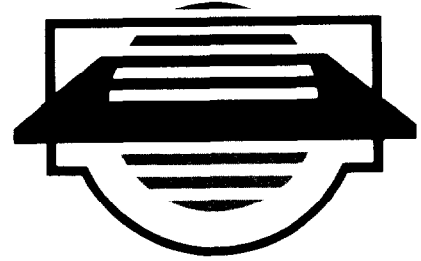Q 126.

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Joshua Lederberg
President
The Rockefeller University

DR. JOSHUA LEDERBERG: Thank you. In fact, I have some trepidation about finding myself on the program this morning at this particular point. My dilemma is not wanting to break the spell, the mood that has been cast by my predecessors, which has engaged all of us so deeply, but at the same time, not to distort my own character, not to break out of the limitations of my own interests and history and expertise, and not to pretend to a culture that I enjoy and admire, but which is not really mine to join as a creative producer.

My theme is the love/hate relationship of modern society with science and technology, to scan something of the sources of resistance to technological progress. Forgive me, if in this morning's mood I do recall that this is no more than an echo of the ancient myth of Prometheus, a myth whose centrality to our culture is evidenced by the endurance of a play that was written and performed over two and a half millennia ago, and has been restated and revived even in the last few years by Lowell.

Do you remember who Prometheus was? He was an engineer, though perhaps if one looks more closely at the magnitude of his claims to have stolen fire and to have invented every useful art, he must have been the CEO of the global technology transfer corporation of his era. He couldn't have done all that by himself. And for his pains, he was chained to a rock and had his liver pecked every day by a bird — which may not be too far

from what a CEO's life is today.

More seriously, it is all of us — and to turn to another manifestation of that myth — who would now also say it is we, the children of Adam and Eve, who are the victim and heir of that same sentence: to live our lives now, by art, by the arts on earth, to be the tillers of the soil and the miners and smelters of metal, and to increase and multiply beyond measure, rather than enjoy the more primitive paradise of hunting and gathering.

Before I attempt a somewhat more systematic sampling of that love/hate relationship — and time, again, may not permit my doing it in the fashion that it deserves — let me make a couple of very general remarks. The Promethean myth, I think, demostrates very adequately that there is a love/hate relationship in our attitudes and feelings about change, and particularly those changes that are upheld by technological innovation.

In Aeschylus's time, as well as our own, most of that resistance came from the traditionalist — we might even call them the radical — conservatives, who were concerned with the established order, with the preeminence of the gods, which in Aeschylus's myth would eventually be toppled by the Promethean insight.

Today, besides that source of anxiety and concern, I believe that we find, paradoxically, that some of the deepest resistance to technological innovation comes also from the radical revisionists, who are concerned that technological progress, economical rationalization, the reform of a liberal society may preempt the more violent political change that many of them espouse. And both from the right and the left, of course, we have resistance from those who are concerned that power will be steered from those who are concerned about the mobilization around political ideologies towards the technocrats, towards the aristocracy of expertise, whose claim to power frightens everyone, even the older technologists in the same tradition who might be displaced by the very rapid pace of new technological innovation.

My second general observation is that, in the framework of this Promethean problem, there is really nothing that remotely approaches the apocalyptic vision of the nuclear holocaust, of the possibilities of large-scale nuclear warfare as a manifestation of what we know we can do to one another with 20th-century technology. This is, in the view of many — I think few will dispute it — the underlying, most pervasive, most central problem of adjustment in our time, based on technological advance.

The reactions to this threat — not surprisingly because of the very enormity of it, and of our difficulty in coping with the grim prospects of the future, for example, as addressed by Peter Jay earlier this week —

are often quite inappropriate. Many of them avow an appreciation of the actual history of the geopolitical framework of national competition and a world system that made it inevitable that some power would discover nuclear weapons, given the immutable fact of nature — which is not an invention of human consciousness, which is not a question of the structure of language, which is an objective reality out there — that the laws of physics, objectively, make such weapons possible. The only issue was when, where and by whom these powers would be uncovered.

Unfortunately, many of those who even espouse the use of nuclear weapons, who have come to grips with that geopolitical reality, perhaps as part of their coping — again, as Peter Jay reminded us — still today pay far too little heed to the profound mischief that may be bursting upon us at the present time from the proliferation of those technologies beyond the seats of larger, more stable polities that originally had them. And I regret that we will, very nearly inevitably, all rue the very low priority that, in fact, has been given to technical and political measures to contain this process. With all of the difficult, if not impossible-to-resolve issues of national competition that we have with other powers, with all the other evil that there is in the world, we must still also recall that the United States, France, the Soviet Union, China, other great powers, have shared interests with respect to this problem that transcend the stakes of the side games that we find ourselves inevitably playing in other modes of internatinal competition.

One of my concerns about their having developed a demonology of technology, and one that points to the technologies themselves, weapons themselves, as being the objects of fear, of concern, of hatred and rejection, is that that mood has generated a tendency to responses, that, I think looking back just over the last 10 or 15 years, we can see as having been entirely inappropriate for the most effective and the most humane ways of containing them. The notion that such powers reflect an overkill, that the weapon itself is what must be the source of our attention, has led, in my view, to an overweening concentration on those measures of arms control that appear to be directed to reducing their numbers. And we heard that statement reflected, again, earlier this week.

I would have no objection to that course if it had not, in fact, papered over the far more serious implications of the continued progress of technologies, of delivery systems, of improvements in accuracy of MIRVing and all of the other measures that the powers undertook, in some degree, in order to evade the limitations on military power which were an obligation under the treaties for the limitation of strategic forces, which were sometimes part of some of the domestic bargains that were needed in order to get to some agreement to comply with the systems. And the result is that it was an entirely inappropriate target at a time when it really hardly mattered whether there were 1,000, 2,000 or 3,000 launchers and where modest differences in the total volume of that weapons capability really did not matter from the point of view of the survivability of the two sides. The cat really has come out of the bag with respect to high-precision delivery of these weapons, the possibility of their being launched from mobile and very difficult to inspect and verify sources and so forth. We really are in the soup today trying to figure out a method that joins the residual shared interests of the great powers in trying to put some cap on this capability for mutual destruction.

This is an area where there have been some important technological fixes, and I can think of nothing more important in this domain of the extension of technology than the development of a reconnaissance capability. That has really been the source of the peace in a major way over the last 20-odd years. Our capability to know what our principal adversaries are up to, and vice versa, under the impact of that kind of capability for national means of intelligence, is the only way that either side could have satisfied itself that there was a potentially stable equilibrium, but it was not necessary to undertake a preemptive strike in order to get there before the other side did and so forth. I just hope that we can find other countertechnologies still more advanced that will cope with the very dangerous situation that we find ourselves in today, from having had an excessive preoccupation with numbers and not paying enough attention to the limitation of issues about precision of delivery and so on.

Let me just sample a few other issues and take a rather different tack with respect to the examination of that love/hate relationship, paying some attention to the cultural framework of those reactions.

There has not been very much systematic study of this question. There are many passionate statements and volumes written, mostly by people with a somewhat anti-technocratic bent, pointing to innumerable abuses and difficulties that have arisen from a wide variety of technological introductions, almost always paying no attention to what the alternatives are or might have been. The underlying imperative, after all, is that what we did inherit from Adam and Eve, we have multiplied to an unconscionable degree over the years. We have widely disparate standards of living, we have rising expectations on the part of a very large part of that ever-increasing world population, and there is simply no way that that is going to be met, except with the introduction of more technology to enable the cultivation of the earth on a scale that will permit its inhabitants in their present numbers to survive at an even approximately decent

level.

But there are problems. I've spent the last 15 years attempting to listen to them with some sensitivity, to try to understand some of the sources of anxiety, concern and opposition, to a set of values, that, as a scientist and technologist, I very deeply sympathize with.

Perhaps first of all I should be careful to briefly elaborate some distinctions between science and technology, just to remind you that they were mentioned briefly by Mr. Levin. Science, at its core, is the pursuit of understanding of the world around us. Technology is the development of those powers to modify the world around us, which are only effective with the exploitation of profound scientific knowledge. You can't build a machine from materials that don't exist. You can't design it in defiance of the laws of mechanics and have it work. You cannot invent new technologies without the discovery of many new natural phenomena, which can then be exploited.

However, they are different enterprises. I know a few scientists who are rather vehement protesters against technological growth, and I know some technologists who don't care much about investing in basic scientific activity, but I think, by and large, those are exceptions. Nor do I espouse the view that there is a linear march from the exploration of scientific pursuits and the accumulation of a storehouse of knowledge, and then, and only then, to the actual exploitation and development of new technologies to use them. Life, as far as I know, has never gone that way, and basic science has been much enriched by the experiences of people who have encountered problems in practice in technological exploitation, as technologists have been stimulated by the discovery of new natural phenomena from observations in the laboratory. So there is an extraordinary degree of overlapping interchange which is unfortunately not reflected in our academic institutions to an appropriate degree. At the present time there tend to be dissertations on cleavage or differentiation between these two branches which are unrealistic and unproductive.

For the time being, I'm going to use these terms interchangeably and leave it to you to understand from the context which of the principal cores of these overlapping enterprises I'm referring to.

There are degrees of resistance. There are some who are so defensive about the nobility of the scientific enterprise — that it represents that which is unique about the human species and its encounter with nature — they hold that anything short of diverting the entire GNP to basic scientific enterprise would be resistance.

More widely, we find a range of reactions that may range from diffidence about support, inevitably from government sources because basic science, by its very nature, is something on which we cannot put a proprietary tag. You cannot properly reap yield on investment in basic knowledge. I wouldn't know how to charge you for what I can communicate to you about what I discovered yesterday in my laboratory. There must be some way of socializing, of generalizing the sources of such generally available knowledge. So that even that diffidence can have, in the end, the same effect as active hostility in frustrating the efforts of individuals in their laboratories to pursue their work. And in this respect, it's very different from literature — almost poles apart from what was discussed by Professor Howe.

If I attempt to make a more systematic overview, I have to ask first of all, by what scale, by what parameter I am going to do this, and in a very hasty effort I've tried to do this by the scope and character of the system, of the belief, or of human action, or of human organization that appears to be impacted by technological development. The first of these has been touched on in a very different vein by my predecessors this morning — the ethical ones — in view of the person in relation to God, or if you would like, to the mystery of his own personality. Here, of course, we have some of the traditional conflicts between science and religion, the processes of skepticism against traditional belief that have gone back through the ages, but which are epitomized today by the names of Galileo and Darwin. In the very process of the exploration of the facts of nature some forms of literal interpretation of mythical belief have inevitably fallen aside. I think here we've had no better and more eloquent statement than that of Iris Murdoch on ways to approach the proper nurturing of the need for religious involvement in human nature, in the face of an evolution of our perceptions about the literality of revealed facts of our origins and of the nature of the universe.

Within the ethical domain we also face profound dilemmas that we fear, such as that we have the power to influence prolongation of life. There can be no deeper ambivalence than, on the one hand, enjoying the possibility of conferring a new episode of life and of health on others, and then the recognition of the dilemmas and the costs and the responsibilities that is then invoked when single individuals must make such decisions: a question of whether to pull the plug on the respirator or whether to pay for a kidney dialysis program that one knows will cost billions of dollars, for a technology which is quite secure in being able to assure the lives of a limited number of others.

These are dilemmas so difficult that individuals shy away from them for decisions that may be put on their own shoulders, and individuals are equally perturbed when they're taken out of their hands and assumed by others. We have yet to learn how to cope with them. I think there is then an unconscious response: Why did

you, the doctor, the medical scientist, the technologist, give us these problems when you gave us these powers to do the very things that we were begging you to do in the first place?

Technological advances, starting with Prometheus, can be given blame for our population explosion — both the enhancement of food supplies and the alleviation of infant mortality, which in the natural balance was the way that populations were sustained at some lower equilibrium. But can you blame anyone for having provided the measures to save an infant's life? Can you blame anyone for applying them? There is such a diffi- cult dilemma that each of us faces, but again perhaps projected at a more unconscious level.

We would prefer to escape from the freedom of choice and from the freedom that these powers offer us. These are then reflected in other areas. I find it bizarre how far we have gone in our anxieties about medical experimentation and the bureaucracy that's been built up to provide the last conceivable iota of an almost impossible-to-define attribution of informed consent. But so long as human beings are involved in experimen- tation there are, of course, necessary measures. It's the depth to which they've gone in the bureaucratization that I think does reflect an underlying concern as to whether we can really cope with the positive consequences of medical advances.

And of course, biological and other technological knowledge opens up all kinds of embarrassing ques- tions. They open up the issue as to whether there are systematic biological differences among the races. Here, as in many other areas, it's the halfway science and the halfway technology that give us the greatest difficulty. Those people who would like to make a great deal out of the speculative possibility of genetic differences among races don't know very much genetics. But even if there was a shred of evidence to support the hypothesis — and, in fact, at the present time there is not — how would it matter?

Someone really versed in genetics does not fall victim to the myth of genetic fatalism — that the con- stellation of genes that an individual is born with is the totality of expectation of that individual's future life. A skilled person, and a fully developed scientific intellect in this arena, knows that genetic factors are necessarily among a great many others that will eventually work together to determine the final outcome, and the more we know about genetic difference among individuals, the more we can do to make those differences irrelevant by providing the appropriate environmental framework. I guess the most obvious examples of this you are already familiar with — diabetes can be repaired with insulin, rare diseases like phenylketonuria can be repaired with an appropriate diet, and there are many other examples.

There are very real concerns that the more we learn of the biology of human nature, the more we provide tools for the potential manipulation of the ideas and ideologies and votes and behavior of large numbers of people. Certainly, it is in the control of the media that I myself have the greatest trepidations and see the greatest opportunities for the humanization of technological development.

Another terribly important system is the land that we live on and the environment that we occupy. Here we know that technological opportunities have arisen everywhere that enable us to exploit a common resource: the amenities of nature and the environmental sink into which inevitable pollutional products can be poured. The very scale of technological enterprise today is a new dimension of this problem. Today, unlike 50 years ago, we recognize that a single corporation is capable of pro- ducing other products and using energy on such a scale that the environment of the entire earth might be influenced by its effluents — that that sink is not infinite, that is has a finite capacity for absorption, before you begin to see the toxic wastes and the smog and the other manifestations of the utilization of that capital resource. I believe it to be primarily a problem of economic and political adjustment, about who has the right to use it, who gets the benefit from its exploitation. It is also a very deep technological problem and here again we're at a halfway stage — we worry about smog, we worry about cancer from toxic chemicals, we do not have a very well-founded scientific technology of assess- ment as to just which of these issues, and at what scale, are really important to our health, and which of them are just yesterday's scare story. Here again, I'm hopeful that we can get over this halfway stage and come to a more equitable and rational adjustment of the utilization of these resources.

In the industrial sphere, the greatest problem is that of the modification and displacement of work by technological innovation. It's not only technological unemployment — there are all grades of this. There's technological obsolescence; there's the assembly line motif that condemns people to an alienation from their product, the removal from their sense of involvement with the particular fruits of their own labor.

Again, I believe this is very much a halfway technology, and that particularly in the arena of the communications and electronic technologies with which your firm is associated, where we have the greatest opportunities to make work that much more creative on the part of a multitude of people. Meantime, we face an impasse.

In the economic discussions yesterday, I had hoped that someone would make a more careful calculation as to whether it was the inappropriate price of labor —

Peter Jay said "a price of labor above the market clearing price" — whether that was really nearly as important as the resistance of labor to technological innovations of any kind because we have not really found the right social and political and economic formulas to maintain a sense of security of life in the face of that kind of technological change. My own belief is that resistance is far more costly and prevents the remedies of increased productivity that would alter the clearing price of labor. These are problems raised by technology that cannot be answered by technologists.

Perhaps it is the very process of economic progress, of economic change itself that poses our most serious problems. Here again, we all share a profound dilemma. I think all of us really know and believe that it is not at the levels of the utmost economic deprivation and oppression, but on those intervals when reform has begun, when economic improvement has begun, when we have individuals who are beginning to receive an education at some scale and an exposure to the opportunities of modern economic society — that it's those rising expectations that are the most explosive from the point of view of maintaining some degree of political stability. Since the whole point of technological introduction is the improvement of economic productivity and of economic conditions anywhere, this is a dilemma that I see no immediate answer to. I can only hope that we find the microscopic ways of dealing with such conflicts place by place, people by people; that can avert the explosions of frustrated expectations. Technologists will still be blamed for it.

The very complexity of the technological industrial system, on the other hand, makes it even more vulnerable to political dissidents and insurgents. Small numbers of people can bring a technological society to a halt by going at its communication systems, at its power supplies, at its airlines. There are such manifest points of vulnerability and so few people. We have built systems that seem to be designed to make us less robust and less able to withstand assaults from small numbers of dissatisfied members of it.

There are ways, I believe, in almost every one of these spheres to combine approaches of technological with those of political and social amelioration. There's not nearly enough discourse between those spheres, as I've already illustrated, I believe, with respect to our approaches to weapons control. Perhaps the greatest opportunity that I foresee is precisely in the area of communications, and I've written about that before this week, so it was not invented for your benefit. And here I think there are options, there are alternatives that we ought to contemplate. It's not easy for any individual or group of individuals to make the guiding decisions about the direction of these technologies — they're usually in

response to market forces outside. But there is some possibility of using one's own ingenuity in certain directions *versus* others.

Now I'll offer some contrasts: Much of television is rubbish, and almost all of it dissatisfies everybody — primarily, I think, because the basic technology and economics of the system have necessitated, during what I hope is a transition period, a highly centralized production of material sent out over the air for limited periods of time. You catch it as catch can. You have only a few competing producers. The eletromagnetic spectrum is just too precious for it to be readily partitioned to a large number of competing channels, and there are just a certain number that are there.

We therefore have not had that much avenue for pluralistic and discriminating subscriber choice in that domain. One person's joy is another person's rubbish. I think one has to take some account of that, but there simply is not room for very much variety, for response to very much pluralism, in a broadcast-oriented system of mass communications. The contrast of that is cable television, the video cassette versus the video disc. The video disc is a product which has a high cost of initial entry. You can replicate it over and over again, but there will be much more limited numbers of them, and the consumer, the subscriber, can't copy them for himself, which I suppose is one of the reasons that it's been propounded. There is an ultimate loss of control in some of these uses of mass communications as compared to others, which I think does deserve some orientation of one's technological ingenuity.

Prestel is the most magnificent, positive exemplification of the the technological possibilities that these new communication technologies offer. It's not a very big leap to think of that becoming universal access to universal knowledge, that we really have the technology by which it's possible for everyone to be in touch with the world brain, with the community of human knowledge, accessible through a wide variety of routes, available to every subscriber from the kindergartener, the first grader, up to the engineer and scientist, with means to access that library of knowledge and to get to it at every level of educational inquiry that one wished to have. It's tantalizing to see such fragments of this readily available and to see how slowly, primarily for reasons that have nothing to do with the technology, such ventures are moving in this country. But they will arrive — they surely will.

Digital communications for similar systems may, I hope, evoke a new literacy. I'm one who believes that we have been tyrannized by the telephone and that the myth of instantaneous accessibility through this instrument has let us forget that it puts us at the mercy of one or two or three layers of secretaries who have to then

schedule our calls, hold people back, and the game of telephone tag, unless you're in a position to change the rules of the game at any particular moment — makes this one of the slower forms of communication. Then, when you've got it, you have no record of it. It's very difficult to prove your authenticity of telephonic communication. It comes on the fly; it's an uninter-ruptable scream, as I am afraid mine is to you, so I'll conclude shortly.

The alternative vision is an extension of the mail, but one which through electronic media makes the dissemination of messages instantaneous. But more important than that, it's multi-point to multi-point at the easy will and interest of the users. If you wish to embrace a larger community of critics and commen-tators on your own work, it's extremely easy to do that through those media. It may put more of us closer to our own verbal productions, taking us away from the tyranny of our secretaries, transcribers and stenotypists and so forth, where we inevitably lose a good deal of the detail that we had wished to insert and it's just too much bother to go through 14 drafts of a letter or a com-munique and so we just let it stand. And it's so much bother to have these looked at by the variety of other critics and commentators who deserve to come into it.

I think we have here an instance of what might be the most creative and humanly oriented development of technology, as against a variety of other alternatives. And I think all of us here have something to say about those options.

Just one final word: There are many technologies, many in the biological sphere, but all of them provoke a certain amount of anxiety and concern, primarily by people who don't understand them very well, but in a number of areas these have already provoked demands for government intervention for regulating their spread. My plea is to avoid the multiplication of victimless crimes by diffuse and not very well specified anxieties about such technologies. There are very few of them that, if used in private by untrammeled private individ-uals, and do not involve harm and damage to other specific individuals, would really warrant the level of policing and control that is sometimes invoked. The development of large categories of victimless crimes and of an entrenched and growing bureaucracy to control them is, in my view, a danger much more serious than what they appear to be addressed to.

There is an enormous educational role for all these new technologies that may bring individual people back to some sense of understanding and control of those technologies themselves, and it is this self-referential use of these technologies that I would advocate to emphasize their most human applications.

Thank you.