat and what we do and where we work and the environment around us and later disease, constitute a frontier of science about which we are going to learn a great deal more between now and 15 years from now. It will become the political focus for organizations like OSHA, which will focus on employee health, rather than safety, and EPA, Environmental Protection Agency, which will focus on issues of health in the environment. Viruses in the water supply, how it is that living under fluorescent lights affect your later health, these are politically acceptable, viable and important.

Let's take the second technology now, electronics. John Platt talked about some aspects of electronics in communications and I agree completely with him about the fundamental nature of this transition. At the end of World War II we had an electronics discipline which involved electron tubes and hand-wired circuits, and ladies that soldered these resistors and condensors by hand. We went from there to the transistor, which replaced the tube. But the real change did not come until the transistor and components which went with the transistor (the resistors, the condensers, the coils) were all photographically printed on silicon chips. This is called large-scale integrated circuitry. It is the technology embodied in your hand-held calculator, in your electronic watch. The Friden that John Platt talked about: the machine cost $500. An electronic calculator that does the same job can be bought now for $4.95.

This technology is profound in its emergence, because the cost per component has been dropping by a factor of 100 every 10 years, while the capability of the circuitry has been increasing by a factor of 100 every 10 years, and both of those trends have been going on simultaneously. It leads now to electronic watches that are $10 or so and disposable, can keep time to 15 seconds or 10 seconds or five seconds a month, which almost instantaneously could replace chronology of the last 400 years. Or chess, being sold as games. As recently as five years ago that was a very, very tough problem for computer programmers to solve, the chess problem. Now you can buy a chess game; there are three on the market, one is called Boris. Boris not only plays chess with you (you program your move into a little calculator-like device, and it comes back with its move, and you move the pieces on the board), but every now and then Boris will say, in LED letters, "I expected that," and that really shakes you up. But if things get too bad with Boris, you can press a button which says "reverse," and Boris has the position that you formerly had and you've got his position.

There are now home hobby computers. One can buy a computer over the counter. We have such a computer at our house. It's made by Commodore, the name of the machine is the Pet, and it's really quite apt. It is a pet, it's just a terrific machine. We use it for many, many things, but I'll tell you just one anecdote about our home computer. First of all, it cost $800. It is comparable to a machine which five years ago would have cost $15,000, to give you an idea of the speed of the drop of cost. It's all nicely packaged. It's a little appliance that sits on our desk in our den. And one of the first programs that I wrote for it was a decision program, to help someone who is using the machine make a decision. It speaks to you in English, you don't need to use FORTRAN to speak to this machine. In fact, one of the first applications my wife made of this was to help her decide what camera to buy. The machine on its cathode ray display says, "What are you considering?" She says, "Nikon, Nikkormat, Olympic." Then the machine says, "What are the criteria on which you will base your decision?" She says, "Size, weight, maintainability, time to failure." And then the machine goes through all the permutations, and it says, "For the Nikon, what is the weight? For the Nikon, what is the time to failure?" and so on, all the permutations. Then it asks for scores, and multiplies the scores out and gives a rank-ordered listing of the highest-scoring camera. She always buys the most expensive anyhow, so it's just a guide!

Well, I came home and saw our soon-to-be-graduated-from-high-school son, sitting at the machine, he didn't know computer programming either, but he was fascinated with this decision program, and I looked over his shoulder, and saw that he had girls' names there. He was deciding with this machine whom to take to the prom. And his criteria were something else! These are friendly machines. These are not those clanking robots that scare us; these fit in, in human, friendly, useful terms. That is the point really that I want to make.

Texas Instruments just introduced a device called "Speak and Spell." Again this is mind-boggling in terms of the speed with which this particular technology has come to pass. This machine speaks. It's designed as a toy, but the technology will become clear enough to you as I describe it. There is a keyboard on the machine, and the child is asked by the machine voice to spell a word like push. He will type in p-u-s-h, and the machine will speak to him and say, "That's right, now spell run." And he'll type in run, and if he misspells it the machine will say, "No, that's wrong, try again." The speaking of the machine is not done in the trivial way that there is a tape playing back, it's done from digital, programmable, read-only memory; that is, memory that is in the form of stored information, which can be called on to speak back to the child. And if we have the talk-back, we have the talk-into literally around the corner. There are automated translators on the market now: type in a French word, get the English back, or vice versa.

Where does it go? It goes to appliances in the home, automated vacuum cleaners that will sense when the rug is dirty and it's not Sunday morning at the same time, come out of their hole in the wall, vacuum the rug, dump their load at the appropriate place and recharge. It goes to electronic funds transfer systems which we see springing up everywhere now, the ability to move funds electronically either at the individual level or the wholesale level. It goes to robots: robots in the factory, robots that can reason, robots that can create. In almost any human term create: create art, create music, solve problems, learn from their experience. And of course, applications to education and video transmission of information are enormous.

The third technology, resources. I'm going to limit myself here to only two aspects: energy and food. With respect to energy, we imported about 30% of our oil in 1974, and currently, despite the price increase of oil and the notoriety that the energy problems have received, we import about 50% of our oil. We believe that there is no technology likely to come along in this 15-year time interval that will change the situation significantly. We will still be importing half of our oil, perhaps more, by the turn of the century, and all of the technologies that we've heard about (coal gasification, coal liquifaction, solar electricity, fusion) these are all technologies for the next century. There are impediments to the development of technology different for each of these. As far as we can see, unless there are surprises lurking there, these technologies are not likely to give us energy independence or reduced energy costs in the short term. And during our sessions afterwards, if you're interested I'll go into some of the reasons for that.

National policy inevitably must move us toward electricity, and the reason for that is that the fuels for electricity (coal and uranium) are indigenous and by virtue of using indigenous fuels, we gain some measure of independence, some decrease in oil importation. Now the problem with using electricity of course is that it is not the right form of energy for many of the things we use oil for. Right now we have no way of using electricity for transportation, for example, or to gain mobility. This leads us to the speculation, the expectation, the electric cars are very much part of this 15-year time interval. Electric automobiles will use electricity and hence coal and uranium to gain mobility. To the degree that we can use electric cars, we diminish the need for importation.

We think coming out of the energy situation is a phenomenon that we've called "conspicuous conservation." Conservation is the policy that will be followed by our government because it is instant in its effects and pervasive in its application. We see, for example, regulations that require automobile manufacturers to improve the gas mileage of automobiles, the entire fleet, to 27 1/2 miles per gallon by the mid-80s. We think that the manufacturers can do that. We will have automobiles that can have that performance by making them lighter, by making them more efficient. Solar heating is an industry which will emerge in the mid-80s, where we capture solar energy, heat water and use that water for space heating. Even though I think that aspect of solar will happen in this period of time, it does not affect to a large extent the broader energy demand of the country. It's miniscule in terms of its consequence, particularly at the beginning.

So, out of these kinds of things, electric automobiles, solar heating, the need of conservation, comes this conspicuous conservation ethic. Don't you think this fits the country? Let me describe it. It used to be conspicuous consumption -- we would all look at who's got the Cadillac and perhaps want one ourselves. But now in this conservation time, conservation will be in and at the cocktail parties we will be comparing the electric car and the solar heater on the roof and we will do so and maintain economic growth in our country while conserving, while distorting the demand patterns that used to give us that economic growth. The key point here is that we can be conserving without stagnating the economy. And that's a direction that we think policy is going to lead us toward.

With respect to food in this third area, resources, one of the S-shaped curves that follows from John Platt's discussion has to do with world population. This is a very hopeful curve that I'm going to draw here. World population has been growing rapidly. World population today is about 4.2 billion people. The rate of growth, however, of this curve has begun to diminish. There is every sign that this curve has now begun to assume an S-shape, and that this rapid acceleration of the last few decades (it was actually compounding at 2% per year) has begun to drop. The population today is growing in the world at about 1.8% per year and that means that the shape of this curve begins to fall over, it begins to reach some kind of upper limit past the turn of the century. That is very good news. It's happened because of the spreading of acceptance of birth control measures throughout the world. And here we are at 4.2 billion; this intersection will be at about 6 billion, almost independently of how much more rapidly population growth diminishes. There is no reasonable scenario that leads to much less than 6 billion by the turn of the century. The importance in pressing for a continuing drop in population growth then is not so much this intersection in the near term, but where these curves go in the next century. And here very small differences in assumptions lead to world populations ranging between 10 and 25 billion, compared to our four, by the middle of the next century.

In keeping good my promise to you, I'm only going to talk about the time between now and the turn of the century, between four billion and six billion. Twenty-two years and we increase world population by 50%. That means for every two people in the world today, there will be three in the world within a generation. Most of those people are being added to poor countries, almost all. By the turn of the century three-quarters of the people in the world will be in poor countries. The question is, among many other questions, can those people be fed? Will there be enough food?

On this issue there is a split among futurists. There are some futurists, the technological optimists, who believe that technology will come to exist, that the lead times will be adequate and we will escape the Malthusian catastrophe once more. They point to the uses of the oceans, growing of biomass in the oceans, domestication of ocean fish, self-fertilizing plants (an invention that comes from the genetic technology), new strains of plants that can grow in brackish water and salt water, new means for irrigation, new kinds of packaging and preservation. And perhaps these technologists are right. But it's not certain. Studies that I tend to believe indicate that the balance is exceedingly precarious. If one assumes high growth in population, or let me just say continued current growth in population, in developing countries and developed countries, and relatively low growth, let's say in continuation of present practices in productivity per acre, then there will not be enough food in the world. In other words, if population continues as it's going and the rate of increase of productivity of agricultural lands increases as it's going, there will not be enough food in the world by the year 2000.

If one assumes, however, population growth rates diminish in a very optimistic way and agricultural productivity grows in a very optimistic way there will be enough food in the world for everybody by the year 2000, except it will be in the wrong place. It will be misdistributed. It will be in the developed countries and the problem will be to get it to the developing countries.

Here's where I worry. The only method that we've found for distributing food, or indeed bringing those technologies into being, is through the free market system. We put our food, our grain, on the market and it's the countries that can afford to buy the grain that do so. In this era, the people who will need it will be poor and the free market system will not solve it. This will lead to a predicament for the United States and for Canada. The U.S. and Canada control grain export in the world to a greater level of concentration than OPEC controls oil, so it is our predicament. We will be profound in our production; there are no other countries that are that productive in terms of output per input manhour. But what shall we do with that productivity? Give it away? That's a trap. As long as population continues to grow in roughly the manner I've indicated here, there comes a time when even the most productive technology cannot cope and certainly the uncertainties of weather lead to an occasional crop failure. When people have come to count on our output and gifts and there is such a crop failure, the possibility of suffering is enormous. This is an exceedingly important policy question. How do we relate, how will we relate to that need for food?

The fourth technology: genetics. I can only agree with John Platt in the profound position that he puts this technology. It is a discontinuity. We're talking here about a technology that's gone under the name of recombinant DNA or plasmid technology. It follows directly from the discovery of Watson and Crick in the mid-50s that the gene is no more or less than the sequence of sub-molecules along a long, helical molecule in the nucleus of the cell called the DNA. That genes existed was known from the time of Mendel. Genetic properties and the way genetic properties were passed from parent plants to progeny plants was well-established. But what the gene was, was physically unknown until the time of Watson and Crick. And what they said was the gene is no more or less than the sequence of sub-molecules along that intertwined helix. Understand the sequence of the sub-molecules and you will understand the genetic properties of the cell.

When that pronouncement was made, there was speculation among futurists and others about the nature of the science of genetics from that point on. We thought it would change and that a great deal of effort would go into what was known then and now as the decoding of the cell, the decoding of the gene, that research would focus on that and indeed it did. The surprise is that that field has moved as fast as it has. Genes have been decoded. More than that, scientists have been able to move genetic material from one species to another and to have the genetic material take in the second species, infect the second species if you will, much as a virus does. And the second species, thus infected, then exhibits the genetic properties of the first, at least for that gene that is transplanted. It performs according to those instructions, and it passes those instructions on to progeny cells as though it were part of its own evolution.

The most spectacular experiment is the one that John Platt referred to. Human insulin genes have been moved to bacteria. These bacteria can organize amino acids surrounding them, as a result of this genetic instruction, into human insulin. Scientists have built a hybrid animal composed of everything that the bacteria are composed of, as well as new newly-inserted genes. Hybrid animals exist. Genetic material has been built out of synthetic chemicals theoretically predicted to produce a certain genetic response and they have.

So, where does it go from here? Self-fertilizing plants and the invention which comes most immediately to mind. The class of plants called legumes have a property of living symbiotically with bacteria in the soil. The bacteria, as part of their metabolic process, fix nitrogen from the atmosphere and that nitrogen is a fertilizing material, a nutrient to the plant. But only legumes have this property of symbiotic relationship with the soil bacteria. Scientists are trying to move the gene from the legume families to wheat and corn and rice, so as to then obtain self-fertilizing plants. What an enormous increase in productivity could be realized from that. Drug production, the use of living material to produce chemicals for human consumption. Special manufacturing processes, the use of biological materials, either these are complete organisms or enzymes or other sub-living particles, to be engaged in manufacturing processes, to make materials that are used in our economy. The Russians, for example, have a bug that they invented (I don't think this is an apocryphal story) called the "red devil," which is an appropriate name if there ever was one. The "red devil" digests uranium as a part of its metabolism. So they take some of these bugs and they turn them loose on uranium tailings, and the bug eats the uranium, then they harvest the bug. And it's a self-concentrating system, if you see what I mean. Once you harvest the bug, you've got all of that uranium there. So here's a designed animal performing a particular function for its inventor. Cellulose production or the use of cellulose, the digestion of cellulose by designed organisms, is also exceedingly promising because of the amount of waste cellulose in the world today. If we could have organisms that would digest it and change it to alcohol or sugar, then we're on the way to using a lot of waste material for very productive purposes.

The technology. Permit me to go to the end of that 15-year period now, perhaps even somewhat beyond. There are some diseases which are inherited in human beings, clearly inherited: mongolism, PKU and sickle-cell anemia are examples. If the technology moves that far, the curing of these diseases at the genetic level, at the nuclear level, cannot be ignored. That's an extension of our medical ethic and if we could attack those diseases before they were manifested in children, we'd certainly do that.

There is another class of diseases which are apparently transmitted genetically, or at least if not genetically, they are received through some genetic-like processes. These are called slow viruses and have to do with viruses that infect over time. Thirty years later, after the infection, the disease appears. There's even the possibility that aging is programmed, that the propensity to cancer for example is genetic. So when we say there are three diseases that we can name quickly that are transmitted genetically, we really don't know the full range of adverse conditions that are genetically transferred from parents to children. If the technology moves far enough, I would guess that we will attempt to intervene in the processes by which those adverse conditions are passed to children. And that is a very significant milestone because it means that we would have, for the first time, intervened directly in the process of evolution. Our indirect intervention is already present of course. But this is direct intervention. This is direct instructions to the genetic process and that lies as a possibility just at the end of this time period.

Those are the four primary technologies, now let me mention some long shots. I would be surprised if these happened. However, if they happen they will be very important and it is not inconceivable at least there is some probability that they will happen in this 15-year time period. First of all: the discovery of coherent radio signals from outer space, intelligent life beyond the earth. We now have the capability of receiving radio signals from huge distances in space. That capability has existed now for ten years, on that order, but for the first time we have programs that are designed to listen and the data to be analyzed to find out if there is anything other than noise out there. The scientists involved in this program are making some very fundamental assumptions that other intelligent species, if they exist, have radio. It need not be assumed that they want to communicate because we could eavesdrop and hear signals from outer space. If these were discovered, think what it would mean. It would mean that we are not alone in the universe, that we are not somehow, as some people would argue, a molecular accident of evolution but rather there are others out there that have evolved as well. Our egocentricity would be tested.

Secondly, I think there's some chance that in this time period there will be a fundamental breakthrough in the character of thought and memory, akin to the Watson-Crick breakthrough in genetics.

There is no one who understands what a thought is or how memory is stored, whether it's chemical, or whether it's physical, or whether it's psychological. There may be in this time period that fundamental experiment, that fundamental paradigm articulated in this field of psychology. And from it come speculations like person-to-person interconnects, if it were to be electrical for example; person-to-machine interconnects, mechanical memory available to human memory directly; the chemical transfer of information: French pills, literally (there are a series of experiments that indicate that memory is stored chemically and can be excited chemically and then extrapolating that); the chemical basis of mental disorder discovered; the effective rehabilitation of criminals through the use of pharmaceuticals or other techniques. With all of the totalitarian overtones that that must raise to your mind, from some of the people on our staff who have studied the future of personality control drugs, these are some possibilities: pills which allow selective amnesia, erase yesterday, pills which enhance feelings of maternality in women (for example, child abuse cases), programmed dreams, at the end of this spectrum, where the dream content is contained chemically: double features for long nights!

Third, the cure for aging which we talked about before. I don't expect it, but the breakthrough is possible.

Fourth, some long shots in energy: in the geothermal area, in tertiary recovery, in the waste cellulose for gasoline. These might happen, but I rather think not.

And finally, the rebirth of the space program. In this 15 years, I think that very unlikely. We have the shuttle program scheduled -- that's going to raise some levels of excitement but I think it's not going to be sufficient to raise our goals of exploration to where they were at the time of the Apollo program. There may be discoveries however, on the outer planets through the robots that we're sending, which will change that and make it desirable again to engage in that great exploration.

Now finally, what does it all mean? Where does all of this come from? Why is this all being imposed on us? Who asked for it? There are three general notions about where technology comes from that I've been able to discern. The first has to do with science. Technology comes from science and what science gives us is, to a large extent, what technology has to work with as its raw material. Therefore it's important to ask in this mode, what drives science? This is a model that comes from Thomas Kuhn of the University of Chicago. He says science generally is unimaginative. It takes existing rules and tries to apply those rules to new situations. That's normal science. And only when those rules don't work is there a crisis in science, in that discipline, and only in the presence of crisis can new ideas be accepted. Therefore, when new ideas are acceptable, those little domains draw the best lines, draw the funding and draw people because publications can be made there and the reward mechanism relates to publications. So with science as the driver, fundability, what can be funded, where are the interests of the individual researchers satisfied, what problems are seen to be solvable; it's those kinds of social factors that lead to the extending of the domains of science. They have little to do with problems, they have little to do with social need, they have little to do with what products can be sold. They have to do with the sociology of science.

The second notion comes from Jacques Ellul, a French philosopher, in a book called The Technological Order. He says technology comes from economic and military need. We will develop any technology we can if there's a market for it or if it helps improve our security. It is a juggernaut. Society adapts in its wake, and the sooner we learn that we must adapt in the wake of that imperative, the sooner we will learn to live with change. That is a very deterministic philosophy. Technology moves for its own sake and society follows in its wake.

The third image is one of Bertrand de Jouvenal in his book The Art of Conjecture, a French political philosopher who's had a great deal to do with futures research and the shaping of the philosophy of futures research. This is the determinable future. It's the basis for planning in the country or wherever. De Jouvenal says the planner must imagine possible futures. Plural, there's no such thing as a single future. There's an array of futures and from that array, the planner must select that which is best, that which is most desirable, and set plans into motion to improve the probability of the most desirable future and diminish the probability of the least desirable future. There are some things wrong with that. There are limits to the imagination. How many futures can we imagine? There is the unknowable quality of the future. And there is most importantly the value dimension to the future. As we imagine what is the most desirable, who is to say what is the most desirable? Even if we could say that somehow we can synthesize society's view of the most desirable future, then we must recognize a time problem. What we consider to be most desirable and therefore leads to our selection of the most desirable future, those people in the future might not consider to be most desirable because technology itself changes values. So as the technology is introduced, the value judgements on which the success or failure of those technologies is based change.

When viewed from a value perspective it's an unstable system. Technology does cause value change. Nicholas Rescher of the University of Pittsburgh recognizes these modes. Technology causes value change through enhanced attainment. New technologies can help us do old things better. If friendship is a value, ham radio can help us. If economic security is a value, automated ticker tapes come to our rescue. Technology affects value secondly through introduction of novelty. Value changes come from sheer boredom, he argues, and technology offers alternatives. Third from redistribution: technology helps us redistribute values. Fourth from restandardization: values are satisfied always only to some degree. If power is a value, new technology enhances power. If mobility is a value, new technology can enhance mobility.

I would add too to Rescher's list value challenge: if we hold something to be of value, technology in taking it away from us, tends to enhance that value. Let me explain. The invention of new technological bugging devices leads to the enhancement of the value of privacy.

But I think best of all is the newly-emerging model of value change which I will call the cohort model. It separates value change into two components, one which is age-determined. We become, to make it very simple, more conservative as we become older. No matter who we are, there is something changing in our way of doing things which is conservative and it is age-related. The second component, however, is experiential and it depends on what was happening when we were a certain age. It is akin to psychological imprinting. If we were 12 to 15 at the time of the depression, we have a certain set of values that accompanies us over time because we experienced that. And it is the sum of the age-determined and the experiential-determined components which gives a value dimension to society at any point in time. There is very, very much to learn about how values change. Yet if we learn it and are perfect in our knowledge, would we not strive to preserve our own values? Are not our values the most precious? Remember De Jouvenal's idea -- pick the best future, best value-oriented, and work to achieve it. If we achieve it and we are perfect in our knowledge of values, then we've locked in the future. We've locked it in and imposed our value set on that time, and this is a tyranny of values. We strive in our planning to protect our children by guaranteeing our values to them, yet our children may not be happy with our values and left to their own devices may find value systems which put ours to shame. Somehow planning, which is at the basis of all of this, must find a premise more encompassing than preservation of values, and I suggest that that is the preservation of personal liberty, where liberty includes preservation of creativity and the right to initiate change. Liberty is <u>not</u> defined, note, as the right to pursue happiness, the right to satisfy values, because in the behavioristically-controlled world happiness may be found in subjugation, happiness may be found in drugs, happiness may be found in many of the technologies that we've talked about. If we plan for an environment which preserves personal liberty, our progeny will have the chance to use their judgment, not ours, in the application of our technology legacy.

When I started I promised to raise some fundamental questions about using technological change as a point of departure. Let me review these questions as a final note. From biomedical progress: do we want a longer life? Are we ready for it, can we cope with a society in which increasing percentages of our people are older? What responsibility does society have to older people? If a cure for aging is found, if immortality is possible, how does religion change? From electronics: the Luddites, you recall, attacked machines when machines were introduced early in the industrial era to replace human error. The argument then was, "Don't worry about it, the domain of humanness is in the mental arena." Now if my forecasts were correct this morning, machines are going to replace people in the reasoning tasks. What is the new role for humans? What new answer do we have to the automated Luddites of today? If we said before that the role for humans is in reasoning and now there are reasoning machines, what is the role for humans? From resources: with the U.S. agricultural system so fecund, what should our role be with respect to feeding the world? From genetics: if we engage in evolutionary modification, who is to say what we should be? There is the whole plethora of questions in this area that we just hinted at related to cloning, to sex choice, to test-tube babies and you are familiar enough with the ethical issues that follow from that. From the long shots: if we had the tools, should society choose to condition out what is considered to be evil with the new discoveries of psychology? If we had the tools to remove criminality, for example, should we use them and under what control, if any? What would the discovery of extraterrestrial life mean to our views of ourselves as the ego-centers of the universe? From my comments about planning: if we succeed in making planning effective, what values should guide us? These then, in part, are religious questions and in their answers lie the future of religion. Thank you very much.