Draft Testimony on

Basic and Applied Research in Health Sciences

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Senator Harris, I know you will understand why I address these remarks to President Johnson, as well as to you. Last summer, Mr. Johnson gave the most urgent expression to the social concern for the underlying motive behind government support of scientific research. He did not invent this concern. As soon as tax-supported research funding approached the billion dollar mark a few years ago, the support of science inevitably became a major issue of public policy, deserving the closest scrutiny. To ask questions, why should we support research, and how shall we find the appropriate balance between basic science and its technological application, is an important responsibility of our political leadership. These questions are answerable, but it is hard to give simple, monolithic answers to issues that are quite central to our very culture.

With the growth of the science budget, the past few years have, however, seen a regression from an atmosphere of mutual trust to one of administrative stringency and suspicion in the relations of government and science. Therefore, many of my colleagues in basic research are very nearly panicked at the atmosphere in which such questions appear to arise now. At the same time our political system is under extraordinary stress. There is great fear that the allocation of a level of support whose growth is reaching a plateau will become more and more deeply involved with the political expediencies of our Constitutional system, to the disparagement of the intellectual merit of individual researchers and their projects. A few years ago, the National Institutes of Health and the National Science Foundation were proud to say that the excellent investigator was the focus of their support. Now, in a strict interpretation of the law, the focus is on the isolated project, a shift that has brought many fussy complications and contradictions requiring meticulous planning of the unknowable. We do have tangible fears that an overenthusiastic insistence on demonstrating social justifications of individual projects may do little benefit for social aims, but may enmesh us in a bureaucratic system for policing these justifications whose cost far outweighs the benefits. Worst of all, it may finally kill the spirit of free enquiry that has underlain a new renaissance of basic science in the last generation.

The recognition of basic scientific research as one of the major expressions of the aspirations of Western culture is a milestone in human intellectual history. It represents for American achievement a movement no less creative than the renaissance of the arts was for Europe after the middle ages. Starting with physics and chemistry, the wave of scientific insight has reached biology and medicine, and is beginning to enrich our outlook into the most important aspects of human personality. Medical research is a major branch of this movement: specific applications to disease problems rest on man's fundamental understanding of his own nature and his relation to the universe.

The scope and pattern of social support of science in the United States are the envy of the rest of the world. What else is the "brain drain" but a manifestation of our extraordinary environment for intellectual expression of the most qualified

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minds? We certainly have every cause for pride in the technological superstructure that we have built on this base, whether in medicine or in civil technology, and it has also given us unexampled power and with it as much security as that kind of power can purchase in the world. That superstructure does indeed depend in part on the factual knowledge gained by our own pursuit of science. However, such facts do not remain proprietary to one country, and therefore will not alone account for our technical and economic supremacy. This I believe comes from the pervasive education that is a constant companion of basic research; our administrators and engineers share with our scientists the experience and confidence of a realistic, analytical approach to nature, to problem-solving as a basic outlook on the world for which published research in an environment of free criticism is the indispensable example.

As a delegate from academic science, I am therefore truly grateful to Senator Harris and his committee for the opportunity to participate in a new dialogue between science and government. We feel deeply frustrated that our message has, seemingly, not been understood; perhaps we have been too busy in the laboratory and not given enough attention to this essential political communication about our purposes. We have tried to teach the substance and purposes of science to our students at the universities. But we know this moves very rapidly, and it is not surprising that many of our findings are couched in such a specialized language that it is hard for our voting citizenry to understand the same material that is a daily commonplace in the highschool syllabus. I have been delighted to write on science for a Washington newspaper and to discover a lively reaction; but I have been chastened that another metropolitan newspaper editor found the same material too "lofty" for his own comprehension. I do not know the best answers to this problem, but we are beginning to recognize its gravity. I can only plead with our political leaders to move very cautiously, not to overturn or starve out an existed proven system of enormous scientific productivity, until we have had a chance to discover our motives in terms that can be fully entertained by the democratic process.

These hearings will not be the final answer to our problem; they can only be a first step. I look forward to them as an important educational experience, and I mean for me and my colleagues no less than for you and your constituents. The scientist is not necessarily the best judge of the social utility of his own work, or that of science in general. His motives in doing research are irrelevant to the consequences of his work for the community. In fact, it is fair to say that society exploits the poetic fascination that motivates many academic scientists, eventually capitalizing on applications that no one could have foreseen. It may even be an undesirable distraction to its rigor and sharpness of focus for the research worker himself to be too sensitive to the unpredictable implications of his own work.

It is important, however, that such utilities be discovered as soon as they can be useful; but this is a function of a whole community of basic and applied scientific effort. To place the burden of such justification on individual projects would be the surest possible way of stifling the most creative, the least predictable advances in scientific understanding. It would be rewarding to expose some tangible examples of the interweaving of unexpectedly inter-relevant bits of knowledge. The theme is a familiar one, and I will leave it to better

journalists than I am to document the examples in more detail. Some well-known chapters might be headed "mental retardation and yeast metabolism", "mongolism and wheat-breeding", tuberculosis, streptomycin and soil ecology", viruses and television electronics". From my own experience, I do not know any scientific or technical advance of any importance that did not make utterly unexpected demands on knowledge from unpredictable sources. We ask, "How shall we cure cancer or prevent mongolism?" Immediately we realize how much fundamental biology we still do not know, the more elusive because we are beginning to understand the magnitude of the problem.

This is all preface, and the statesman might reply: "I have heard all this before, and I might almost be willing to believe it. Nevertheless, to paraphrase Mr. Johnson, are we making the most effective allocation of our resources for the public good? Are we doing all we can to 'make sure that no life-saving discovery is locked up in the laboratory'? How can be achieve the most constructive 'payoffs in terms of healthy lives for our citizens'?" If we can reach these questions in an atmosphere of sober inquiry, and allay any mistrust that they might be intended to undercut the support of basic science, we will have reached the most important purposes of these hearings, and of the continuing dialogue that should follow.

These are questions of technological development, not of basic science, though these functions are profoundly interconnected. Many discoveries in physical science have resulted in practical utilities rather quickly -- it took only six years from the first observation of nuclear fission to proving how to make the earth uninhabitable, and hardly longer to go from the principle of the transistor to portable TV. Can we not emulate such rapid progress in the health field? What are some of the difficulties and challenges in the health field? Can we also foresee some of the stressful and unwanted side-effects of some branches of health technology?

May I first comment on some of the difficulties and obstacles. Some of them are unfair burdens to place uniquely on biomedical science when they reach some of our most pervasive social problems. Nor can we consider the manipulation of human nature in a vacuum that ignores religious and political controversy about its proper bounds and some of the most poignant ethical and moral concerns for life and death. We are charged to comment on obstacles to the utilization of scientific knowledge for the individual and social good. Some of us have read into this charge the implication that as scientists we might be diverted from the laboratory to implement social change, more bluntly that our science budgets should be divided to help pay for these applications. I hope this is an obvious absurdity; but our concern for an absurb implication should not deter scientists from displaying any insight they can muster to help show what should be done.

The homeliest examples may be the most instructive. It takes very little biological science to know that babies who do not get enough to eat are unlikely to develop into healthy, socially well-adjusted and economically productive adults. Throughout the world -- and still even in this country -- there are at least a few children who are not getting the benefit of this scientific information, because their parents can't afford it. As important as I believe the furtherance of basic science to be, if I had to choose between it and the applied science of feeding hungry children, I would choose the latter. But I would also ask why that particular choice was obligatory; why is it not made over a wider range of priorities?

Only a question of scale distinguishes this question from many others of economic allocation. Some hundreds of patients with kidney disease are still dying each year essentially because they can't afford an artificial kidney machine. It is also true that we might be unwise to sink all of our resources into this year's technology, when it is advancing rapidly. But meanwhile, there is a simple economic discrimination for the chance to live. Is this a problem chargeable to biological research? If we deal with it on the customary scale for basic research, the cost will inevitably be several hundred more lives than if we gambled a few hundred millions of incentive money to distract some mechanical engineering inventiveness into kidneys away from washing machines.

This does illustrate one of the main problems of health technology: how to provide economic incentive for a new industry, and how to relate federal support on issues of human life and health to a body of talent which is now embedded in profit-oriented commerce.

It is too obvious to need mentioning that medical care is still not evenly available, that economic factors still dominate access to advanced technical skills in medicine -- like psychiatry, nursing care, or batteries of laboratory tests. IN the long run, skilled manpower is again the limiting factor in making the best of existing knowledge freely available, though better techniques could be developed to make more effective use of the scarcest kinds of people. The education of the patient population is also of the utmost importance in improving health, by evoking intelligent avoidance of quackery, and encouraging the use of preventive facilities when they are available -- like prenatal care and survey screening for cervical cancer.

The discrepancy between existing scientific knowledge and its public availability and acceptance is immediately visible in attitudes on narcotics. The medical case against alcohol and tobacco is overwhelming, yet these agents are tolerated by the establishment. This might seem to reflect a principle that the law hesitates to intervene against determined self-abuse by legally competent adults, despite the enormous health problems raised by the easy availability of these commodities. But then the savage recriminations against marijuana are incomprehensible, except insofar as pronouncing any synonym of "hashish" is spitting in the face of organized society. This issue is somewhat remote from the consideration of social benefit of science. However, the failure of the law to follow pharmacological science and discriminate carefully among different drugs in some relationship to their actual hazards is encouraging a defiance of the law in far more damaging ways, like taking on LSD and opiates. In general, the law on narcotics remains the despair of rational medical science, and is a testimony to the power of symbols of conformity. This is a controversial position, but there will be general agreement that social rather than scientific perplexities frustrate our dealing with the narcotics problem.

The situation is even more complicated where conflict of religious belief still enters into public policy. For a long time the importance of birth control for the health of the family has been universally conceded, but a militant religous minority nevertheless opposed the spread of the appropriate knowledge, and only grudgingly acquiesces in its availability now, even to members of other faiths. Since contraception has been practised throughout this period by the whole middle

class, the practical consequences of this perverse class discrimination have been to deepen the gulf between rich and poor, by class and by race. The Administration has finally gathered the courage to insist on a rational policy in furnishing birth control information, and we need not resuscitate settled controversies.

However, a similar conflict is following a similar course in the related field of therapeutic abortion. A scientific understanding of man is of the utmost importance for social policy here in several ways. Most important is the discovery of a number of catastrophes where the continuance of a pregnancy can be predicted to result in a deformed child, or in serious physiological or psychiatric injury to the mother. Then techniques for the safe interruption of pregnancy are now well established. Perhaps most important, biological science offers no support for the theological speculation that the fertilization of the human egg immediately results in a "human being". On the one hand, the fertilized human egg differs from that of an ape in a finite number of DNA components; on the other hand, any tissue of the human body, including cellsof the menstruum regularly discarded by every woman, has in it the same hypothetical potential to participate in a developmental process. The egg does eventually develop into a human being, but only gradually does it become differentiated from the forms of other animals. By the time it is a viable infant, we have no doubt about enfolding it into the species, but every scientific observation shows his development to be a gradual elaboration of the potentialities ultimately inherent in every cell.

A Senate Committee may be a strange place to defend a heresy, but if we are to ask honestly about the impediments to the utilization of scientific knowledge for human benefit, we must include these strictures despite their relationship to religious controversy. The consequence of a dogmatic position about therapeutic abortion is hardly to prevent the practice. Instead it has been forced underground, and perhaps a sixth of all pregnancies are now terminated illegally under conditions that are a serious medical and psychological hazard to a million women every year! Judging from trends around the world, however, we may hope for a gradual transition of authority in this area from the penal code to private morality where it has a place I would not presume to intrude upon. Our political problem is how to respect the conflicting passions intensely held by different groups of constituents, giving the utmost latitude to individual liberty where it does not intrude on the welfare of the whole group.

The questions I have just discussed are remote from the immediate legislative responsibilities of this committee, but they help to illustrate the complexities of applying merely scientific attitudes to human problems. The allocation of resources is likely to remain subject to the same complexities.

The fruits of biomedical investigation are more importantly medical molecules than even the elegant medical machines like the artificial kidney. It would be highly desirable to subject the whole process of drug research to an operational systems analysis and attempt to rationalize it once and for all. Under the impact of federal support for research in medical schools, and an aggressively defensive patent policy connected to that support, fundamental biochemical research is becoming less and less effectively coupled to the actual development of useful drugs in the pharmaceutical industry. Indeed, with more effective regulation of drugs, and appropriate demands for more rigorous testing, and with legislative interest in drug pricing, there is serious danger that tisk capital for drug development

will be choked off, that a larger and larger proportion of capital investment in that industry will be devoted to the promotion of existing agents, the few that have passed the scrutiny of an agency pressed to assure the impossible goals of absolute security and perfect efficacy. Promotion versus research is also encouraged by the growing bewilderment of an over-busy medical profession unable to sustain its own education for discrminating criticism of new drugs, and therefore increasingly reliant on the drug industry's slick ads and detailmen for its own expertise.

Here, the ultimate problem is the inability of the medical profession to keep faith with the demands of the times. By failing to maintain its own capacity to judge the merits of new agents, it has abdicated its responsibility to a federal agency that inevitably must follow the most cumbersome procedures towards monolithic judgments about their safety and efficacy. In the process, a great deal of flexibility is lost; only those drugs can be allowed even on the ethical market which are safe for the average practitioner who is assumed to be guided by the fine-print disclaimers and precautions in the manufacturer's literature. To the extent that only an enlightened minority of the practising physicians remain in contact with modern medicine through systematic post-graduate training, the profession as a whole will remain at the mercy of self-interested advertising, which in turn does have to be policed by a regulatory bureaucracy. The profession itself must accept the responsibility of qualifying its membership; the government could, however, accelerate this process by recognizing a gradation of responsibility that can be assumed by practitioners with more sophisticated training -- a result towards which the roster of qualified drug-experimenters is a useful step.

The expertise of the medical profession is, however, so vital to our national well-being that we should also begin to consider more far-reaching measures. The most essential is the reinvigoration of our centers of medical education to encourage the training of many more physicians over a wider variety of skills and specialties. Some of these centers must also be dedicated to the continuing education of mature physicians, being training and information centers for the latest advances. We have modern techniques of dissemination at our fingertips -- wideband communications, computerized information retrieval videotape libraries -- but we have not yet learned to apply them to this vital use, more out of perplexities of economic policy than because of technical limitations. One of the fundamental difficulties is that the time of the mature physician is so valuable he can hardly afford even his present efforts at continued self-education. The organized profession's tacit attitude in its public representation that every physician is equally and identically perfect offers the most limited encouragement to his self-improvement. It should be possible to devise tax incentives or even more direct subventions to encourage a more positive trend. Consider, for example, the career scholarship proposal. A meritorious fraction of medical students should be offered full scholarships covering their own living expenses and the cost of their education throughout their initial training period -- usually at least seven years after the college degree. These scholarships would, however, be loans rather than gifts: the regular means of repayment would be not in cash but in credits from 1) later national or community-oriented service, 2) regular intervals of postgraduate education, the credits partly compensating for the time taken from their practice, or 3) time spent in clinical teaching, as is now generously volunteered by many of our finest specialists. If the prorated cost of education were included in the

stipend, the system would already provide a big step to funding the needed expansion of medical education, and the students themselves would constitute a very broad selection committee for allocation of support to beneficiary institutions. Such a program is undoubtedly self-liquidating in terms of the tax yield from improved earnings, but even if it were not,the social interest even exceeds the personal interest of the physician in his own continued education.

Analogous approaches are worth considering to encourage the most creative deployment of the resources of the drug industry. In view of the restraints on profiteering on drugs, secondary incentives for risking capital in research are essential. The operations of FDA ought to be financed by a manufacturer's excise tax on drugs amounting to, say, 25% of their wholesale value, or about 10% of the consumer price. However, the company's research and testing costs (its investment in innovation) should be credits against that tax. Furthermore, companies that contribute matching funds to university research should be franchised to be able to participate fairly in patents in which the government now would retain a preclusive interest, and even worse, a vaguely defined bureaucratic involvement. The lack of clear definitions of the scope of government interest in patents that bear any relationship whatsoever to federal health research support is an intolerable bar to industrial-academic cooperation. Perhaps we might bar patents altogether for the more fundamental aspects of drug innovations, and leave them only to the fruits of the later, costlier development work for which industry is better suited. For example, a drug might be patentable only at the stage where it could qualify for FDA approval, the company being allowed some period of time after preliminary registration during which to pursue the development work, the registration itself entailing a substantial commitment of effort.

Every possible measure should be considered to minimize the commercial value of a brand name, which is generated by the huckstering of the medical profession, in favor of the actual merit of the innovation in the drug itself. Another way to approach this is to relax the law that requires a prescription to be filled by the brand-specified product, so as to encourage the use of generic names. Physicians must, however, be left the discretion to specify a particular formulation and manufacturer.

In sum, we need to reconstruct the whole system of therapeutic innovation so that the drug companies are encouraged to reinvest in research and development, and so that the medical profession is kept in life-long contact with disinterested centers of medical education.

Fundamental biological research has made the most extraordinary advances within the last decade, especially in the elucidation of the genetic material, DNA, and the chain of events that links this to the synthesis of the proteins from which cells are made. This solid basis for biology is a credit to a cadre of fundamental scientists who function as teachers as well as researchers. Their domain of teaching includes the undergraduate who matures into our informed citizen, and also their own graduate students who will continue the traditions of fundamental research. It also includes the applied biologists, the physicians who need a sound perspective on human biology to pursue their art by the highest contemporary standards of skill and science. Outside the classroom, basic research also teaches all of us the reality of an elusive nature that will give its secrets to no wishful hopes, but only to hard work, ingenious intellect, rigorous measurement, and dispassionate analysis.

The rapid extrapolation of these research findings to human problems requires a superstructure of which we have only the barest framework. Clinical research on human beings is incredibly slower and more expensive than comparable work on microbes and laboratory animals. It is also fraught with grave moral problems. Whenever any one of us gets effective medical treatment, we benefit from the risks, inconveniences, and sacrifices of others who have participated in the clinical trials to prove the efficacy of that treatment. How do we measure our responsibility to others to help in this process? But the most stringent bottleneck at present is in trained people -- the very clinicians who might be best able to do this kind of research are the busiest people in the community, working overtime in the care of patients. If we are to get good clinical research, they need relief -- which means financial support for our medical schools to hire two in place of one person to do the work of three, and a new look at the manpower goals of and recruitment for medical education, which is still the stepchild of federally supported graduate training programs.

Besides the manpower shortage in clinical research, this field suffers from serious difficulties in the collection of data on the life-histories of human beings. For example, in 1955, at least 4,000,000 children were inadvertently inoculated with a virus, SV-40, that contaminated some polio vaccines. Subsequent studies on the geographic incidence of various diseases have shown no relationship to the distribution of SV-40 exposure, and we can possibly breathe a sigh of relief that this was not the worst medical catastrophe of modern times. However, our health data management is so bad that it would be almost hopeless to correlate individual cases of future disease with past exposure to this virus. We are confined to rather general comparisons of time and geographic trends, which would be quite insufficient to detect risks which, while far short of catastrophic, would generate considerable alarm if attached to other drugs. The same concern attaches to other drugs in wide use. For example, the oral contraceptives as a group have been exonerated from any acute, substantial risks -- compared for example to the hazards attached to the normal pregnancies they are intended to avert. It is very difficult to evaluate very low-level, long-term hazards -- or for that matter, incidental benefits -- with our existing techniques of population study. A number of different agents and dosage forms are already on the market, and over a ten-year period it will be quite useless to get reliable information on exposure-history by retrospective interrogation of a woman who may turn up with some or other disease which might or might not be within the range of average expectation. Situations like these cry out for definitive registration, but there would be a justifiable outcry of potential invasion of privacy if data like contraceptive-prescriptions were centralized. Yet there is an outstanding social need for such information on a large scale. The concept of the data bank has already been introduced before Congress, and vigorously criticized.

Within the existing legal context, I would have to support such criticism. The compulsory registration of personal information has already reached the margins of abuse, and it makes little difference whether the data are managed by a computer or not, except that the constructive uses are more likely to benefit. However, so long as transactions within the executive branch are virtually insulated from judicial overview, the private citizen would have little recourse against political blackmail. I believe the dilemma may be soluble, however, by a legal definition of the rights of privacy -- by making the divulgence of personal information from the data bank a crime that can be punished by the courts. However, since the courts will not act against the President, the data bank should be confided to a semi-public corporation whose transactions are then vulnerable to

judicial oversight according to the law established by Congress for privacy. It would not be difficult to construct computer-coding techniques that would ensure the registration of every access to privileged information. The Bureau of the Census has in fact operated under a system of privileged information for many years, with no known example of abuse. Like the Census, this form of the data bank would have a purely statistical function, and should never be used without consent to impinge in any way, good or bad, on the life of an individual citizen. It is urgently needed for public health research, a field in which we are being rapidly outstripped by British science as a side-effect of their National Health Service. It could nearly pay for itself by such mundane services as mail forwarding by social-security number to those citizens who volunteer their current addresses, and can thus reveal themselves to banks, estates and corporations who now spend a great deal hunting lost beneficiaries. It could also help locate unfortunate patients who may have received mislabelled drugs or agents later found to be hazardous.

Medical machines pose the obvious challenges, for the gaps are in many instances technological rather than scientific, that is, they depend on great investments in design and development, with a relatively small distance of untraversed knowledge. The artificial kidney is the outstanding example of a device whose utility was proved long since, and for which cost factors have been the outstanding obstacle. However, no very fundamental obstacles stand in the way of similar developments for the heart or lung, and the payoff is that much larger in proportion to the incidence of serious diseases affecting them. This kind of engineering is, however, extremely expensive, of the order of hundreds of million of dollars like the investments we make in weapons systems, nuclear energy spacecraft, or supersonic aircraft. Our health statesmen have yet to learn that they can think in these terms and carry Congress' enthusiasm into support of the necessary gambles. Much the same can be said for extensions of the human limbs and senses: only a rather large amount of money stands in the way of very substantial improvements in artificial arms, legs and fingers, or in surrogate eyes and ears.

These remarks take for granted the need for substantial federal participation in the research and development costs for medical machines. The arguments for this need are even more compelling than those which have been forwarded for the supersonic transport. There are inordinate risks for attracting private capital, and the investor would face the likelihood that even if his risk paid off, the social attitude against "profiteering" would keep him from making any really substantial return. Even after a successful device has been engineered, it must then undergo very costly certification, and after that may still be liable to civil litigation in the event of unforeseen shortcomings. More important, a new industry must be vitalized on a large scale to pool the diverse talents needed for real innovation in medical machines -- the necessary combination of biomedical and engineering skills does not exist at the present time. However, as with the aircraft and other advanced technologies, federal investment need be only the starter, and the odds are high for considerable momentum once medical machines are under way. In fact, since people are bound to invest every resource they have for their own well-being and productivity, there is every reason to anticipate that health, in the broadest sense, will emerge as the leading industry of advanced countries.

The industrial plant that most urgently needs modernization is the hospital. It now functions with a strange mixture of the most sophisticated and well paid of professional management, the physicians, the most exploited, the nurses, and an

excess of unskilled labor subject to the most costly turnover and unsystematic training on the job. To develop the computerized management and mechanical aids to revolutionize this system entails an investment beyond the reach of any isolated unit in this diffuse, non-profit industry. It could give the highest overall social payoff of any of the applications of system engineering now visible. Following quickly behind it is the research process itself. There are many sophisticated instruments, or more broadly, services -- for example, the sequence-analysis of proteins, or the calculated synthesis of known sequences -- which now occupy an enormous amount of routine effort in academic laboratories, that belong in just the same category. Once again, university scientists have been too accustomed to think very small, in terms of their individual project budgets, to specify the kind of development support that would ultimately magnify their efforts many fold. With the leadership of the Department of Defense, other science-oriented agencies have begun to realize that large scale facilities like computers, as expensive as they are, have become indispensable for the full realization of the intellectual capabilities of scientific research workers at the universities. Why is it traditionally Defense, rather than Health, that commands such leadership?

Engineering support for development work is not in competition for the same manpower needed for the conduct of scientific and medical research. It has, however, been suggested that the funds for target-oriented work in health be allocated in competition with those for basic research. The logic of this competition eludes me. As our civilization grows more complex and its problems more demanding, we should and do place an ever-higher premium on intellectual attainment and our institutions for education to it. The fastest possible growth of individual educational accomplishment remains the most plausible goal of our efforts in that area, a principle that could well furnish the backdrop to questions about where we should accept a plateau in supporting science. When it comes to technological development, we have a much larger aggregate investment than we do in basic research at our educational institutions. That investment is, by necessity, spent very abundantly for national defense. We must learn how to allocate the resources we do have for technology -- mostly contracted with industry -- to meet our own priority decisions among defense, health, urban affairs, and all the other needs of our society.

As important as it is, the optimization of our economic resources to encompass the health sciences and technology is only part of a larger political and social problem. The application of science to biology has reached near the fundamental secrets of life, and whether it be twenty years or two hundred, we are still very close to the ultimate scientific revolution: the precise control of human development. Wise decisions about the uses of such power can only be made in a climate of effective communication between the political and scientific communities, in one of continuing mutual education about social purpose and scientific opportunity. If we demand narrow payoffs too quickly, we may indeed get them, as we already have -- and then find ourselves with nuclear weapons, but insufficient means of control and inspection; with splendid automobiles, and unmitigated smog; with innumerable healthy babies and an inadequate base of population control. Our capacity to react quickly to the next generation of technological problems, the progeny of the first payoffs, depends on the broadest base of scientific knowledge and the techniques of new discovery. Too narrow a perspective about

human biology will bring about paradoxes even more disruptive than those from the physical sciences. The public educational value of hearings like these can hardly be underestimated, and they themselves form an indispensable part of our answer to how we can learn to make the most effective use of our unprecedented scientific potential.