Science and Technology Task Force Papers [2]

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CARTER-MONDALE CAMPAIGN

SCIENCE AND TECHNOLOGY TASK FORCE PAPERS

Edited and sections commented upon by Dr. Lewis Branscomb, Task Force Coordinator

Assisted by Dr. Michael Michaelis and Carl W. Shepherd

Submitted to
Noel Sterrett
September 13, 1976

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The administration is vulnerable on employment and the economy, and has failed to mobilize the effective use of technology to make the U.S. more competitive. Several indicators of technological health (rate of productivity growth, percentage of R and D manpower in labor force) stopped improving about 1968 and has slumped.

Attached is a summary paper plus an excellent background document on innovation by Gellman, an economist and entrepreneur who is a qualified expert. Also included, five other related background papers by Gellman.

This perspective on uses of science for public benefit could be an important conceptual initiative for a technically qualified President.

This subject is appropriate for first debate.

ISSUE

Ever since 1968 it has been increasingly obvious that the health of the American economy was a matter of concern, and was an increasingly important component of national strength and security. Economists know that technology and the training level of the work force are the source of much of the productivity growth in the economy. They are the source of virtually all new industries. U.S. productivity has, during this period, grown more slowly than almost all of our commercial competitors in world trade. U.S. public and private investments in R and D and in new capital facilities to use the new technologies have lagged. Inflation and unemployment are associated with this trend.

IT IS TIME ... U.S. research and development expenditures, public and private, began a precipitous decline in 1968 from (2.9% of GNP in '68 to 2.3% in '74), while the Japanese, West Germans and Russian investments have continued a steady rise. Similarly, 1969 saw a maximum in the fraction of the U.S. work force engaged in R & D. This percentage has declined steadily throughout the Nixon-Ford years; while it continues to rise in the USSR, Japan and Germany. These trends reflect a pattern of neglect of an important body of talent for solving a problem in America. The consequences of this neglect are seen in a decline in U.S. productivity, a loss of U.S. competitiveness and postponed commitment to solving energy, environment and resource problems.

I would act on several fronts to change this trend:

1. Enhance the inate ability and innovative power of American industry, and its dependence on research and development a cornerstone of economic policy.
2. Give America's demoralized scientists and engineers the opportunity to work with government to rebalance priorities in federally sponsored research, strengthening basic research in the universities and assisting them to rebalance training of scientists and engineers to meet future needs.

✓3. Direct the OSTP to assist me to improve the management of the 15 billion dollar federal R & D enterprise to simplify the chaotic organization, eliminate paperwork which is choking our universities, increase reliance on private sector research - especially when economic objectives are foremost.

Even the Nixon administration recognized the seriousness of the threat to our leading industries from the growing technology strength of other nations. But the response was vacilating and ineffective.

While virtually every other industrialized, market-economy nation has established both policies and programs for revitalizing their economies by encouraging industrial innovation and organizing applied research and development programs intended to create employment and economic strength in the private sector, the U.S. has continued with a technologically toothless Commerce Department, with technology policy made by default by the Treasury and Justice Departments, with no effective dialogue on R and D matters with the private sector, which performs 70% of the R and D in the U.S.

In the fall of 1971, the Nixon White House discussed a "new technology opportunities" program. The only result of this supposed billion dollar investment program was a $44 million program which has been cut and trimmed until today its only vestige is the "Experimental Technology Incentives Program" (ETIP) in the National Bureau of Standards. This subcritical activity is only a symbol of what needs to be done. (See Gellman paper on ETIP.)

The major difficulty is that the administration has been unsuccessful in organizing federal R and D programs in such a way that the results can be effectively picked up and translated into jobs and new technology for the public throught the private sector. The most obvious example is the

national energy program in ERDA, which still fails to engage the best efforts of the national technical community, to stimulate private investment in new energy technologies.

Science and technology and the economy.

ISSUE: How can government more effectively promote employment, productibility and trade by encouraging effective use of R and D in U.S. industry? Today economic policy is made everywhere in the federal government; technology policy is made nowhere. The Department of Commerce should be technologically upgraded and renamed so it can deal with assessments of the technological strengths and weaknesses of U. S. industry, can cope with the overt and massive subsidies in R and D being given to competing home industries by other nations, and can devise the policies and the programs that will re-energize U.S. industrial technology.

Recent presidents have been pursuaded that the health of the economy can be addressed through monetary and economic policy alone. But questions of industrial technology performance are microeconomic matters. Government must have the capability to evaluate the opportunities for technology to improve internationsl competitiveness, create jobs and improve the quality of the work environment. This must be approached on an industry-by-industry basis.

To insure that the research capabilities of the universities and private sector laboratories are able to make their contribution to healthy economic development, four policy elements are required:

1) government policies (regulatory, tax, and procurement and patent policies) that provide a more competitive, innovative and productive environment for American business, so business will have the confidence and the daring to reach out for new technology for the future.

2) a national science and engineering manpower policy which aligns the training of scientists with the needs of a vigorous scientific-industrial enterprise. (Today, half the science PhD graduates enter jobs essentially unrelated to their professional training. Universities haven't the resources to develop the new programs that would permit them to meet the demand for new skills, such as software engineering, for which there is unfulfilled demand and bring their programs up to date.)

3) A re-emphasis of government-funded university and national laboratory research on a balanced program of both basic and applied research aimed at challenging long range goals. We must get away from the current effort of the administration to demand economic justification on the basis of near term benefits from academic research (a required that industrial research managers do not place on their must long-range exploratory research, despite the view to the contrary held by Ford's OMB). Instead we should replace the beaurocratic paper-shuffling criteria for program priority and project selection by the best scientific and technical judgments the experts in America have to offer. The technological users of new science should participate in these judgments, which calls for greater involvment of experts from industry as well as universities and other laboratories.

4) In the conduct of research and advanced development to stimulate the civil economy and solve identified national problems, better ways of coupling the researcher to the end user must be found. Projects jointly carried out by university and industry teams should be encouraged,with the results in the public domain expensive demonstration projects should be restricted to technically meaningful tests of daring new ideas. Where possible the sector of industry that must ultimately deliver the service should be involved.

DICTATED BUT NOT READ.

SEVERAL THOUGHTS ON SCIENCE, TECHNOLOGY AND THE UNITED STATES ECONOMY

1. In the United States we clearly must translate promising technological possibilities into marketable innovations more speedily than is presently the case. This pertains especially to those technological possibilities developed with public funds. Mechanisms must be developed to have these technological possibilities exploited in order to improve productivity, increase employment opportunities, and to solve particularly vexing problems such as those which often plague the elderly, the handicapped, and the disadvantaged.

We require new initiative to stimulate innovation based upon our massive national inventory of technological possibilities. Such initiatives are long overdue; the present Administration has failed utterly to recognize the problem, much less undertake any such initiative. The Carter Administration will quickly devise and implement programs to enable science and technology once more to contribute to the nation's economic and social well-being to their full potential.

It is well to keep in mind that to assure long-term economic growth and welfare, fully one-third of United States jobs at any time should be in industries created during the preceding 25 years through the successful exploitation of technological possibilities. This was the case in the United States through the 1960's but, largely because of anti-science policies and out of apparent ignorance of the critical role of technological innovation in the nation's development, the Nixon-Ford Administration has presided over

a marked reduction in our reliance on new technology to help achieve critical national economic and social goals. We shall correct this situation by stimulating timely exploitation of promising technological possibilities in both the public and private sectors. Means for doing this will likely include tax incentives and grants of a measure of exclusivity for those desirous of exploiting public technology, coupled with experimental programs designed to determine what federal policies will serve best to return the U. S. to the course where considerable benefits of science and technology are once more delivered to the public.

* * * * * * *

2. The continuum from science to technology to innovation has been referred to previously. Without a science base, there can be little in the way of new technological possibilities. The value of science to society is therefore largely a function of its being translated ultimately to products and services for which there are substantial markets. But without science, an industrial economy such as ours is doomed to little or no economic and social growth regardless of what other strengths it may possess. Despite the critical role of science in economic development, the U. S. has clearly given short shrift and short rations to the scientific community since the Nixon-Ford Administration took over the reins of government. Not only has this demoralized the scientific community, but it has positively reduced America's ability to counter such problems as inflation and unemployment through the

exploitation of technological possibilities which are fewer than ever, significantly because of our failure to support basic science intelligently. This situation, too, will be redressed in the new Administration.

* * * * * * *

3. The effects of economic regulation on technological innovation are often most profound even while being the most difficult to observe. It is surprising that until recently there was very little question but that the economic regulation of industry in the United States was neutral as to technology. Certainly the Nixon-Ford Administration had never even considered such a relationship notwithstanding its crucial nature, especially in such pivotal areas as transport, energy, communications, and health care. The Carter Administration will not fail to identify and address such issues and will discharge its responsibility to the public to assure that exploitation of science, technology, and the process of innovation will be interfered with in the course of regulation only where it is clear that such interference is, on balance, in the public interest.

With respect to government regulation, the new Administration will establish a mechanism requiring that the effects of such regulation on technological innovation be assessed explicitly as part of the regulatory process itself. A "technology impact statement" will be sought of those charged with establishing regulatory policy and with issuing regulations of various kinds. The science and

technology community will in this way have the opportunity to support or challenge such statements, which is in sharp contrast with past practice where science and technology considerations have literally been ignored in virtually all matters of economic regulation.

The new approach should itself be a substantial catalyst to the development of science and technology as it holds great promise of removing perceived and real barriers to investing in science and technology that have gone up especially since the present Administration took office in 1969.

* * * * * * *

Gellman (B)

Gellman Research Associates, Inc.

August 23, 1976

"DICTATED BUT NOT READ."

Dr. Lewis M. Branscomb
5 Hidden Oak Lane
Armonk, New York 10504

Dear Lew,

I returned from an extended business trip to find Harry Schwartz' invitation to serve on the Science Policy Task Force in support of Jimmy Carter's election. I am pleased to do so, especially since I surmise it will operate under your leadership.

Several months ago I was approached by two Washington-based members of the Carter staff with respect to science and technology policy. (At that time I had already begun serving on the Transportation Task Force and had become acquainted with these people in that context.) In response to a request from one of them, Dick Creecy, I produced two related memoranda that are relevant to the present task force and in the event you have not seen them, they are enclosed.

Unfortunately, I am committed to another trip over the next ten days which makes it difficult for me to give proper attention to all the science and technology policy issues that I would like to address in the context of the Carter task force. I hope there will be time to do so when I return on Wednesday, August 25. In the meantime, I want to respond by accepting the invitation to serve with you and by forwarding the enclosed material along with the following general observations.

Especially in a period characterized by inflation and insufficient gains in labor and capital productivity, it seems critically important to approach "science policy" on a broader basis--science and technology policy. After all, the value of science to society is very much related to the extent to which the outputs of a scientific endeavor are translated into marketable products and services. In an economic sense, the output of science, standing alone, is the sound of one hand clapping. As an economist, I suppose I am especially sensitive to this point but I think it important in both political and practical terms to orient the efforts of the "Science Policy Task Force" in such a way as to reflect an understanding of the

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relationship between science and those activities which lie downstream in the process of innovation and which must be successfully completed if significant economic growth and development are to be realized from the achievements of science. I would add that to express the mandate of the task force in these terms promotes our consideration of critical public policy issues which have great political significance and which a responsible presidential candidate--and President--must address.

Given my present time constraint, I can now only hope to provide a partial list of issues which need to be ventilated in the context of the Science Policy Task Force. If any of these need to be fleshed out and you believe that I can make a contribution by doing so, perhaps my secretary might be told while I am away so that I can get right to it when I return.

(1) In fact, most of the issues that require urgent attention are fairly obvious to those who have been longtime students of science policy and the process of technological innovation. For example, the role and status of the patent system in the United States, and the relationship of the United States patent process to that of other nations requires review once more. But this time such a review and analysis must have more of an economic-technology orientation in contrast to the largely legal approach which most previous government-sponsored studies have taken. Mr. Carter might be well advised to recognize this in any science/technology policy statement.

(2) Science and technology policy formulation and execution suffer substantially from a paucity of relevant data. We do not know nearly as much as we should about the quantity and quality of resources going into science and technology development and into technology delivery systems--and yet much useful data are readily "gatherable." On the other side of the data equation, by what means, and in what terms, should we measure the contributions of science (and of technology) to society? How do we identify the value which flows from such activities and identify the individuals and institutions which are benefited thereby?

(3) Present policies toward the exchange of scientific and technological information between the U. S. and other nations are outmoded and should they be revised so as to serve better the interests of the United States. What effects do constraints on international flows of scientific and technical information impose upon United States scientific and industrial development and are the costs overweighed by the benefits, whatever they are found to be?

(4) There is a great need to project the requirements for scientific and technical manpower with greater accuracy and to "track" the supply of such persons in such a way as to promote the development of the necessary skills in advance of a national requirement for them. Perhaps we should suggest what means are at hand or can be developed in the public sector for stimulating relevant science and technology education where such is warranted (and to indicate how the present administration has failed utterly in this regard).

(5) It is my strong view, as you may recall from previous contacts, that not only do science and technology policy go hand in glove but also that we operate much more in the dark than is necessary when we do not know as much as we can learn about innovation as a process. This leads to the unhappy observation that the substantial resources devoted to the two programs initiated by the Nixon-Ford administration which were expressly intended to illuminate the process of technological innovation have largely been failures. In fact, the NSF/ERDIP program has, if anything, done far more harm than good not only because it has produced little useful knowledge and has actually led to the drawing of some very wrong conclusions. While NBS' ETIP program has been somewhat more productive, even there the insights derived have been far less broad and deep than they ought to have been. It is worth pointing this out, I believe, in order to state forcefully that the Carter administration would redress the present situation by identifying the relevant issues and establishing the mechanisms through which the public sector (as well as the private) can efficiently and speedily gain the requisite knowledge about the process of innovation and then build science and technology policy upon a firmer foundation than has ever been the case in the past. In this regard it may be worth observing that the recreation of the Office of Science Advisor to the President will give the new President the opportunity of selecting people for such posts who understand the role that science plays in a society such as ours--individuals who understand that the value of science is importantly bound up in the extent to which science is ultimately exploited in the form of beneficial innovations which reach the marketplace.

(6) Another area which needs to be examined by the new administration concerns the extent to which the federal government grants (and can grant) a measure of exclusivity to those who develop technological possibilities with some federal support. Certainly this issue is not a new one but it is one that has not been thought through, in my judgment. Governor Carter may wish to observe that intelligent policy here can be developed only with some appreciation for the major magnitude of the costs which society bears as a result of the nihilistic philosophy which currently prevails in Congress and the Administration on this issue.

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(7) Associated with the immediately preceding comment is the suggestion that a legitimate concern of science and technology policy ought to be the extent to which the federal government should continue funding R&D projects which are carried out by enterprises whose focus is entirely an R&D result rather than a product or service introduced into the marketplace. The criteria need to be developed by which decisions are made as to whether a given R&D program is more appropriately the province of a specialized R&D firm or of enterprises which have an interest in seeing successful R&D results translated into innovations. Unfortunately, there has never been proper consideration of what constitutes appropriate public policy in this area.

Given the little time I currently have to go further, Lew, I will break here with the expectation of hearing from you if you would have me do anything specific to support the work of the Task Force. Incidentally, I would be pleased to know the other Task Force members and how Governor Carter anticipates using its output.

I had the great pleasure of meeting your wife recently--in the context of the Carter campaign I should add--and I would appreciate your conveying my regards to her.

Cordially,

A. J. Gellman mrp

Aaron J. Gellman
President

Enclosure

cc: Harry K. Schwartz

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By Aaron Gellman

SCIENCE, TECHNOLOGY AND INNOVATION

Science does not exist in a vacuum. Science has significant value to society only if its development is followed by exploitation through the generation of technology which, in turn, is used to support innovation.

With few exceptions, science is most effective when it is pursued with at least a minimal appreciation for the downstream uses of science in the forms of technological possibilities and innovations.

As is now being widely appreciated for the first time, there is a complex process of innovation which must be worked through if the benefits of science and of technology are to be "delivered" to the market in timely fashion so as to benefit society.

The process of innovation breaks down into several specific and identifiable phases. In general terms, these phases are: (1) the conception/research and development phase; (2) the production phase; and (3) the marketing or diffusion phase. All too often it has been assumed that innovation is synonymous with research and development (R&D) and, in its most virulent form, this notion has led to the further assumption that R&D output leads "automatically" to "innovation". Since innovation does not take place -- or more precisely -- since the process of innovation is not complete until there is introduction of the technology into the market in the form of a product or service, it is clear that there is no guarantee that "successful" R&D efforts will lead to innovation. For those necessary phases and activities in

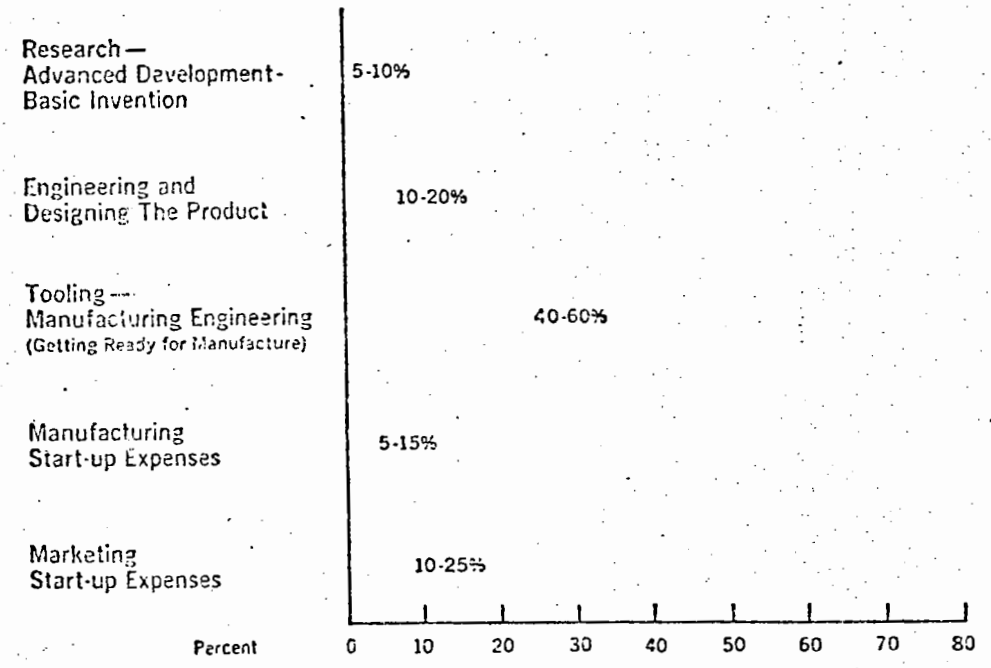
the process of innovation which are "downstream" from R&D but which are prerequisite to innovation, the term "technology delivery system" is appropriate.

In quantitative terms it has become clear that the bulk of the resources required to carry through the process of innovation are involved in the technology delivery system rather than in conception/R&D activities. Specifically, in the typical case some ninety percent of the resources required (when calculated in monetary terms) are consumed in the technology delivery system (Figure 1) which obviously makes this a far more important and highly leveraged set of activities than has generally be recognized. In qualitative terms, regardless of the character of the resources, both human and otherwise, which are committed in the R&D phase of the process of innovation, the resources required in the technology delivery system are not only more extensive, but are generally far more varied since they encompass all manner of activities ranging from engineering to advertising, from production to transport. Figure 2 presents a flow chart diagram showing the expansion of activities from basic research through technology delivery in the process of innovation.

Since the innovation process is completed only with the "delivery" of new products (or services) to the marketplace, it is most important that the structure of the technology delivery system be largely market-determined. There are, nevertheless, several very important ways in which the government can effectively foster beneficially technological innovation.

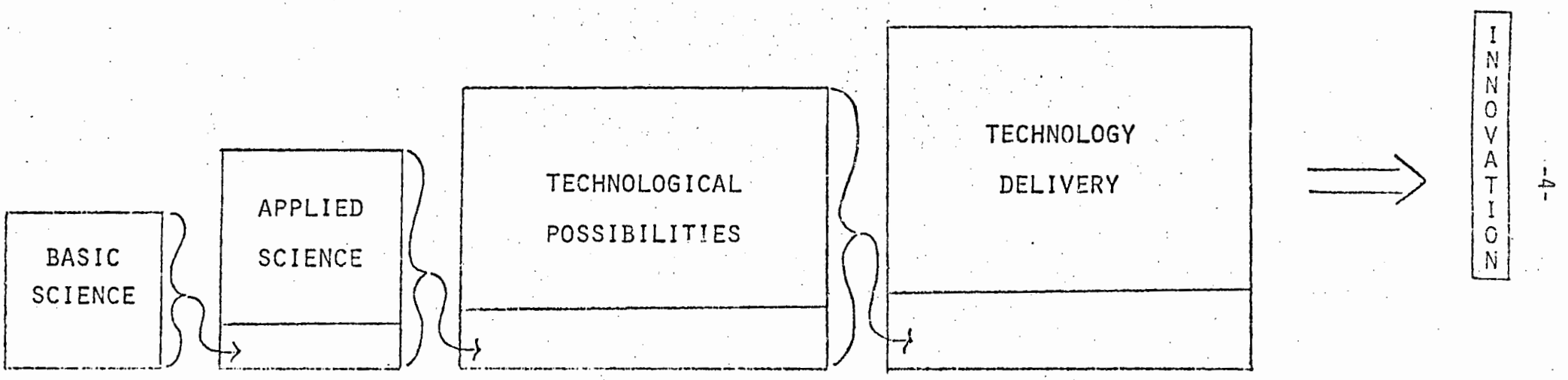
Figure 1

TYPICAL DISTRIBUTION OF COSTS IN SUCCESSFUL PRODUCT INNOVATIONS



Source: Robert L. Charpie, Technological Innovation: Its Environment and Management, U.S. Department of Commerce Report; GPO: 0-242-736 (Washington, 1967).

Figure 2


BASIC SCIENCE
APPLIED SCIENCE
TECHNOLOGICAL POSSIBILITIES
TECHNOLOGY DELIVERY
INNOVATION

Government has especially high leverage where economic regulation is applied. Certainly, the directly regulated industries (such as transportation, communication, power, etc.) operate under externally-imposed rules which severely constrain them in many dimensions that inevitably impinge upon the process of innovation. Again, other governmental rules and regulations, including those related to health and safety, and antitrust, influence, if not completely bound, what innovating entrepreneurs and managers of technology delivery systems can accomplish. It is therefore incumbent upon government to identify and understand fully the impact on technological innovation and technology delivery of the policies, procedures, rules and decisions and which relate to the practice of entrepreneurship either directly or indirectly. Jobs are at stake as is economic growth and a more equitable distribution of income. Clearly, technology or innovation policy are critical to the nation's long-term economic well-being.

B, Aaron Gellman 301

EXTERNAL BENEFITS AS A SPECIAL CONCERN OF TECHNOLOGY POLICY

Among the benefits of innovation -- new employment possibilities, new classes of products and services, more efficient use of resources -- are a class of benefits of special interest for government. These are the external benefits which often flow from successful innovation. They are "external" because they are not reflected in the costs experienced by the producer of an innovation; nor are they reflected in the prices paid by the purchasers.

The principle of external benefits may be illustrated by a simple example. A highway safety program to improve highway conditions and to educate drivers to safety hazards costs the government money for the material and labor which are directly expended in the program, costs ultimately paid by the taxpayer. If successful, the program will have benefits, however, which are external to the purchase of materials and the hiring of personnel. A decline in traffic accidents will generate substantial savings by freeing the resources of the health care system, the police, the courts, and especially the personal financial resources of individual families, so that they may be devoted to other, more positive ends. Perhaps the most important external benefit of such a program is the substantial saving in human capital which it makes possible. None of these benefits are reflected in the direct cost of the program, nor in the price paid by the taxpayer for it.

Externalities can be positive or negative, depending upon circumstances. Negative externalities, or external costs, can also be

of profound concern to the government. For instance, the American SST was defeated in the Congress largely because of alleged external costs associated with innovative aircraft designed to permit supersonic airline flight. These anticipated external costs, of course, include the sonic boom and atmospheric pollution primarily related to the ozone content of the regions in which such aircraft must operate.

Government should encourage the development of innovations which show great advantages in beneficial externalities. Government should also inhibit the introduction of innovations with significant external costs, since, by definition, these costs will not be reflected in the market price for such innovations, depriving consumers of necessary guidance in their optimal use. Government, therefore, has a part to play in determining, first, the size and sign of the net externalities associated with specific actual or potential innovations and, second, the types or classes of R&D activities that are most likely to convey substantial external benefits.

As for government encouragement of innovations which have great net external benefits, it is worth noting that each step in the technology delivery system has its own externalities both as to character and as to impact. The earlier the step is in the process, the greater the external benefits as compared with the resources expended. This is because the R&D efforts which come early are the indispensible bas for what follows in getting the benefits of technology to the public. These R&D benefits, however, are importantly external and

largely can be realized only through completion of the innovative process -- only by working through the technology delivery system. Therefore it does not make substantial sense on economic grounds for government to be a major contributor of resources to commercially-oriented R&D activities. In fact, generally the more federal support is provided at the upstream or research end, the more justifiable is such support since, other things equal, the externalities are relatively greatest there. As we proceed through the system of technology delivery for civilian-oriented innovation the benefits of the investments in technology and innovation become more "captureable" by the private sector so that little or no federal support in the form of grants or contracts is required or is justified. The support that becomes most meaningful -- and most important -- as the technology delivery system gets closer to the market is related to removing barriers to the completion of the process.

Additionally, government can foster innovation through programs to educate entrepreneurs and managers of the technology delivery system concerning the myriad complexities and challenges of the process of innovation. This may be accomplished through the achievement of a better understanding of the process itself. A measure of support for R&D and for innovation on the part of government, for example, could come through the development of better statistics through which we could know with some precision the level of the reservoir of R&D results, and through which we could know the absolute and relative

levels of resources going into innovation from year to year. As it is, we are forced to use R&D expenditure data as poor surrogates for the total resources going into the innovation process. This is most unfortunate since (a) R&D accounting by various entities is anything but uniform, (b) R&D expenditures are a minor proportion of the resources necessarily committed to achieve successful innovation and (c) there is typically a substantial -- and varying -- lag between the end of the R&D phase of innovation and the actual introduction of an innovation into the market. In short, if we knew more about what was going on from time to time across the innovation spectrum, even on a macroeconomic basis, we could allocate resources, both public and private, more wisely to R&D and to other innovation-related activities.

A NOTE ON SCIENCE AND TECHNOLOGY AND THE PRESERVATION OF THE U. S. COMPETITIVE POSITION

A great deal has been published concerning the roles of science, technology and R&D relative to the United States position in international markets for R&D-intensive products such as aircraft, jet engines, nuclear reactors, etc. In a recently published report, the National Science Board itself makes the point that the United States is beginning to fall behind other industrialized nations in terms of its R&D output as measured against various standards such as gross national product, productivity, etc. This lends considerable support to the view that the Nixon-Ford administration has let the country down in yet another fundamental way. It also suggests that substantial scientific research and technological development are required to re-establish the United States competitive position vis-a-vis other highly industrialized nations.

With respect to the sorts of R&D that have the highest payoffs in the context of exports and the nation's balance-of-payments position, it is useful to distinguish between process innovation and product innovation even though the two forms of innovation are often interrelated. In many respects, national comparative advantage in competitive situations is most effectively obtained and held as a result of an underlying process that permits a different and superior product to be turned out. In aviation this was demonstrated in the years following World War II by the publicly-funded heavy press program.

The heavy press program resulted from R&D and associated government activities which underlay the development, procurement and installation of very heavy presses to produce unprecedentedly large extrusions. In turn, these large extrusions permitted the U. S. aircraft industry of that period to achieve successful market results with lighter-weight, lower-cost, civil transport aircraft because the United States among free-world nations was for some time preeminent, if not alone, in having such processes. The heavy press program, then, helped to establish and maintain for a considerable period the U. S. competitive position in the aviation field.

R&D in support of process innovations often leads to the least perishable sort of competitive advantage which suggests that a substantial proportion of R&D resources should be devoted to generating processes which will be made available to U. S. industry and serve to keep U. S. products on the frontiers of technological possibility even while they remain economically competitive in world markets.

Those engaged in R&D product planning, whether in the public or private sector, whether related to domestic or international markets, must be sensitive to a wide range of public policy issues. As an illustration, consider such issues which can and must influence the development and production of new types of aircraft and aircraft subsystems. One example will suffice to make the point: Given the march of technology and of time, it can be projected credibly that before the close of this century an aircraft designed primarily for airfreight services which is on the order of twice

of the size of the Boeing 747 will be technologically and economically feasible and at the same time will find a large enough market (domestic and overseas) to require production of a significant number of units.

But "significance" in terms of demand has different implications for different parties to the process of innovation. The demand may be significant in terms of the airlift capacity the market requires; again, the ton-miles of airfreight transportation per year which can be produced by the new fleet may be quite dramatic as compared with the present airlift capability of the world's air carrier network. But for airframe manufacturers, given the nature of competition and their production cost functions, the quantity of aircraft required may not represent an opportunity to achieve long production runs, relatively low-cost production and profits. And this raises a number of public policy issues which are very much linked to the R&D resource allocation and R&D project specification decisions.

For the sake of argument, accept that over a 10-year span the total anticipated production run of a large cargo aircraft with a maximum certificated gross takeoff weight on the order of one and one-half million pounds (about twice the Boeing 747 or Lockheed C-5 in "size") would be about 250 units. This is a relatively small unit demand for an airframe company, especially if more than one producer is anticipated in this segment of the worldwide market for transport aircraft. This hypothetical, though believable, situation gives rise to two very important issues which, once more, are highly relevant in the context of aviation R&D policies and programs,

given the fact that the way these issues are resolved will very much determine whether the hypothetical aircraft can in fact be built in the United States by manufacturers in the private sector.

The first of these issues relates to the antitrust field. In order to generate enthusiasm from the airframe producers (and perhaps in the engine area as well) it may be necessary to allow otherwise competitive firms to get together and form a joint venture or consortium which would then develop and produce the large cargo aircraft the market has been judged to require. Early in the planning process, it is critical to determine whether antitrust policy will permit such cooperation between otherwise competitive producers. It is no longer acceptable for lawyers and agencies that establish and modify antitrust policy to say they cannot deal with such issues until the specific situation is presented to them. Not only does such a posture needlessly burden the technology delivery system but it also makes it highly unlikely that private capital will come forward to support development and production of such an aircraft because uncertainty in this regard beclouds the project. The antitrust issue must be settled far in advance of its becoming a tangible constraint; if this is not done, massive R&D resources might be misallocated and, perhaps even worse, the United States might miss the boat entirely where a very substantial domestic and international market is concerned.

A second issue which is to some extent mutually exclusive with the antitrust issue relates to participation of United States firms in

multinational consortia. Given the necessity to make a choice between U. S. participation in multinational consortia and an all-U. S. cooperative venture between otherwise competitive manufacturers, the public policy issues must be ventilated thoroughly and early so that an unequivocal position emerges which is then supported by specific federal action or programs. Only in such a climate can we expect maximum private-sector participation in research, development and beneficial innovative activity.

A NOTE ON THE ECONOMIC MULTIPLIER EFFECTS OF R&D EXPENDITURES

Given the paucity of data economists have to work with, it is very difficult to be precise in estimating the size or character of the economic multiplier of research and development expenditures. The causal relationships that determine the effects of R&D expenditures are myriad and usually highly complex. Moreover, they are frequently displaced in time and geographically spaced such that they are difficult, if not impossible, to detect--at least with present data. Based upon statistical evidence derived from numerous industrial settings and numerous countries, it can be asserted that those industries and nations which have the benefit of substantial R&D programs seem to fare much better in an economic sense than those which do not have such underlying support for their growth and development.

With respect to public policies which can favorably influence the economic multiplier of R&D expenditures, such policies can operate in either or both of two general areas. First, policy can be designed to increase the multiplier directly, i.e., lead to the generation of R&D results in such a form that they will be more highly leveraged in the economic development sense than has usually been the case in the past. Second, public policy can explicitly seek to reduce or eliminate many of the lags that are present where R&D results are being translated into marketable products or services. It seems clear that the formulation of policies and programs which deal with the latter area should have the highest priority at the present time. This is because an R&D result, without more, is essentially the sound of one hand clapping from the standpoint of economic growth and development. Even the

most successful R&D effort will not in and of itself generate employment and economic activity beyond the R&D project itself unless the opportunity presented by the R&D outcome is exploited in the context of a market. This is where "technology delivery" comes in.

The efficiency with which the technology delivery system works very much determines the economic multiplier both in absolute terms and in terms of the discounted value of that multiplier. It is important to recognize that the multiplier should be couched both in absolute and discounted terms given the fact that timeliness is of great importance not only to industrial entrepreneurs but also to those concerned with public policy formulation and with the allocation of public funds to R&D and other activities associated with innovation since they seek from such policies and expenditures the greatest possible beneficial results. It all adds up to the proposition that those concerned with R&D and innovation in both the public and private sectors, whether they are responsible for formulating policy or because they allocate relevant resources, must be aware of the technology delivery process which inevitably lies between the successful completion of R&D and the market introduction of a viable product or service. Indeed, with the very limited exception of those engaged in performing or managing pure research activities, all individuals concerned with R&D and technological change must be thoroughly familiar with the barriers and catalysts to the market introduction of products and services embodying R&D results. Unfortunately, all too often there has been a tendency to go about the nation's R&D business with too little regard for the necessity of translating R&D results into marketable

products and services. The waste that has resulted from this special sort of myopia has reached new heights with the present Administration; the situation must be redressed.

Perhaps the best way to bring an end to the general failure to couple R&D results to a marketable product or service is to place the responsibility for gaining an understanding of the technology delivery system on those who formulate policy and allocate resources relative to R&D itself. Specifically, where government is concerned, those responsible for R&D program planning and execution must henceforward consider, analyze and assimilate knowledge of the technology delivery system both as it related to R&D programs in general and to specific major R&D efforts in particular. This will require a substantial broadening of the present scope of "R&D activities" in those agencies which spend or administer research funds so as to assure that R&D managers become well-grounded in technology delivery system problems and opportunities; but this will be a modest, if highly beneficial and profitable investment for the public to make since, without a sufficient stock of intellectual capital about the technology delivery system, it is impossible to achieve the best allocation of R&D resources in terms of ultimate benefits for the economy.

The present Administration has been unable to promote conversion of even a small proportion of the R&D results and technological possibilities developed with public funds into innovative goods and services which will benefit the nation. As the new Administration acquires and diffuses the requisite knowledge of the technology delivery process through appropriate

government agencies and the industrial sector alike, the U. S. can look forward to both substantial and desirable economic development as both existing and future R&D results and technological possibilities are exploited to the full for the very first time.

R&D IN SUPPORT OF GAINS IN PRODUCTIVITY

The concept of productivity refers not only to labor but also to capital, land, energy and other resources. In the present context, another dimension of productivity needs to be explored--that of "R&D productivity."

All engaged in establishing R&D policy and in allocating resources to R&D activities need to know a great deal more about the use to which successful R&D results are put and about the technology delivery system through which such results must flow in order to reach full flower in the form of successful innovation. Determination of the productivity of R&D requires detailed understanding of these subsidiary processes and, once obtained, it is possible to develop at least relative measures for R&D productivity through which to compare R&D productivity across industry lines and even across international lines. Clearly, then, a modest amount of the public resources devoted to R&D should be devoted explicitly to the development of both absolute and relative measures of R&D productivity so that in future public policies in the United States can be established and implemented on a far more enlightened basis than has been the case to the present.

Concerning productivity in more conventional terms, it is worth noting that a recent National Science Board publication, Science Indicators 1974, states (page 22) that "while the effect of R&D on productivity growth is not known precisely, the general conclusion based on a large number of studies is that the impact of R&D is positive, significant, and high." Not only is this "general conclusion" consonant with logic but it also is supported by a

substantial body of circumstantial evidence; yet the present Administration, claiming to be dedicated to the enhancement of labor productivity, has nonetheless proceeded to cut resources to science, both basic and applied, notwithstanding the jeopardy in which it places the nation's war upon inflation, which requires heavy reliance on both short-term and long-term productivity gains.

The precise relationship between productivity and the level of R&D activities is difficult to determine with any degree of precision because of the complexity of the relationship and the varying and often great time lags between the undertaking and completion of R&D on the one hand and market introduction of a product or service on the other. It is nonetheless important to recall that there is much indirect evidence that there are important linkages between R&D and productivity. Consequently, in contrast to present Administration behavior, the Carter administration will not be asking whether the nation can afford to continue both public- and private-sector support for R&D activities but whether it can afford not to support such R&D activities, perhaps even at a higher level than has been the case in the recent past (as measured in real terms rather than dollar terms).

In this connection, support for R&D on a national level should in a sense be viewed as something as an insurance policy that provides the nation with the reasonable expectation that we will not be caught dangerously short either in the context of worldwide market competition or with respect to productivity gains. To deny public support to the science community and for

certain types of R&D is similar to the curtailment of public funding of fire companies with the critical difference that in the case of science and R&D the lags are usually so very long and the loss of skills so difficult to reverse that if one subsequently found there was insufficient support for R&D activities, it would be difficult to re-establish a position simply by throwing massive resources at the problem in the hope of playing catch-up successfully. Yet the Nixon-Ford era has seen a growing anemia in the science and R&D communities in the U. S.--in sharp contrast to the situation in certain other parts of the world. This situation can and will be reversed--beginning next January.

TOWARD A TRANSPORTATION R&D POLICY

Introduction

Transportation is of special significance in the American economy. It represents a "universal input" to virtually all goods and services and the efficiency (or inefficiency) with which transportation is produced reflects itself directly and swiftly in the prices of myriad products and services. It is therefore of prime importance that the technology employed in the transport sector always be that which produces transportation at the lowest feasible long-term cost. This requires that all appropriate technological possibilities be investigated and, if warranted, exploited in timely fashion in a transport context.

The special relationship between transport and the rest of the economy gives rise to the generation of both actual and potential external benefits for society. Moreover, government is already deeply involved in transport production and regulation. Therefore, sound public policy requires explicit consideration of transport-oriented research and development (R&D) as a means for achieving desirable, necessary--and practical--improvements in transport efficiency.

External Benefits as a Special Concern of Transport R&D and Technology Policy

Among the benefits of successful R&D when translated into innovation--new employment possibilities, new products and services, improved trade balances, more efficient use of resources--are a class of benefits of special

interest for government. These are the external benefits which often flow from successful innovation. They are "external" because they are not reflected in the costs incurred by the innovating entrepreneur, nor are they usually reflected in the prices paid by the purchasers. Transport policy must address such issues because transportation generates abundant external benefits and costs.

(The principle of external benefits may be illustrated by a simple example. A highway safety program to improve operating conditions and to educate drivers to safety hazards costs the government money for the material and labor which are directly expended in the program, costs ultimately paid by the taxpayer. If successful, the program will have benefits, however, which are external to the purchase of the materials and the hiring of personnel. A decline in traffic accidents will generate substantial savings by relieving the resource needs of the health care system, the police, the courts, and especially the personal resources of individual families that were not subjected to the trauma of a serious accident. Perhaps the most important external benefit of such a program is the substantial saving in human capital which it makes possible. None of these benefits are reflected in the direct cost of the program, nor in the price paid by the taxpayer for it.)

Externalities can be positive or negative, depending upon circumstances. Not only benefits are to be calculated: negative externalities, or external costs, should also be of profound concern to government. For instance,

advent of the Concorde has engendered legitimate concern on the part of government with respect to the possible external costs such as can emanate from sonic boom and atmospheric effects primarily related to the ozone content of the regions in which such aircraft must operate.

Government must make special efforts to encourage the development of innovations which show great promise in terms of net beneficial externalities. At the same time, it is proper for government to inhibit innovations with significant net external costs, since, by definition, these costs will not be reflected in the market price of either such innovations or of the services they produce. Consequently, consumers are deprived of the opportunity to make a thoroughly rational decision in the marketplace. All in all, then, government has a crucial role to play in determining the size and sign of the net externalities associated with both actual or potential innovations through its support for those R&D activities most likely to lead to the development of innovations which convey substantial external benefits net of external costs.

As for government's encouraging innovations which have great net external benefits, it is important to recognize that each step in the overall process of innovation has its own externalities both as to character and impact. The earlier the step in the process, the greater the external benefits as compared with the resources expended. This is because the R&D efforts which come early in the process of innovation are the indispensable basis for what follows in getting the benefits of technology

to the public. These R&D benefits, however, are importantly external and usually can be realized only through completion of the innovation process--by working through the technology delivery system. In general, direct federal support provided in the upstream or pure research/R&D phase of the process of innovation is most justified since, other things equal, the net beneficial externalities are relatively greatest there. As one proceeds through the system of technology delivery for civil, private-sector innovation, the benefits of the investments in technology and innovation become more "capturable" by the private sector so that less direct federal support in the form of grants or contracts is required or is justified. The support that becomes most meaningful--and most important--as the technology delivery system gets closer to the market is related to removing barriers to the completion of the process. While this may require public expenditures for facilities needed to prototype or test equipment or components, the barrier-removal role of government is generally of a different character--though no less critical--than is government's role as sponsor of pure research and R&D activities earlier in the process.

Not all activities in support of transport (or other) R&D and innovation are hardware-oriented. For example, government can foster innovation through programs to educate entrepreneurs and managers of the technology delivery system concerning the myriad complexities and challenges presented by the process of innovation. This is best accomplished through acquisition of a better understanding of the process itself. A measure of support for R&D and for innovation on the part of government, for example, could come

through the development of better statistics through which it could be determined with greater precision the level and character of the reservoir of R&D results, and through which both the absolute and relative levels of resources going into transport innovation from year to year could be determined. As it is, we are forced to use R&D expenditure data as poor surrogates for the total resources going into the innovation process. This is most unfortunate since (a) R&D accounting by various entities is anything but uniform, (b) R&D expenditures are a minor proportion of the resources necessarily committed to achieve successful innovation, and (c) there is typically a substantial--and varying--lag between the end of the R&D phase of the process of innovation and the actual introduction of an innovation into the market. In short, if more were known about what was going on from time to time across the innovation spectrum, even on a macroeconomic basis, both public and private resources could be more wisely allocated to transport R&D and to other innovation-related activities.

THE EFFECTS OF REGULATION ON TRANSPORTATION R&D

Especially in transportation, among the elements in the process of innovation which lie "downstream" from the successful completion of R&D are many aspects of regulation. To the extent that such regulation promotes or thwarts the translation of R&D results into marketable products or services, then such regulation is highly relevant to those who allocate public and private resources to R&D activities as well as to those who carry out R&D projects. Since a very substantial portion of the innovations in transportation are greatly conditioned by the extent and character of various sorts of regulations, it follows that such regulations profoundly influence the nature and thrust of much transport R&D.

Perhaps the most influential sorts of regulation where transport innovations are concerned are (a) economic regulation such as that promulgated by the ICC, CAB, FMC and several state and international agencies; (b) safety regulations issued by various public entities; and (c) environmental regulation as administered by a growing mix of federal, state, and local bodies.

Environmental regulation is relatively new. For this reason alone, such regulation obviously interposes new and different barriers to technology delivery. Moreover, regulation of this character makes the exploitation of R&D results both more difficult and more expensive--as well as less certain. Consequently, such regulations cannot but make R&D productivity less than it

would otherwise be where the R&D is directed at the development of, say, an aircraft or a major aircraft component.

In sharp contrast, environmental regulation has also opened up entirely new avenues for R&D activities. That is, once noise and emissions regulations became effective, there was (and had to be) some scrambling about to reorient R&D priorities to address environmental problems lest transport economic and technological progress be jeopardized or even thwarted. Here is a classic case where the imposition of regulations of a new sort have stimulated R&D activity and where, because of the stress on the amelioration of transport's environmental impacts, the translation of R&D results into products and components has been carried out more efficiently and more expeditiously than would otherwise have been the case. So it can be seen that regulation can be either a catalyst or a barrier to the exploitation of R&D results in the form of innovation and that some sorts of regulation can simultaneously be both a barrier and a catalyst to innovation. This is not to say that the class of regulation represented by environmental (and safety) regulation is wholly necessary or beneficial, but only that such regulation can catalyze both R&D output and technology delivery, especially when such regulation is new and sweeping.

Notwithstanding the foregoing, in the transport sector the effects of economic regulation on technological innovation are often the most profound even while being the most difficult to observe. It is surprising that until recently there was very little question but that the economic regulation of

industry in the U. S. was neutral as to technology. Certainly the Nixon-Ford administration has never even considered such a relationship, notwithstanding its critical nature especially in such pivotal areas as transportation, energy, health care, and communications. The Carter administration will not fail to identify and address such issues and will discharge its responsibility in such a way as to assure that exploitation of science, technology, and the process of innovation will be interfered with in the course of regulation only where it is clear that such interference is, on balance, in the public interest.

With respect to government regulation, the new Administration will establish a mechanism that requires that the effects of such regulation on technological innovation be assessed as part of the regulatory process itself. A "technology impact statement" will be required of those establishing regulatory policy and issuing regulations of various kinds. The science and technology community will then have the opportunity (and obligation) to support or challenge such statements. This will be in sharp contrast with past practice where science and technology have literally been ignored in virtually all matters related to economic regulation. The new approach will itself be a substantial catalyst to the development of science and technology as it holds great promise of removing many of the perceived and real barriers to investing in science and technology that have grown up, especially since the present Administration took office in 1969.

Through the mechanism of the technology impact statement, it would be necessary for each agency charged with economic regulation to determine the effects and relationships between economic regulation on the one hand and technological change and innovation on the other. Detailed analysis of the technology delivery system in the transportation field clearly indicates that economic regulation imposed without regard to the effects on technological change and innovation has been one of the major forces leading to the discouragement (or distortion) of private-sector R&D activities and the wasteful and needless misallocation of both public- and private-sector R&D resources as a result of artificial economic regulatory barriers which were erected without any attention whatever being paid to the implications of such regulatory constraints on technological change and innovation. Merely to require regulatory agencies to address this critical interrelationship would have substantial and early benefits for technological change and innovation and for the allocation of resources to the R&D activities underlying the development of technological possibilities.

ROLE OF OSTP IN WHITE HOUSE

This is an issue on which Nixon was culpable (having abolished OST and having fired his Science Advisor) and Ford is vulnerable. It can be used to show weak management of $25 Billion in federal R and D programs. and to illustrate a mechanism for accomplishing reorganization of federal R and D for better effectiveness.

See, also, supplementary paper by Harold Brown, prepared for Watson's transition preparations. It contains a convincing argument for a strong OSTP role, including support to the NSC in defense technology issues.

ISSUE:

After four years of abandonment by the present administration, OSTP has been recreated by statute. How effectively this office is staffed and used by Pres. Carter will be watched intensely by scientists, engineers and all those concerned with the technical components of public decisions. The key indicators are the personal relation of the OSTP director to the President and white house staff, the scope of the OSTP, its role in reorganization and R and D management appointments, its utility to the president for early warning and for keeping the agencies technically honest.

. The development of science and technology policy: role of OSTP

PROPOSED POSITION:

OSTP is a particularly important office in the Executive Office of the President because of the accumulated problems during the four years of republican neglect. The Director of the Office will also serve as the President's Science Advisor, in addition to his statutory duties, to insure that the President is aware of the critical scientific issues in major public decisions and to help the President foresee long range issues that result from new scientific knowledge.

Scientists and engineers in America share ~~the~~ Gov. Carter's own conviction that the nation's technical capabilities are not as effectively contributing to the people's long term well being as they might be, and a vigorous, productive and well challenged scientific community is essential to this end. Thus, the OSTP will not be the voice for science in the White House, but the voide of science and engineering providing objective evaluations of the technical aspects of important public matters. This high level, independent source of technical evaluation and judgement will help insure that individual departments and agencies do not take an excessively parochial view, that technical issues are dealt with on a consistent basis accross the government, that technical risks are squarely faced before new programs are launched.

OSTP will not attempt to rely on its own staff for its evaluations. The president will insure that the scientific and engineering skills of the agencies are available for addressing specific issues. More important, the OSTP will draw upon the best talent and experience in the nation, outside of government for advice.

OSTP can make important contributions to better management of

federal R and D programs. The Advisory Committee called for in the statute willcarry out the mandate fo theCongress to consider alternatives for reorganizing the federal agencies dealing with science and technology. Thus OSTP will have a major contribution to the President's determination to streamline the governmental structure, improve its efficiency and make its activities more responsive to public needs.

A critical factor in the federal government's technical competence and efficiency is the qualifications of the Assistant Secretaries for Science and Technology or Research and Development in the major departments, and the heads of major independent R and D agencies. The Director of OSTP will be provided hte opportunity to suggest experienced scientists and engineers for these positions, and will have the opportunity to comment on their professional qualifications during the process of White House review of proposed appointments.

OSTP will have to deal with economic aspects of technological issues; this calls for close working relations with the CEA and particularly with the OMB. There is no R and D program for which costs are not a matter of concern. OSTP will be expected to provide critical evaluations of proposed and on-going federal R and D programs of particular importance to insure that their goals are technically appropriate, the approaches and schedules are realistic and the benefits are correctly defined. These evaluations will be made available to the Director, OMB and will form a part of the budget and program development process.

OSTP will give special attention to the development of the capabilities of state and local government to deal with technical matters. This is particularly important as increasingly the politically difficult issues concerning scientific questions involve subjective estimates of public risk. It is desirable to internalize as many of these decisions on the local level as one can consistent with a coherent national strategy.

NIXON-FORD RECORD

Destruction of the Office of Science and Technology, Nixon, Feb. '73, and dilatory efforts to re-establish a central policy-making capability by Ford (August, 1976).

In Feb. '73, Nixon fired Science advisor E.E. David, Jr., and used his authority under the reorganization act to abolish the Office of Science and Technology in the Executive Office of the President. Nixon's hostility to the scientific community was open. Evidence can be found in the "enemy list", in his orders to cut off all research support to M.I.T. (not carried out by the agencies), by his failure to name any recipients for the national medal of science for over a year and a half.

As a result of this hostility the agencies of government began to lose contact with the new ideas arising in the universities and other laboratories. Worse, the President lost a technically competent mechanism for objective, independent judgments about technology issues arising in the agencies. By allowing the only technical expertise to exist in the agencies, he made the presidency helpless in the face of the narrow self interests of those agencies and their constituencies. Thus, for 4 years the federal government has been drifting, without a clear sense of purpose in science and technology, without strong management of the agencies, and with ineffective contact with the majority of scientific expertise, which exists outside government.

Pressured by committees of both houses of congress, which held extensive hearings on the need to establish a central policy-making capability for science in the executive office, President Ford finally sent forward a bill to establish an Office of Science and Technology Policy. This bill was a watered down version of the legislation originating in the House and

Senate. The President took little interest in it personally, turned over the entire matter to the Vice-President. Even after the bill passed and was signed in the early spring of 1976, months went by before the President sent up a nomination for the director of the office. This delay was largely the result of hostility to the choice of Dr. Guyford Stever, Director of the National Science Foundation, on the part of conservative Republican senators. Thus Dr. Stever will take office as director of OSTP during the waning months of the term; little can be accomplished before January.

The nation has suffered during this four year period of neglect of the responsibilities of leadership, not because science has suffered but because the attainment of important national objectives has been frustrated. The four years of lost time have extracted their toll in many fields - environment, health, energy, defense, economic vitality, and agriculture. In each case - and in others - the stimulation to excellence and the strength of coordination of federally sponsored R and D have been missing.

H Brown
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SCIENCE AND TECHNOLOGY ORGANIZATION IN THE EXECUTIVE OFFICE OF THE PRESIDENT

ISSUES

1. Should there be in the Executive Office of the President a Special Assistant for Science and Technology/Director of the Office of Science and Technology Policy?

2. If so, what are the appropriate functions? Line or staff? What size?

3. What should be the relationships of such an office to: a) the line agencies; b) other White House Offices (OMB, Special Assistant for National Security Affairs, Domestic Council); c) outside agencies (Office of Technology Assessment, state and local governments?)?

DISCUSSION

One possibility (it was the case between the late 1940's and 1958, and from 1973 until now) is for the President to rely on technical inputs from line agencies (some of which are principally technical in nature, some

not) and from technical people in other White House staff components (OMB, NSC, Domestic Council). The President already has too many individuals reporting to him. It can be argued that he should get problem-oriented, not functional, advice; he doesn't need more representatives of special interests. During the period 1973-6, the President relied (in theory but not in fact) on the Director of the National Science Foundation for much of the needed technical advice outside the area of national security.

Most observers argue that the White House/Executive Office structure needs, and the President himself ought to have (if he is willing to use it), a separate component which will provide advice technically oriented and staffed with highly qualified, technically trained people with a mixture of experience--academic, bureaucratic, managerial.

An example of its utility can be drawn from defense programs. These include such items as: the major weapons systems, their feasibility and management; the state of the underlying military technology; the decisions on when some area is ripe for a big push; and academic science's

relations with the military and other national security agencies. It is the experiental result of several different regimes in the Defense Department that even a highly competent and analytical Office of the Secretary of Defense will over the years fall in love with its own programs, no matter how dispassionate and competent a job it was able to do in analyzing and either disposing of or advancing the programs of its predecessors. In general, the clout of the Secretary of Defense and his associates, particularly if he is respected for his abilities, will allow him to resist within the Executive Branch opposing views on his programs, perhaps even somewhat more than the merits of the case would justify. This is probably as it should be, but there should be a check somewhere in the system. Within the Executive Branch, this check can be provided by fiscal constraints, either through the Bureau of the Budget (now Office of Management and Budget) as was the case in Maurice Stans' day, or the Treasury Department as in George Humphrey's. In principle, so can the National Security Council staff, although there is little precedent for this, even in its most imperial days

under Henry Kissinger. Outside the Executive Branch, Congress can provide a check.

But none of these alternate sources of countervailing views has in the past or is likely in the near future to be able to provide a technically valid critique of defense programs. Experience with BOB, for example, was that when it cut programs down or out, the reasons tended to be quite arbitrary, without technical (or for that matter, programmatic, political, or strategic) basis. When the OST-President's Science Advisory staff attacked a program, they had both better reasons and better alternatives. Thus decisions adverse to defense programs based on OST staff papers were less likely to produce butchered or voided programs and more likely to produce useful alternative programs.

With respect to policy questions including the purposes of military forces; military strategy and the capabilities of weapons systems; war gaming; vulernabilities, etc., the situation is rather more complex. It also includes the interaction of technical and military with diplomatic,

economic, and political factors in the equation of national security, specifically including arms control. There are in principle other agencies within the Government that can provide alternative policies in these areas to those of the Defense Department. Specifically these include the State Department, ACDA, and in the broader area of national security Treasury and Commerce. Moreover, there exists already within the White House the National Security Council apparatus whose function it is to assess the various agency positions, analyze and compare them, come up with possible additional alternatives of its own, and then make recommendations to the President. In fact, though without technical competence in the other agencies the problem of finding a balance to DOD is more difficult, the NSC could serve to some degree in their absence. However, if NSC lacks a technical capability, either of its own or associated with it in a separate Executive Office/White House entity, the President and his Special Assistant for National Security Affairs will find it difficult or impossible to arrive at an alternative course of action to that presented by Defense except by using intuitive or purely political

grounds. That would be and perhaps now is a most serious defect in the National Security policy structure.

It can be argued that it is possible for both the NSC staff and the OMB staff to include scientific specialists of their own. Such an arrangement would be better than having no identifiable scientific and engineering capability at all in the White House. But putting it that way immediately exposes a defect. With each having one, which technical input would be the authoritative one? Furthermore, recent experience suggests that if scientific and technical inputs are filtered through an organization whose purpose is other than that of giving a scientific or technical view or assessment, strange things can happen. The scientific evaluation of some question can easily end up being made by a political scientist or economist who once knew a scientist or took freshman physics. Overall decisions need to be made by generalists, and there are many generalists (including, fortunately, a number of political leaders) who can understand authoritative technical advice and weigh it against other components.

The experience in the late 1950's and the 1960's was that BOB and NSC relied on the staff of the OST. The Budget Director, the National Security Advisor, and the President himself relied on the President's Science Advisor for technical inputs of some objectivity to provide them with options to the courses of actions suggested by the various departments of the government involved in national security (DOD, CIA, State, ACDA, etc.). In principle that is probably the best system. Of course, the system will not work optimally if the President is not interested in the advice of his Scientific Advisor. It will work still worse if that attitude is shared by the Director of OMB and by the Special Assistant for National Security Affairs. But under those circumstances, not much can be done by way of structural change to improve the situation within the Executive Branch.

To summarize, given willingness of the President and of his principal National Security and Budget/Economic Advisors to seek alternative options and hear alternative evaluations (and the President can assure that this is true for the others if it is sufficiently true for him), the White House

structure needs a way of obtaining balancing views from various agencies with their own vested interests. Still more does it need relatively unbiased views from within the Executive Office. These views, particularly in both the program and policy areas of national security, must be soundly based technically. This is so in evaluating present policies and determining future ones, in considering expensive weapons systems with strong even if unseen policy implications, and in being alert to new technological developments that can alter the national security picture. It is hard to see how this can be done without a strong technically oriented presence in the Executive Office. Organizationally, it seems most sensible to have it be a separate entity.

The above description provides a framework for the analogous issues that arise in areas whose focus is principally domestic, and for which the organization in the Executive Branch, and in the Office of the President, is not so clear as it is for National Security. These include such matters as energy, food, and health. Though food might be thought to be comprised within the Department of Agriculture and health within the Department of Health,

Education and Welfare, clearly there are other interests involved. Consumers also have an interest in food, and the malpractice question shows that lawyers as well as physicians and patients are concerned with health (which has usually been too narrowly defined in any event). In these areas, the Domestic Council, of which the Director of OSTP is made a member by recent legislation, presumably plays a centrol role, though that Council has not yet shown a stature comparable to that of the NSC.

The Science Advisor may be in the best position, in some of these cases, to pull together for the President the various aspects of an issue that crosses the boundaries between domestic agencies or between domestic and National Security agencies. An example is the effect of promotion of the domestic nuclear industry, which might have beneficial effects in producing energy domestically at a more acceptable cost, on the likelihood of proliferation of nuclear weapons to additional countries. Another example is the effect of advanced technology on increased productivity, and possible effect of both together on the number of available jobs. A third would be the prediction of climatic change and its effect on food production. Obviously, some of these

examinations might well be assigned to other components of the Executive Office of the President. But the Science Advisor has in the past often produced for the President's consideration useful policy alternatives to those suggested by the line agencies. On occasion, agency heads have wished to avail themselves of such advice from outside of their own departments. The Science Advisor has in the past had a particular ability to call upon advice from a wide variety of experts from outside the government. These individuals, some from academic, some from other nonprofit, some from business and industrial organizations have brought a diversity of viewpoints not easily found in the hierarchic and bureaucratic structure of government. This value bears on the issue of the size and organization of such an office in the Executive Office of the President. Twenty-five or thirty professional people of high quality, who have ideas of their own but who devote more than half of their time to working with panels of such outside experts have in the past proven to be an effective staff in terms of numbers and in function. During the recent consideration of the question by Congress, arguments were made for a much smaller organization which would work principally through the line agencies,

and for a larger organization to take on additional functions. The former risks losing the ability to get inputs from outside of the government, the latter has the potential advantage (but also the disadvantages) of providing a greater degree of centralized control, as well as the disadvantage of the bureaucratization within the office itself that would go with a larger size.

A President who himself has a technical background may be in less need of such an advisor, since he himself will look at these problems at least in part from a technological viewpoint. On the other hand, such a President would probably profit more from that advice, because he is better able to understand it and its implications. Increasingly the problems that a President will face will cut across the divisions between domestic and foreign policy, and across the various departments and agencies of the government. The most important of them will have national security implications, economic and social implications, domestic and political implications, legal implications. Just as it is wise to have economic, political and legal advice on these broad questions, so it is wise to have technical advice. Depending

upon the particular problem, it will be desirable to assign the staff action of producing alternatives and making recommendations on such issues to one or another of the advisors, depending upon the content of the problem, the President's perception of it, and his relationship with the individuals in question.

A summary of the place of a Science and Technology Advisor to the President in the Executive Office of the President is as follows. If the President is to have only three or four people in the White House report directly to him, it would probably be unreasonable to expect one of them to be a scientist or engineer by training. If the President has as many as eight or ten such advisors, it would be wise for one of them to meet that criterion.

The purposes of an Assistant to the President for Science and Technology have included: to give advice to the President from the scientific and technological point of view on issues not wholly or even primarily technical (such as the deployment of an anti-ballistic missile, the prospect during

the 1960's of an energy shortage during the 1970's, the effect of pesticides on the human health); the state of health of the scientific and technical enterprise, the best methods of improving it, and the costs, monetary and otherwise thereof; examining the overall research and development budget of the Federal Government, including agencies whose principal function is scientific or technological, or whose principal expenditures are on science and technology, as well as agencies which have a broader function of which support of scientific and technological activities or of research and development is a component. Because the Office has been (and should be) small, the specific issues examined by the head of the Office have been limited in general to those that had high public visibility, seemed to him and his staff to have important long-term effects, involved substantial commitments of money and trained personnel, or held particular interest for some senior government official, particularly the President himself; to advise on scientific and technological considerations with regard to Federal budgets and to assist throughout the budget development process.

A number of other functions have been suggested and at times included in the functions of the Director of the Office of Science and Technology/Special Assistant to the President for Science and Technology. These include: functioning as an advocate for the scientific and technological community, its programs and its well being, within the Executive Office; coordinating and assisting the President in general leadership of the research and development programs of the Federal Government; aiding other levels of government in identifying and defining problems whose resolution may be assisted by science, engineering and technology.

Of the functions mentioned in the previous paragraph, the first has often been mentioned by individuals in the scientific and technical community as the principal one for the Special Assistant for Science and Technology. Indeed, this may necessarily seem to be so to that constituency. On the other hand to make that a substantial part of the role of the Special Assistant is to make him almost useless to the President in any of the other, more important, roles indicated particularly in the first paragraph of this listing.

Of course, the Special Assistant for Science and Technology is likely to be aware of the special needs of that segment of American life. He should be aware of, and press, the abilities of science and technology to help solve national problems. But at the same time he needs to be aware of their limitations in providing such solutions to problems which are at least as much political, social, andeconomic as they are technical. His function is to assist the President; he should no more represent the needs of scientists and technologists than the Chairman of the Council of Economic Advisors should represent the professional welfare of economists. The other two functions mentioned in the preceding paragraph have at various times been formalized by the chairmanship of the Federal Council on Science and Technology (in the recent "National Science and Technology Policy, Organization, and Priorities Act of 1976," the "Federal Coordinating Council for Science, Engineering, and Technology" and, in that same Act, through the Inter-Governmental Science, Engineering, and Technology Advisory Panel." Most of those with experience in the Federal Government would probably

agree that these functions are subsidiary. Past Special Assistants for Science and Technology have made considerable, though not always successful, efforts to delegate such functions.

Key issues in the functioning of past Special Assistants and Directors of the Office of Science and Technology have been the relationship with the Office of the Special Assistant for National Security Affairs (and with the Defense and State Departments) and with the Office of Management and Budget. Of the questions discussed in this connection above, the most important are probably participation in the formulation of policy and program decisions, and in budget hearings by OMB, of the Director of OSTP or his staff. Similar questions arise with respect to the Domestic Council and corresponding domestic questions.

With respect to the line agencies, it has been suggested that their R&D budgets be "authorized" by the Director of OSTP. This would involve an examination for technical validity and implications prior to or in parallel with the financial examination by OMB. By analogy, negative decisions could

be overturned only by a successful appeal to the President by the agency head. But such a situation implies a substantially larger OSTP staff than now contemplated.

Since the 1973 demise of the OST, Congress has set up an Office of Technology Assessment to advise its committees on various matters; the OTA's record of success has been mixed. With different responsibilities, different kinds of organizations, and responsive to different kinds of political entities (executive and legislative), the relations between OSTP and OTA will need to be worked out.

The recent legislation set up within the Executive Office of the President a President's Committee on Science and Technology, including the Director of the Office of Science and Technology Policy as a member but not necessarily as Chairman. In fact, President Ford has named as Chairman of the Committee, Dr. Simon Ramo, while Dr. Guy Stever, formerly Director of the National Science Foundation has been appointed as Director of the Office of Science and Technology Policy.

The Committee is charged with examining and analyzing the overall content of the Federal science, engineering, and technology effort and organization, with issuing an interim report within 12 and a final report within 24 months, following which the Committee shall go out of business in 90 days unless the President before that time determines that it is advantageous for the committee to continue in being. A new Administration would have to make a determination on the relationship to OSTP of such a committee, and the detailed nature of its studies.

What needs to be done during the next six months?

Legislation establishing an OSTP (plus a Panel, a Council and a Committee) was passed by Congress in April, after a year of House-Senate-White House negotiation. In July, President Ford named the Director of OSTP and the Committee Chairman, but not the (four authorized) Associate Directors of OSTP or the other panel members. Clearly, this is a holding action.

A new President will have to:

a. decide whether to work with the existing legislation (which contains some nuisances, but gives fairly wide discretion) or introduce changes.

b. appoint (if he decides he wants one) a Director of OSTP and associate directors.

c. decide how OSTP should participate in the formulation of the revisions of the FY 1978 budget.

d. decide what relation OSTP will have with other White House offices.

e. decide how OSTP will function with respect to line agencies. The first signal would be the participation of OSTP Director in the staffing of technical positions in those agencies.

f. decide what he wants the President's Committee on Science and Technology to do (including studies of government organization of S and T, and various long-range plans) and what relation it should have to the Director of OSTP.

g. decide which, if any, interagency questions should become the staff responsibility of the Director of OSTP.

August 23, 1976

This paper, prepared after extended consultation by Prof. Raymond Bowers, as approach to the one issue of greatest concern to university scientists and others engaged in research - the federal stewardship of the nation's basic research resources.

A frank discussion of financial limitations and of responsibilities of the scientific community is envisioned.

A speech to an academic or research audience, well covered by the technical press, could produce a favorable contrast to Ford's weak position. In such a speech the economic issues (see paper on this topic) should also be covered.

Also attached is an excellent paper by Prof. Helen Whitely. One point is controversial: reorganization of federal R & D agencies into a Department of Science and Health.

Further attached is a related paper by Aaron Gellman.

Attached: Bowers paper

Whiteley paper

Gellman paper

August 24, 1976

Raymond Bowers
109 Hanshaw Road
Ithaca, New York 14850
607-272-6794

MEMORANDUM

TO: M. Michaelis, C. Shepherd, S. Eizenstat

FROM: R. Bowers Raymond Bowers
cc: L. Branscomb

SUBJECT: Position Paper On Support of Basic Research

Lewis Branscomb asked me to send you a copy of the enclosed position paper.

Some of the ideas in the paper resulted from a conversation I had with H. Bethe but he has not reviewed the final draft. F. Long reviewed an earlier draft. I want to acknowledge their help but you should not assume they are in agreement with all points made in the final Draft.

The present document could be improved by further work. I would be glad to refine it if you feel it would be useful. However, I feel it is adequate to stimulate your first reaction.

August 24, 1976

Raymond Bowers
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607-272-6794 (home)
607-256-3810 (office)

Position Paper On Support of Basic Scientific Research Prepared For The Carter Campaign

Governor Carter should issue a statement to the press or give a speech concerning his attitudes to the scientific enterprise in the United States. This position paper suggests some of the substantive points that should be made and also includes some language that might be used in public statements.

I. Basic Position

The United States must maintain a position of leadership in scientific research and steps must be taken to terminate the erosion of that position which has occurred in the past two administrations.

He knows from first hand experience with nuclear energy how much the future of the country depends on a vital and productive research base.

The highest level of research and the production of highly trained people to occupy critical positions in the private and public sectors will be necessary as the nation deals with major problems in the areas of:

Economic Growth
Supply of Food and Materials
Preservation of the Environment
New Sources of Energy
Quality of Health Care
National Defense

To neglect these areas is to ensure that the quality of life in the U.S. will deteriorate; to invest inadequately in research will also threaten our competitive position with respect to other advanced industrial societies.

II. The Federal Responsibility for Basic Research

Most of the nations' research and development is and should be applied, directed to solving specific problems relevant to our national needs. But this applied research and development draws on a reservoir of scientific knowledge which is supplied by basic research in the physical, biological and social sciences. Such research, whether on the structure of the nucleus, the genetic code or the mechanisms of visual perception is at the core of our scientific enterprise. It is valuable not only for its foreseeable applicability to national problems but also for its potential to make revolutionary and unforeseen discoveries. Nuclear fission, the transistor, penicillin and even the thermos bottle were products of the basic research laboratory.

The National investment, federal and private, in basic research is only 13% of the total expenditures on research and development (38 billion in 1976). But it is a vital 13%, providing much of the fuel for the larger technical enterprise. Federal funds for basic research account for less than 10% of these total expenditures.

The involvement of the Federal Government on a major scale in the support of basic research resulted from the lessons we learned in World War II. The knowledge that results from such research is public knowledge to benefit all of our people; that is why the government must support it. Much of the basic research is conducted in Universities providing them with an important means for contributing to the solution of national problems, as well as contributing to their educational goals.

III. The Problems

The past two administrations have dissipated the morale and sense of purpose that characterized the scientific research community in the sixties. They did this by:

1) An excessive emphasis on short term returns from

scientific research. It is very questionable whether these policies increased short term returns; it is certain that the policies have discouraged important research of a long term character.

2) Abolition of the Office of the Science Advisor to the President, which closed an important avenue for the contributions of scientists to national policy formulation.

3) Reducing the effective level of federal investment in basic research. If the funds are expressed in constant 1967 dollars so as to take into account inflation, the federal investment dropped from a peak of 2.2 billion in 1968 to 1.9 billion in 1974. Total Federal R&D investment dropped from 1.7% of the GNP in 1968 to 1.2% in 1974. For 1976, the investment remains near 1.2% of the GNP. It is ironic that these changes occured at a time when the importance of R&D intensive products to our balance of payments was increasing substantially.

Among the consequences were:

1) Growing conviction in the scientific community that the federal government was losing interest in support of research.

2) Severe budgetary problems in a number of areas, e.g. engineering sciences, physical sciences and mathematics, leading to reduction of productive programs.

3) Substantial discouragement of talented young people wishing to become scientists. Their loss is serious because they are necessary for the renewal of the enterprise.

4) Many young scientists were forced to accept employment in situations where the country could not benefit from their skills.

5) New scientific initiatives were stifled because prospects for new programs seemed very unfavorable.

6) The growth of a dangerous conservatism in the conduct of research programs.

IV. What Needs To Be Done

Improvement in the situation will require efforts on the

part of the Federal Government and the scientific community. Neither can solve the problems alone. A new partnership is necessary and it is feasible. Increased expenditures may be necessary in some areas even recognizing that investment in science must compete with other national needs. The policies must be oriented to the long term; moderate but stable growth in funding will be more effective than short term major increases.

a) What the Administration Should Do:

1) Express its commitment to a long term view of federal support of basic research.

2) Provide stability to the funding with a moderate growth rate in line with the growth of the over-all economy.

3) Except in cases of national emergency, avoid crash programs or even programs with high rates of growth that can not be sustained. They are wasteful of human and financial resources.

4) The Science Advisor to the President should be charged to review the mechanisms and proceedures for support of basic science, most of which have their origins in the post World War II period, and make recommendations for bringing them in line with current conditions. Since much analysis of these problems has already been undertaken, it is feasible that the Science Advisor could make a report within a 6 month period.

5) Adopt policies which will provide an appropriate balance between sustaining existing institutions of the highest quality and the development of new centers of research based on innovative proposals.

6) Direct mission oriented agencies to support programs of basic research relevant to their mission. By this means, diversify the sources of support for basic science and stimulate contact between those doing basic research and those responsible for applied projects in the agencies.

b) What the Scientific Community Should Do:

1) Develop criteria and procedures for establishing research priorities, since not all deserving projects can be supported. Similarly, develop criteria for the termination of research projects which are no longer productive.

2) In conjunction with federal agencies, devise means to avoid overproduction of trained manpower in areas where the subsequent employment situation looks unfavorable.

3) Achieve greater efficiency in the performance of research through the use of shared resources and equipment.

V. Concluding Comments

The deterioration in the relationship between the Federal Government and the scientific community can be stopped. It should be replaced by a new sense of shared objectives. If the new administration demonstrates its understanding of the importance and long term character of research and provides a climate of stability and modest growth, the scientific community can be expected to respond by devising improved procedures to ensure that public money is well spent. Support for scientific research ultimately depends on public confidence. The scientific community is not exempt from accountability.

The United States must have a vital and dynamic research enterprise. Science is now fundamental to American Society--it is part of our culture. The new administration will have the opportunity to restore the positive and constructive relationship that existed between the government and the scientific community more than a decade ago. The opportunity must not be lost. If eight years of drift and mistrust can be replaced by several years of purposeful leadership and mutual confidence, the scientific community can once again become one of the most productive elements in American Society.

Appendix

Basic Research

(from Science Indicators 1974; Report of the National Science Board,

INDICATOR HIGHLIGHTS

- The Nation's total expenditures for basic research rose continually during the 1960-74 period in current dollars; in constant 1967 dollars, funds for basic research in 1974 were equal to the 1965 level, and almost 13 percent lower than the peak year of 1968.

- Universities accounted for approximately 55 percent of the Nation's total expenditures for basic research in 1974 (versus 37 percent in 1960), followed by the Federal Government and private industry at some 15 percent each, and other sectors with the remainder.

- The Federal Government provided the largest share of support for basic research during the 1960-74 period, increasing from nearly 60 percent of all such funds in 1960 to almost 70 percent in 1974; industry's share declined from 28 percent in 1960 to 15 percent in 1974, and the universities' share increased from 6 to 11 percent over this period.

- Funds provided by the Federal Government for basic research increased each year (except for 1971) in current dollars, but declined 13 percent between 1968 and 1974 in constant dollars; the largest reductions in constant dollars were recorded in the physical sciences which declined approximately 25 percent between 1969 and 1974.

- University expenditures for basic research (from all sources of support) rose continuously in current dollars between 1960-74, but declined some 5 percent in constant dollars between 1968 and 1974; this decline is due to reduced growth of Federal support in combination with inflation.

- Basic research expenditures by academic institutions in 1974 were concentrated in the life sciences (51 percent of all expenditures), engineering (12 percent), physical sciences (13 percent), social sciences (8 percent), and the environmental sciences (7 percent).

- Federal support for basic research in universities, which accounted for 70 percent of all such funds in 1974, increased in current dollars between 1964-74 in the broad fields of science and engineering; the level of research effort as reflected by constant dollar expenditures, however, was lower in each field in 1974 than in previous years, with the largest reductions occurring in engineering and the physical sciences.

- Federal support for universities in 1974 was provided primarily through six agencies—NSF, HEW, DOD, USDA, AEC, and NASA—with no more than two agencies supplying at least 70 percent of all Federal basic research support in each major field of science; the NSF provided either the largest or second largest amount of funding among these agencies in each field.

- Expenditures for basic research per scientist and engineer in doctorate-granting institutions were almost 30 percent lower in constant dollars in 1974 than in 1968; the largest decline was in physics, where reductions were nearly 40 percent from 1966 to 1974.

- Federal laboratories accounted for 16 percent of the total national expenditures for basic research in 1974; current dollar expenditures by these laboratories increased throughout most of the 1960-74 period, but the level of research effort in terms of constant dollars was some 20 percent lower in 1974 than in 1970, the year of highest real expenditures.

- Private industry was responsible for 16 percent of the total national expenditures for basic research in 1974; although current dollar expenditures have risen, particularly since 1972, inflation reduced real expen-

ditures in 1974 to approximately the same level as 1961.

- The number of research publications from major fields of science increased generally throughout the 1960's, but leveled off in several fields in the early 1970's; publication output in chemistry, engineering, and physics, for example, has remained at a nearly constant level in recent years.
- Universities are by far the largest producers of published research reports with some 75 percent of the total in 1973, followed by the Federal Government and private industry with approximately 10 percent each, and other nonprofit institutions with 5 percent.
- Basic research contributes increasingly to technological innovation, as reflected by the growing number of citations to research in patents associated with major advances in technology; the frequency of such citations increased 17 percent between the 1950's and 1960's, while citations to other patents declined by almost 25 percent.
- Research performed in universities is most frequently cited as the origin of patented technological advances, accounting for almost 55 percent of the cited research in recent years and replacing industry as the prime sector in which such research is performed.

Basic research is the quest for fundamental understanding of man and nature, in terms of scientific observations, concepts, and theories. Such research is generally motivated by curiosity and the desire to advance scientific knowledge, with the opportunities for its advancement determined primarily by the existing state of scientific understanding itself, rather than by practical need or potential application. As an activity, this research ranges om efforts of teams of scientists working with rge facilities such as particle accelerators to the efforts of individual scientists using little or no research equipment. And basic research, being international in its nature, joins the activities of scientists from many countries.[1]

Although curiosity is frequently the prime motive of the individual scientist for performing research, potential applications often underlie the private and public support of basic research. There is as yet, however, no method for correlating the cost of such research with its total returns—intellectual, economic, and social. But the many and varied uses of basic research suggest that the benefits may be substantial, particularly in comparison with the relatively small investment involved. The findings of basic research represent much of the objective knowledge of the physical and social world which forms a major part of the educational curriculum of the general population, while both the results and the conduct of such research constitute the core of advanced education in the sciences and engineering. Basic research provides the fundamental knowledge on which modern technology increasingly depends. This research, in addition, supplies indispensable knowledge for planning and directing the rest of the R&D effort. Finally, the maintenance of a wide spectrum of basic research can provide the new knowledge needed for responding to challenges in the future—challenges which may not be foreseen at present.

Indicators of the state of basic research presented in this chapter consist largely of the financial resources committed to research and preliminary measures of outputs and their application in industrial technology. The "input" indicators provide information on national expenditures for basic research, the extent of research performed in universities and other sectors, and trends in expenditures for basic research in the various fields of science. "Output" indicators include publications of scientific research produced by different sectors in major fields of science, and measures of the extent to which such research underlies advances in technology.

The present set of indicators are deficient in a number of major aspects. They do not encompass substantive aspects of basic research, such as advances in knowledge achieved in the various scientific disciplines. The indicators, further-

[1] For further discussion of international aspects of science, see the chapter entitled, "International Indicators of Science and Technology" in this report.

Sept. 7, 1976

Dr. Lewis Branscomb
5 Hidden Oak Lane
Armonk, New York, 10504

Dear Dr. Branscomb:

The enclosed represents a first draft of a paper on the four main issues in scienc policy which should be considered by Gov. Carter either during the election or very soon after the election, assuming that he is elected.

The four issues listed on the first page represent not only my personal view but are the top four issues proposed by the Public Affairs Committees of three major biological societies: the American Society for Microbiology with 28,000 members, the Federation of American Societies for Experimental Biology with 15,000 members and the American Institute of Biological Sciences with 12,000 members. I was not able to get hold of Dr. Bowers to discuss these issues with him. I did talk to Dr. David Baltimore and he agrees that these are major science policy issues which should be considered by Gov. Carter.

The text that begins on page 2 expresses my own views and should not be attributed to the three societies named above. It is written entirely from the point of view of a biologist and/or a biomedical scientist since that is my area of expertise. It addresses several of the topics you listed as "Ten Issues in Science Policy" and may be of some help on topic #1 (The role of OSTP), #7 (Basic Research and Academic Science) or #10 (Reorganization of federal Science R and D Agencies). I apologize for sending this to you in a less polished state than I would like. We are leaving for Europe tomorrow and it seemed better to send it as is rather than to wait until our return October 1st. If I can be of any help after that date, please let me know.

Sincerely yours,

H R Whiteley

H. R. Whiteley
Professor
Department of Microbiology
University of Washington
Seattle, Washington, 98195

Major Science Policy Issues

1. Advances in science and technology affect many of the nation's major problems: the economy, agriculture, health, environment, energy, education and even defense and international affairs. The major need is to establish a system to identify the long range needs of the US and determine priorities so that the science aspects of these needs can be met by the scientific community.

2. In almost all fields, the successful solutions of our present and future problems will depend on the acquisition of new knowledge and our ability to apply this new knowledge rapidly. It is essential to develop a system which will assure the continuity of funding for basic research and to improve the dissemination of new information to permit its rapid application.

3. Coupled to the evaluation of long range needs and the support of basic research, there must be continued training of essential personnel.

4. Almost all of the departments in the federal government have agencies involved in research and development that involve some aspects of science. The organization of science in the federal government must be improved for more efficient operation and to provide advice to the executive and legislation branches of government. Biomedical and life scientists should be included in advisory panels recommending national priorities and evaluating technological progress.

1. Identifying priorities

Biomedical and life scientists list the need for a mechanism to establish priorities as the most important science policy issue. They realize that not all the problems that involve science and scientists can be given unlimited attention and support simultaneously. Budgetary restrictions, a shortage of trained personnel and, most important, lack of knowledge in many fields will require that choices be made among many highly important problems.

In terms of the US needs and in terms of the coming campaign, it is most important to emphasize the need for long range planning as opposed to the present approach which is either total neglect or haphazard, constantly changing, and often conflicting, sets of goals. Policy decisions should result from orderly and planned consideration of issues; they should not be made by the OBM on the basis of short term considerations, or by the federal science establishment acting alone or by disorganized, piece-meal legislation.

The question of how priorities can be determined impinges on the problem of the organization of science in the federal government (section 4). Important decisions of this type should not be made by political appointees but should involve both the lay public and especially the scientists who know the problems. With the establishment of the OSTP, Gov. Carter should propose the creation of several panels, each headed by a member of an adivsory committee to the OSTP. For example, the panel to consider priorities in biomedical fields should be headed by a distinguished biomedical scientist who is a long-term member of the advisory committee. Similarly, problems of of pollution should be addressed by a panel headed by a biologist who is a member of the advisory committee, etc. The panels themselves should consist of emminent scientists and distinguished laymen (hopefully, Gov. Carter will not be tempted to appoint popular entertainers to such panels). Each panel would work to develop priorities for several years to come (5 years?), and the work of the many panels would be coordinated and put into broad perspective by the advisory committee. The recommendations of the advisory committee would go to the head of OSTP and then to the President who could then initiate programs and legislation.

2. Support of research and the application of research findings in ways which will better serve the public.

The public and Congress (especially Senator Proxmire) have a poor understanding of the value of scientific research and the role it plays in the cultural and intellectual life of the nation, in health, agriculture, economy, education, etc. Gov. Carter should pledge himself to support the nation's research programs to provide a continuing flow of new information and a rapid dissemination of this new information to improve all facets of our national life.

A. Basic research

In the past, the medical and biological research programs of the US were the best in the world. Most of the major discoveries in these fields in the last 30 years have come from the US, as evidenced by the Nobel prizes awarded to American scientists. Today, our research programs can still be considered good but they are suffering from the stop-and-go funding of the Nixon-Ford administration and the effects of inflation. The uncertainty about the level of funding and the decrease in funding from the major federal granting agencies has had serious consequences: valuable research has been interrupted and sometimes suspended, much time is lost in futile applications for funds and most significant, the young scientists who will be leading our research efforts in the future often cannot get funds at all. Since the funds are limited, the tendency is to support already successful investigators, i.e., the more senior research scientists.

An additional factor is that increasing charges for over-head are levied against all research programs by the institutions where the research is performed. There are many justifications for such charges and they probably should be continued but they now account for a large percentage (20-40%) of every research grant. These charges should be clearly identified as administrative costs and separated from funds allocated to research. Perhaps academic institutions could make a single application for the administration of all research grants within that institution. Such charges constitute support of educational facilities. This is surely needed but not at the expense of already dwindling research monies.

Biomedical and life scientists would welcome a higher level of support of basic research but what they desperately need is a constant level of funding. Knowledge is accumulated over many years of effort. Significant scientific advances often are based on discoveries made many years earlier and often in unrelated fields. Thus, a sustained program of research is essential. Most nations devote a higher percentage of their total R and D dollars to basic research than we do. Gov. Carter should publicize the advantages of a strong continuing program of basic research and recommend that a constant percentage (10%?) of the total R and D funds be allocated for this purpose.

The economic justification for strong basic research is readily apparent. In the biomedical field, the advances made in the past 20 years have saved thousands of lives and spared thousands of people great pain. While the value of a human life cannot be expressed in dollars, the saving in hospital care and income losses can be. It has been calculated that eradication of just one disease--polio--saves the US $6 billion annually. Similarly, the new knowledge gained in the past few years on measles, hemolytic diseases of the newborn, hepatitis and kidney transplantation saves the US $3.3 billion per year. The research that is making this possible is estimated to cost only $33 million per year. At a time when health care costs are escalating, these figures take on additional significance. No matter how you look at it--the money spent on basic biomedical research is one of the best investments that the US taxpayer can make.

The best and most efficient means of achieving high quality basic research is through investigator-instituted research grants. Peer review should continue as the sole means of determining merit. Distribution of funds on the basis of political or geographical considerations is wasteful. It is better to have fewer excellent centers of knowledge than many mediocre ones--peer review serves to monitor excellence. Contract research should be severely curtailed, especially by research corporations operating for profit. This, too, is wasteful since there are scientists in academic institutions capable of doing the same research without charging profit. The funds spent on biomedical research through academic institutions are accounted for meticulously. Thinking especially about the fraud which apparently accompanies Medicaid-Medicare, the taxpayer should be assured that research funds awarded the individual investigators are surely the most carefully spent monies dispersed by the federal government.

"Conquering" a specific disease by crash programs is a poor investment. Nixon's separation of the National Cancer Institute from the NIH and the allocation of large funds to this Institute has not resulted in the conquest of cancer. It has led to false hopes, tremendous shifts in the emphasis of training of scientists and has curtailed important research in other areas, some of which are vital to an understanding of cancer. Some good work has been done under the sponsorship of this Institute, but the same results could have been achieved at far less cost if this huge program had not been started.

B. Applied research and the practical use of new knowledge

Most of the funds allocated to science generally are devoted to the application of basic research. Understandably, applied research receives heavy support from industry and all departments of the federal government. There is, however, considerable confusion in Congress and in the public's mind about the differences between basic and applied research and between research and the delivery of the results of such research as health care, environmental protection, etc. The misunderstanding is so great that a good case could be made for proposing that funding be clearly identified as either for basic or for applied research. Funds allocated for health care delivery programs or environmental protection should not be included with funds for research. At the present time, Senator Kennedy is attacking the biomedical community, claiming that new knowledge has not been applied to health care. The fault is not in the basic research but in the transfer of information and its application. Sen. Kennedy's solution is to cut funds for basic research. This will not yield better health care and it will surely cause serious interruptions in vital programs.

At the present time, the transfer of new knowledge, its application and its ultimate delivery to the public as better health care, environmental protection, more productivity in agriculture, new products, etc. is haphazard. Science and technology encompass such large segments of the economy and are so complex that this is inevitable. Often there is a large time lag between the discovery of some extremely useful principle and its application. Solutions to this problem will be difficult and will depend on the disciplines

in question. Gov. Carter should pledge that every effort will be made to develop systems for the more rapid transfer of new knowledge and its application. He should caution, however, that not all new information can be translated into practical use and that some information can only be used after a long delay. OK

In biology, medicine and other "pure sciences", the scientists themselves could be asked to note the possible practical applications of their work. Each investigator receiving federal funds for the support of either basic or applied research could evaluate his own work for its potential practical applications. These ideas could be made available as a yearly or biannual summary to all branches of the federal research establishment (and to industry and private agencies?) to alert scientists in other disciplines that new methods, procedures, etc. might be applied to their problems. A more feasible approach would be to have each federal agency select areas for practical testing and application. The latter would have to be a combined effort by industry, private and federal agencies. An important point is that if there are difficulties in converting basic research to practical application, that more effort be put into finding ways to achieve the application rather than stopping the basic research. As stated above, the testing and application aspects should not be funded by monies earmarked for basic research. The selection of areas needing greater effort in practical application would depend on the priorities set by the advisory committee to the OSTP (section 1 and 4) and by progress made in the selected areas. Greater cooperation with industry and the private sector is essential since federal agencies should not take over functions of the private sector.

3. Training of biomedical and life scientists

An adequate supply of scientists is important to the nation's well being since the US depends on the continued discovery of new knowledge and its use. At the present time, manpower needs are analyzed by the National Academy of Sciences. However, this analysis ignores scientists below the doctoral level although such personnel perform valuable research and service activities and also serve as the pool supplying the future doctoral trainees. Manpower surveys are essential but they should include the total population of scientists.

Long-range planning for training programs is essential to ensure the proper number of well-trained scientists both for research and for service. Long-range planning should be undertaken promptly with projections of needs for 10 years, if possible.

The stop-and-go support of training programs and the constantly diminishing levels of support of such programs during the Nixon-Ford administration have been highly disruptive. Because of the complexity of science today, students in biomedical and biological disciplines spend 6-8 hears in graduate and postdoctoral training, largely to gain competency in research. Thus, training programs and research programs are closely inter-related. Young scientists who were trained earlier now have difficulties finding jobs

because of the drastically curtailed training programs and research opportunities. When they find jobs, they cannot obtain research grants. Consequently, many are turning to other fields. This is a waste of the nation's talent; it is also poor economics since it creates a gap in the flow of trained personnel which we will need in the future.

Training in biomedical fields can best be administered through the NIH and biology through the NSF. Training funds should be allocated separately and should not be created by converting monies allocated for research. The distribution of funds between predoctoral and postdoctoral training and the disciplines which will need particular support should be coordinated with the priorities set by the OSTP and with the support of basic research.

4. Reorganization of science

The present lack of organization has evolved over many years of adding independent agencies created to take care of specific needs. Gov. Carter should recommend a thorough review and amalgamation of most of the science agencies in a single Department of Science and Health. The health component of HEW is sufficiently large by itself to merit creation of a separate department. The addition of other independent science agencies would permit complete reorganization, condensation and grouping of these many independent units in a single department. This should result in much greater efficiency and more important, more coherent policy making.

The new department should include the NIH, NSF, ERDA and many independent agencies but hopefully would not include weapons research, purely social or educational agencies. The non-medical sciences such as biology, chemistry, physics, geology, oceanography and meterology should all be grouped under a revitalized, strengthened National Science Foundation which would represent the Science segment of the new department. The organization of the biomedical disciplines would be strengthened by reinstating the National Cancer Institute within the NIH. The alcohol, Drug Abuse, Mental Health Administration should also be under the NIH which would, in effect, govern the Health portion of the new department. Each of these two large strong branches should be represented by assistant directors serving under the head of OSTP; these individuals should also serve on the policy making advisory committee described in section 1. However, even if a new Department of Science and Health is not created, the OSTP should have at least one assistant director representing the biomedical disciplines.

The present system of panels and advisory committees to the NIH, NSF and the National Academy of Sciences should be continued, free of political intervention. Every 5 years, these panels should provide an evaluation of the state of the science that they are concerned with. These panels could also help to identify advances in basic science that are ready for practical application. The evaluations of the panels should go to the OSTP and also to the Office of Technology Assessment (OTA). OTA could have a structure parallel to that of OSTP. Its function should be to evaluate progress, to assist in the transfer of new knowledge to practical use and to advise Congress. The chief role of the OSTP, on the other hand, should be that of policy making and providing advice to the President. The OSTP

could, however, also provide advice to Congress and to the Department of Science and Health. This separation of policy making functions under the OSTP and the evaluating functions under OTA would provide the checks and balances needed to insure proper oversight of the progress of all scientific programs.

Gellman

THE NATURE OF PUBLIC INVESTMENT IN SCIENCE AND TECHNOLOGY

It will be a cardinal principle of science and technology policy in the Carter administration that government will seek to derive every possible measure of public benefit from each dollar of public investment in science and R&D. It follows that government must not--and will not--substitute public capital for private where science and R&D are concerned. Rather, government must strive to use its investments in science and technology to catalyze innovation processes and spur private-sector investment in science and technology, especially in those industries "vested with the public interest" such as transportation, communication, energy, etc.

R&D investment decisions in the private sector are properly made either on the basis of faith, of statistical probability, or on "hard" return-on-investment (ROI) calculations. Sometimes a combination of these is employed. As a manager of a private enterprise moves from the most basic research to the most specific, goal-oriented development activity, the decisions are based less on faith and more on the "hardest" estimates of return. For example, clearly the decision to support basic research, in either the public or private sector, must be based on faith, or at most, on statistical probability calculations which demonstrate there is a positive correlation between basic research undertaken and successful (i.e., beneficial and/or profitable) results in the context of innovation. Therefore, it is entirely rational to support basic research, and even perhaps some applied research, on the strength of the least precise, most circumstantial sort of "evidence."

But as pure research gives way to applied research and to goal-oriented development activities, it becomes more likely that conventional investment decision-making methods can (and will) be employed in the allocation or resources. This is true in the private sector as well as the public sector even though there is often less specific rationalization in the latter than in the former, perhaps due to the organization of government agencies which contrasts sharply with that of private entities where the objective of profit maximization is more easily quantified and where resources are managed explicitly to achieve a single-valued objective.

Especially at the early stages of the process of innovation, where the spotlight is on basic rather than applied research, private sector R&D decisions are very much conditioned by the question "Will the government do it for me if I fail to do it for myself?" In many instances, such as in the field of aviation, there is a long history of government's taking substantial responsibility for <u>at least</u> the basic research and the earliest of applied research activities so that the private sector has come to expect public support for these sorts of R&D almost as a matter of course. In this case, such a policy has paid off for the U. S., given the quite impressive performance of the United States in its use of air transportation and in its exploitation of overseas market opportunities relative to aviation products and services. It is important, however, to examine each industry where public support is an issue to assure that maximum public benefit is realized from each public dollar committed. Moreover, public-sector

participation in or support for R&D must interfere minimally with the private-sector's propensity to finance itself the various stages in the process of innovation, including R&D.

It is not surprising that the further down the development cycle one gets, the more inclined is the private sector to undertake the expenditures necessary to achieve the desired and required results. After all, under present policy, if the government sponsors such development activities, private entrepreneurs are effectively denied the proprietary exclusivity which they correctly prize so highly. And this is as it should be. Indeed, one overriding objective of R&D policy, technology policy, or innovation policy should be to preserve the conditions under which the private sector increasingly bears responsibility for R&D the further one gets from the conception or invention end of the innovation spectrum and the nearer one gets to the marketplace.

It is also important to recognize that R&D investment decision-making in the public sector and in the private sector responds to quite different objective functions. That is, the results being sought through private-sector R&D investment may properly be very different from those sought through public-sector sponsorship of research and related activities. For example, the greatest financial risks in the process of innovation are often found in the earliest stages, including especially basic research. Since private-sector investors rationally abhor risk, it is not unreasonable

that, to the extent the public sector finances activities in support of the process of innovation at all, such support should be heavily concentrated in the high-risk areas such as basic research. Again, given the substantial difference in discount rates between the public sector and private sector, the time horizon for private entrepreneurs is substantially less than that for government. In turn, this makes it rational for the latter to support those activities associated with the process of innovation that have the very longest lead times and which therefore represent relatively unattractive investment outlets for private capital.

Private-sector entrepreneurs are most inclined to make positive R&D investment decisions if such decisions are anticipated to place products or services in the marketplace which can be priced at a very substantial margin above cost. Such a condition obtains only where the value flowing from the product or service is quite substantial in relation to the producer's costs. Increasingly, however, the value flowing from technological innovations in fields such as energy, communications, and transport is generated through external benefits and it becomes difficult, if not impossible, to price an innovation so as to achieve the significant margins required in the first place. Where the external benefits (net of external costs) are great but are very widespread and therefore not capturable by a private-sector entrepreneur, it is appropriate for government to support the research and development which is a sine qua non of innovation. It follows that in support of R&D program development there should be the

constant effort to identify those special cases where the net externalities are positive and widespread and difficult to capture by the entrepreneur.

Carter says he will bring better management to defense and produce savings. He has the personal experience to make this credible. But conservatives answer that liberal democrats sometimes prefer less defense, may question his intentions. To balance this laudable position he should have a parallel approach to HEW programs, which cost more than DOD.

This approach retains an altruistic view of social responsibilities, but introduces a more business-like and scientific approach to testing social programs and learning to manage them.

This is the right way to use social science research in managing major programs. Paper by Eleanor Sheldon, President, Social Science Research Council.

August 31, 1976

Dr. Lewis M. Branscomb
5 Hidden Oak Lane
Armonk, NY 10504

Dear Lew:

In the end, the enclosure was rather hastily put together. Though I did not follow your suggested outline I think that the major points have been covered. Herein some added thoughts:

During the past five to eight years some program proposals have been tested (most notably the negative income tax.) Some of the tests (experiments) were done well (given the state of the art), some poorly. The know-how of experimentation has improved considerably; criticism, both internal and external to the social science community, has sharpened, but the experience has provided an invaluable education. Many social scientists have learned about the difficulties of doing this type of research - which too often in the past failed to provide strong and interpretable results.

There now exists a relatively small group of researchers and policy analysts (Rand, Mathematica, University of Wisconsin, etc.) trained in experimental techniques - a valuable pool of researchers with much empirical and analytical expertise. They are important contributors in raising the level of policy debate.

Experimentation is to be used judiciously (e.g. not a promising technique for approaching short-term or cyclical issues), for less expensive techniques are sometimes adequate.

These addenda may or may not be appropriate for insert in the enclosure.

Sincerely yours,

Sheldon

P.S. An administration should exercise care in not seeming to utilize experimentation as a delaying tactic. Nixon and Congress have been accused of this, particularly with regard to authorizing more experiments rather than instituting a family assistance program based on the major findings of the

Negative Income Tax Experiment in New Jersey and Pennsylvania. Nixon has also been accused of prematurely invoking some findings from an evaluation of Head Start to deprecate or diminish it. For whatever reason, however, the early Nixon administration was supportive of experimentation - perhaps influenced by Moynihan. Some disaffection seems to have set in since, though I have not systematically reviewed its status in the current administration.

By Elinor Sheldon

9. Managing and testing new social programs.

HEW's budget is now larger than that of DOD, which reflects a proper reordering of priorities. However, the social programs of HEW, and the programs of HUD, DOT, the VA and Agriculture - and other agencies intending to provide a better life for Americans are not subject to the kind of careful evaluation and evolutionary development that is most likely to insure their effectiveness.

The social sciences are not without tools to make a much more effective contribution. Recent experience provides some examples of the value of trying out new proposals on a relatively small scale, subject to careful professional measurement, before launching them on a massive scale. Such tests have been - or are being - made for

housing allowances

national health insurance

negative income tax.

The primary purpose of testing new social programs before they are launched on a large scale is to learn how to intervene effectively to ameliorate some social problems - for example, how to intervene in the educational process so as to improve pupils' reading abilities. Considerable resources and energy goes with a wide variety of intervention schemes (social programs), but the task

is not always well-done. Many social programs, in fact, are partial or total failures. Some public housing programs designed to improve the quality of life of lower income families seem to have destroyed the social fabric of many neighborhoods and to have made certain types of crime more likely. Many of the anti-poverty programs of the 1960's failed to achieve their objectives; treatments for convicted criminals have not been particularly successful.

The idea of experimenting to test the effectiveness of a proposed program before launching it on a large scale is attractive for several reasons. It seems a prudent thing to do - to try out a new idea on a scale to see how it works; to "get the bugs out of" a new program or procedure that has not been used before; it is relatively economical. A more important feature of an experimental trial, however, is to put the question of effectiveness in a comparative context - to ask whether a proposed program is more or less effective compared to something else (nothing at all or rival treatments).

The advantages of "prototyping" new social initiatives are several.

1) A trial as a precursor to a national program engages a substantial sample of the public as participants, thereby testing the critical elements in attitudes towards the program and its acceptability.

2) A trial, clearly labeled as such, may fail (many will fail in the sense of not producing a dramatically effective redress to the problem in question) but it is then politically possible to go back to the drawing board. Had such a program been instituted on a nation-wide scale initially the chances of retracing, modifying, or even of acknowledging that the effort had failed, would be rather slim. Investment in a trial experiment is then relatively small.

3) Using experiments in trials as precursors to the development of large national programs may demonstrate more progress in solving social problems. In the past very little has succeeded, and most of our efforts in manpower, poverty and education have failed. Among the reasons for this is that they are very complex and possibly intractable problems; they may not be susceptible to easy solutions. However, another reason for failure in our social program efforts is that they were started not through the systematic development approach, but because some said, "Here's a problem; let's do something; let's spend a half-billion dollars." Whether for political or other reasons almost all the decisions to institute programs and later to expand, reduce, or terminate them are made without an adequate empirical base. We keep failing because we proceed prematurely. Thus, experiments may offer the promise of making headway against our major social problems.

4) Experiments or trials provide a strategy of program development which should result in less waste of scarce national resources by reducing the number of ineffective programs and increasing those of greater effectiveness.

5) Trial runs before nation-wide implementation of social programs provide an opportunity to experience and think through the multitude of administrative and management problems associated with turning an idea into a program. Management systems for program implementation are designed, tested and modified during the course of an experiment, thereby providing a base on which to operate a large scale program. Further, alternative administrative techniques can be tested.

6) The experience of design, research, analysis, implementation and management with one program can often be used in the mounting of another.

7) Successful use of experimental trials might reduce the level of political cynicism in the nation. An approach which might produce more success could result in people being less overwhelmed with a sense of failure about social progress.

There are also serious disadvantages to this approach:

1) The process is time consuming. If there is sufficient concern in the country and in Congress to support

an experiment on a particular problem the public and Congress may not be willing to wait for the results before enacting legislation and launching programs. Furthermore, it is possible that the concerns which initiated the experiment will not persist during the time of the experiment thereby weakening the usefulness of the results for a still-vital problem.

2) There is a lack of confidence on the part of Congress, the bureaucracy, the general public that social science or experimental trials will produce a workable solution - or that the outcome will be worth the wait.

3) Many program administrators and others fear that negative results will be found in the experimental tests. To date, many program evaluations have shown that a given program has not produced an effect thereby threatening the continuation of the program. Better to dispense with the experiment than risk negative results?

4) There are many problems in mounting and conducting the types of research involved in trial of social programs. In addition to the timeliness problem referred to there are legal and ethical issues which must be addressed (informed consent, assignment to treatment, etc.)

* * *

The feasibility of an experimental approach to planning social programs includes factors of costs and time and the political and social consequences of taking too much time to find a dependable answer, or providing money that might be used to operate a program rather than using it to learn whether the program is worth operating. Past experience with the politics of experimentation has varied from the frustration of having results ignored or misunderstood to the threat of having the experiment wiped out or the preliminary results irresponsibly used by journalists or in premature legislative proceedings.

* * *

Research, no matter how pertinent and competent, cannot tell us what national policy ought to be. However, it can provide some hard data on the value of some approaches as compared with others and as such is a useful input into the decision process that must weigh competitive demands for scarce public resources. The political and other difficulties inherent in an experimental approach call for strong leadership from a President who responsibly recognizes that resources are limited and promises must be restrained.

* * *

While this issue is narrow, it is very topical in California, where media has sensitized the population. The administration has tried to duck responsibility for facing up to needed leadership.

For a California speech this material will posture the candidate as farsighted, sensitive to public well being and courageous enough to assert that government does have responsibility.

Professor Frank Press is the expert, is President of the International Geophysical Union, and is perfectly willing to be quoted. He has been widely covered in the media and is well supported by other scientists.

My copy

EARTHQUAKE HAZARD MITIGATION Frank Press

If an earthquake similar to that in 1857 occurred in the Los Angeles region, a reliable estimate of probable losses in Orange and Los Angeles Counties alone are as follows:

40,000 buildings would collapse or be seriously damaged,

3,000 - 12,000 people killed,

12,000 - 48,000 people hospitalized,

90,000 - 360,000 people injured,

15 - 25 billion dollars damage.

Failure of one of the largest dams could leave 100,000 homeless and tens of thousands dead.

There is little doubt in the minds of seismologists that such an earthquake will occur at some time in the future. Other parts of California, Alaska and the western states are similarly vulnerable to great earthquakes. It is not generally known that the earthquake hazard east of the Rocky Mountains is not insignificant. Although these intra plate earthquakes occur less frequently than those in the west, their damage potential is huge. Such great earthquakes have occurred in historical times in the Mississippi Valley (Missouri), Boston and Charleston, South Carolina.

A particularly worrisome phenomenon was discovered this year when it was found that 4,500 square miles of southern California, mostly in Los Angeles County, rose 5 to 10 inches since 1961. The Palmdale Bulge, as it is known, is centered on the San Andreas fault just north of Los Angeles where the 1857 earthquake took place. Destructive earthquakes at San Fernando, California in

1971 and Niigata, Japan in 1964 were preceded by land uplifts of less than 5 inches. Although some earth uplifts have occurred without subsequent earthquakes, the Palmdale Bulge occurring near one of the most dangerous sections of the San Andreas fault is a bad sign. In China and Japan it would trigger a intermediate term warning and a vigorous program of special studies. In recent years there has been rapid progress in our understanding of earthquakes and in our ability to design structures to withstand them. As result of research in China, Japan, the Soviet Union and the U.S., earthquake precursors have been discovered which open up the possibility of earthquake prediction. Indeed the Chinese predicted a great earthquake in February 1975 and western scientists who visited the area estimate that 100,000 lives may have been saved as a result. The Chinese successfully moved people out of their homes a few hours before the shock occurred. The Chinese research program in prediction as well as their procedures for education and preparing the public for earthquake disaster is perhaps the most advanced in the world. Both the Chinese and the Japanese believe in the concept of the "Right to Safety" by which governments would be held responsible for the lack of disaster preparation.

In view of the potential for a disaster exceeding any that has occurred in the history of the country, and the indications that with sufficient research earthquakes can be predicted and structures designed to withstand shocks, it is incomprehensible that the U.S. program has suffered from a lack of support and direction from the Federal goverment in recent years. The research budget is inadequate to achieve the capability of prediction within the next decade, the population is misinformed and unprepared, and local, regional and Federal government officials

wonder who will do what in the case of the major disaster.

Consider the research budget. For the years 1973 through 1976 the U.S. Geological Survey (the lead agency for earthquake prediction) has been level funded in the area of the earthquake hazard mitigation. For 1977, the budget request was down from $11.3 to $10.5 million. The special add-on of $2.4 million was provided for the Palmdale Uplift which places the agency $1.6 million ahead of its FY76 level. Perhaps $3 or $4 million is needed to instrument and analyze the data from the Palmdale Uplift. This means that the USGS will have to cut earthquake studies in other parts of California in order to properly instrument the Palmdale Uplift. Playing musical chairs on the San Andreas fault is inadequate planning. In a recent RFP issued by USGS for earthquake federal research, some $21.5 million of proposals were received from the best university and industrial laboratories in the country. Only $2 million was available to support these proposals. Congress, exasperated by the executive branch's inability to respond to the growing earthquake danger and the new opportunities in the field, is now trying to get some action. The Senate passed unanimously a bill introduced by Senator Cranston which would, for the first time provide adequate funds for earthquake hazard mitigation. The House is considering similar legislation.

If the U.S. could achieve an operating earthquake prediction capability, one which could duplicate the Chinese achievement of last year in providing an alert many years in advance, and a warning a few days to a few hours in advance, the benefits could be enormous. With a warning years in advance, weak structures could be strengthened, public education campaigns could be intensified, emergency plans could be carefully layed out and rehearsed,

disaster relief could be planned and responsibilites assigned. In the final days or hours, nuclear power plants could be turned down, gas lines could be turned off, dam levels could be lowered, people could be evacuated from particularly hazardous sites, workers could be sent home, and food and medical resources could be distributed. Police and firefighting units could be deployed. Casualties could be reduced enormously by these procedures and property damage reduced significantly. None of this will occur unless the Executive Branch's attitude of benign neglect changes to one of accepting the concept that the American people have a "Right to Safety".

Prof. Frank Press
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This excellent paper by G. Low serves as an excellent illustration of an industry in trouble with a technology base dependent on government policies and programs.

He does not discuss alternative financing mechanisms for the government R & D, nor does he address an issue of critical concerns to labor unions in the aerospace industry - coproduction arrangements overseas.

This NASA program could well be expanded at the expense of a stretch-out of the schedule of the space shuttle, whose economic benefits are both more distant and more dubious.

AVIATION -- AN INDUSTRY IN TROUBLE

By George Low

1. Background

- The United States has built the foremost aviation industry in the world. This industry not only provides an excellent transportation system on which every aspect of American business and many individuals depend, but it also represents an important factor in our economy. Eighty-five percent of the free world's aircraft were built in the U.S. Aviation accounts for an annual business volume of $32 billion, provides 1,000,000 jobs, and brings $6 billion to the U.S. yearly in foreign trade.

- This is the result of many factors, including a continuing stream of high technology and innovation; a skilled and competitive industrial base; a steady flow of military development with a resulting spinoff into the civilian market; and, in the past, a regulatory environment which served both the public and the industry well.

- In spite of these past accomplishments, the U.S. aviation industry is now in serious difficulty. Many of our airlines are operating at a loss, and have done so for several years. Aircraft manufacturers are also in financial difficulties, have a very low volume of current orders, and dismal projections for the future.

- This situation results from overly optimistic market growth projections just prior to the recent economic slumps; overbuilding of airplanes and overequipping of airlines based on these projections; and extraordinarily high fuel costs.

- Even though manufacturing and airline efficiency productivity is higher in the U.S. than elsewhere in the world, the current situation causes an ever steepening spiral of failure. New airplanes will only be ordered if they are much more efficient

than previous models. Increases in efficiency demand higher and higher investments in technology and in the associated production know-how. Manufacturers do not now have the money to invest in improved technology; hence, they are unable to offer more productive aircraft, which, in turn, causes airlines to stay with some equipment which is no longer profitable to operate.

- Meanwhile foreign competition is growing rapidly in Government-supported industries. European industries are catching up or surpassing us in medium-sized long-range subsonic transports, have already captured a large share of the helicopter market from us, and, of course, have the only supersonic transport in the Western World.

- Finally, even the most conservative projections show a great need for additional aircraft, amounting to many billions of dollars. However, the U.S. share of that market may be much less than in the past, for reasons just stated.

2. Possible Avenues for Solution

- Reduced to the most elementary principles, aviation economics depend on three factors:

    a. The fare structure
    b. Filling seats on airplanes
    c. Low operating costs

  The first two of these factors have to do largely with regulation, while the third has to do with efficiency and technology.

- Insofar as regulation (or deregulation) is concerned, one needs to decide whether our airlines should be a utility or a competitive industry. Once that decision is made, it should follow how best to regulate the industry -- either more so or less so than now. This is an extremely complex question which needs to be studied in great depth. It will not be addressed further in this paper. But a solution is urgent.

- Low operating costs require efficient airplanes and efficient operations. Insofar as operations are concerned, our airlines compare very favorably with those of the rest of the world. Efficient airplanes require higher and higher technology. As a result of advanced technologies (jet engines, swept wings, new materials, new design concepts, etc.), airline ticket costs decreased year by year until recent rising fuel costs overrode all possible economic gains. Continuing advancements of technology are required to provide increasingly productive (and, hence, competitive) aircraft in the future.

3. Technological Thrusts

- New aircraft developments are expensive. The development cost of a new subsonic transport may be several times the capital worth of the company developing it. The costs of advancing the technology are also very high, generally more than any single manufacturer can afford. Also facilities, such as wind tunnels, needed for technological innovation are expensive. For these reasons the U.S. government has supported much of the aeronautical research and development activity in its own laboratories since 1915 (at first NACA, and now NASA).

- An additional source of technology for civil aircraft has been the development of military aircraft. However, military and civilian design objectives are now diverging (higher, further, faster for military; more efficient, quieter, cleaner, safer for civilian), so that this source of technology is decreasing.

- All of this means that a strong aviation technology program is urgently needed. Some of the elements of this program should:
  - drive those technologies needed for energy efficient subsonic transports. Fuel savings of up to 50% are possible.
  - develop helicopters which are more efficient, somewhat faster, easier to operate, and environmentally more acceptable.

- improve utility aircraft, such as agricultural aircraft, which can provide enormous economic returns.
- do advanced research toward supersonic transport aircraft, so that when the time is right, the U.S. industry can develop an economically viable, quiet, non-polluting supersonic airplane.

- The capability and capacity for these developments exist in the United States today. However, the scope of today's effort is inadequate to meet U.S. needs.

4. Conclusions

- Aviation in the U.S. has, for many years, been an important national asset. It has provided an excellent and essential transportation system, and has been an important factor in our economy. It has led technological developments in other fields. In short, it has been a source of pride for our country.

- For a number of complex and interacting reasons, the aviation industry (airlines as well as manufacturers) is in extremely serious financial difficulties.

- There would appear to be only two solutions: nationalizing the industry, or providing the proper environment for the industry to save itself. Only the latter course is thought to be acceptable.

- The proper environment involves regulatory reform, which is urgently needed, but not addressed in this paper; and, equally important, a continuously advancing high technology input.

- Traditionally, in the U.S., aviation technology has been advanced by the Government. This has resulted in what used to be a highly productive industry, and this is what is needed today. With current financial constraints, there is no way the industry itself can afford to advance the technology.

- What needs to be done in terms of technology has been well defined by the industry, by the Congress, and by NASA. However, the program has not been implemented in the manner needed to give the necessary push to turn the industry around. Doing so represents an opportunity, a challenge, and above all a pressing need.

GML/8/19/76

This paper illustrates a long term issue, but of very great consequence: Is government basing agricultural and foreign policy on fellacious assumption about climate? Are dust-bowl weather conditions returning? If so - what about food grain reserves and export policy?

The recommendations are focused mainly at contingency planning. But additional research is needed. Prof. Munk comments that this field of science has expanded rapidly recently - but the new knowledge about climate is not integrated with overall planning.

Useful as demonstration of farsighted concern with issues of global importance to humanity.

DRAFT: For information purposes only. August 30, 1976
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CLIMATIC CHANGE: IMPLICATIONS FOR SCIENCE POLICY*

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*Prepared at the request of the Carter/Mondale Science Policy Task Force.
**The views expressed here are solely those of the author, and not necessarily those of the National Center for Atmospheric Research or its sponsor, The National Science Foundation.
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SUMMARY OUTLINE OF CLIMATIC POLICY ISSUES

Major Issues:

A. Short-term: Food production is vulnerable to climatic variability; need adequate reserves.

B. Middle-term: Be certain that progress in achieving reduced population growth rates through improved living standards for developing countries is rapid since:

C. Long-term: Consequences of large global population is that large environmental insults are felt from same per capita use of technologies (particularly energy consumption). This leads to the possibility of irreversible climatic changes associated with vastly increased energy production. Issue is weighing social and political risks of inequitable distribution of resource usage versus long-term risks of climatic and other environmental damage that is likely to result for increased environmental insults.

Resolution to Scientific Issues:

Need coordinated national climatic research program, including study of at least: effects of climate on food, effects of various technologies on climate, and effects of climatic change on society.

Public Policy Measures (partial list:)

A. Adequate food reserves to hedge against precedented climatic variability.

B. Planetary "bargaining" to A) decrease population growth rates in developing countries while increasing per capita living standards, and B) to reduce waste and growth rate of resource use in rich countries while increasing likelihood of a sustainable world order.

C. Develop consciousness for new "ethic of prudence", through courageous leadership, and judicious regulation of environmentally unsound activities.

D. Develop inter-disciplinary granting and review structures.

E. Develop structure to separate scientists' implicit value assumptions from their scientific expertise in testimony on public policy issues.

Administration Shortcomings:

A. A food reserve policy based on values that fear surpluses and lowered profits for grain traders more than food shortages and price rises in rich countries and famine and instability in poor nations.

B. Refusal to support national climate research programs (costing tens of millions of dollars) needed to narrow uncertainties while approving tens of billions for new exotic military hardware.

C. Opposition to significant energy conservation and the "ethic of prudence". Their defense of the status quo in energy and economic growth issues will make achievement of a catastrophe-free transition to a sustainable world order more difficult.

D. Opposition to the U.N. resolution banning sinister uses of weather and climate modification.

CLIMATIC CHANGE ISSUES

Climatic variability plays an important role in human affairs, primarily since food production fluctuates along with the climate. This has been dramatically demonstrated over the last several years, and it has been reported frequently in the popular media. The world food crisis in 1974 was related to climatic variability, and the summer droughts in 1976 in western Europe, England, and much of the northern U.S. plains has again dashed the world hopes of rebuilding significant grain stocks, stocks depleted by a combination of deliberate food policy of the present administration and difficulties with the weather.

Climate effects on society can, for the sake of simplicity, be classified in three categories: short-term, medium-term, and long-term influences. The most obvious manifestation of climatic variability is the short-term effect it can have on global food production. For example, throughout the 1960's and early 1970's, world food production increased at 3% per year, while population growth only increased at 2% per year. Many people have felt that technology (i.e., the Green Revolution) had rid the world of famine, and banished the specter of Malthus once and for all from the face of the earth. Of course, as is now common knowledge, the climate in 1972 played havoc with world crops. That year saw delayed monsoon rains in India dashing that country's recently proclaimed status of self-sufficiency, an off shore current change near Peru devestated the anchovy catch, flooding in Pakistan, and a drought in the Soviet Union so severe that it ushered in the era of massive Soviet purchases from the then unsuspecting North American grain brokers. World food production in 1972 dropped by only 1% over the previous year; but remember the global population growth rate implies that we need at least a 2% increase in food production yearly merely to standstill in per capita consumption. With this perspective, it is little wonder that prices doubled and talk of famine was again rife. Most of the loss in productivity in 1972 was made up from global grain stocks, which were then at about two month's supply. The major holder of grains, the United States, reversed years of experience in saving grains and followed the deliberate policy of liquidating government reserves. The administration had primarily two reasons: a)that reserves stabilized prices and diminshed profits for farmers and grain traders, and b)that technology had insulated us from weather variability and thus, by implication at least, grain reserves were less necessary than in the past. I believe that their point (a) can be challenged on both practical and moral grounds, and know that point (b) can and was severely challenged on technical grounds (see the attached paper). For instance, recent studies show that the period between 1956 and 1973 in the U.S. plains states, a period which has been taken for granted as experiencing "normal weather", was actually a period of remarkable climatic stability. That is, summer temperatures were either normal or below normal, and summer rainfall either normal or above normal during this period. These abnormal conditions are precisely those optimum for most major crops for the region. Thus, many believed that the low variability in crop yields during that time was attributable to our technologies, and that food reserves were less necessary. The disasterous corn and soybean harvests in 1974--of which a number of climatologists warned the U.S. Department of Agrigultural officials were quite possible--certainly proved that our agriculture still remains significantly vulnerable to climatic variability. The simplest hedge against the food consequences of this kind of weather

In the medium-term, the main climatic issues of concern are to maintain food reserves at an adequate level to hedge against climatic variability, while at the same time working primarily in developing countries to increase food productivity way ahead of their population growth rate. This is essential if there is to be any hope of achieving reductions in birth rates in developing countries. Often, the interim strategy of improving the living standards in developing countries--a goal which enlightened Americans are beginning to embrace increasingly for both practical and humanitarian reasons--very often requires the application of technologies--particularly energy production. Unfortunately, state-of-the-art climatic theory suggests that if present energy consumption and population growth rates continue, the Earth may be faced with some potentially major and possibly irreversible climatic changes. Even by the year 2000, these could be as large as any of the documented changes since the end of the last ice age. Although the climate has changed considerably because of natural causes throughout history, the Earth is now at a stage where through the use of energy, humans may already be causing significant inadvertant climatic modifications, and we can expect that the human influence will grow with increasing pollutants. Unfortunately, unlike studying past climates, for which historical records exist, human perturbations to the system have no analogy in history, and thus require theoretical constructs to estimate potential effects. However, climatic theory is presently far from being sufficiently well-established to yield more than order-of-magnitude insights, and present inferences are highly dependent upon the results of mathematical models, which still require further development and verification. Yet, this raises serious policy issues, for it may very well be that it will take atmospheric scientists as long to refine and verify their models (in order to narrow the uncertainties surrounding the potential irreversible modification of the climate from human activities) as it will to have the atmosphere "perform the experiment" of proving whether present estimates are too high--or too low. Clearly, whether to take such risks is an issue of values and belongs in the realm of science policy, not "expert" consensus.

The long-term aspect of climatic issues essentially relates to the ultimate steady-state level of world population and the total per capita use of technologies--particularly energy consumption. Since the environmental insults from energy production is proportional to the total amount of energy consumed around the world, which in turn, is the product of the per capita consumption times the total number of people on earth, the long-term climatic impacts depend very much on how rapidly the world's peoples are able to succeed in the interim phase of improving the human condition and getting population growth rates down as urgently as possible so that the steady-state population size is as small as possible. The fact that some technological solutions with lesser impact on the environment may one day be invented is of little comfort to those who demand more energy equality with conventional technologies--even if they have significant environmental risks.

Further long-range climatic issues involve the potential effect of concentrating heat sources into "power parks" with the consequent possibility of generating severe storms (thunder storms, hail storms, or tornadoes), the possibility of significant climatic modification from the end use of energy (for example, the propellants in aerosol spray cans or the use of nitrogen fertilizer may affect the atmospheric ozone layer) or, ultimately, the possibility that climatic "control" might be attempted by some nations to either maintain the climatic status quo or gain political or military advantage. It is imperative that the spectre of geophysical warfare, be limited by global agreements as soon as possible (the United States was one of only a handful of countries that opposed the resolution before the United Nations to ban the military uses of weather and climate control).

In sum, it is not so much the fear of a deteriorating climate, but rather the fact that we have permitted ourselves to be increasingly vulnerable to precedented climatic fluctuations which raises the major immediate climatic issues that deserve policy consideration. Furthermore, the possibility that there are "climatic limits to growth" suggests that Americans, indeed all the world's inhabitants, must recognize that the indefinite use of technology (particularly energy consumption) cannot be tolerated by Earth without the likelihood of severe climatic consequences. In view of the uncertainties of present scientific estimates, perhaps the wisest strategy is to hedge our bets by diminishing those insults on the environment thought most likely to be serious, thereby buying more time for the scientific community to study problem--breathing time before the atmosphere itself "performs the experiments" for us. However, this also involves risks, since the inhibition of needed development could cause social and political strife. The one thing that is clear, however, is that these issues require urgent attention.

RESOLUTION OF THE ISSUES

The faster the scientific community can narrow the technical uncertainties surrounding the likelihood of a plethora of climatic problems, the easier will be the task of the policy maker. In order to accomplish this scientific goal several steps need to be taken.

A data base of variations of important climatic variables taken from both conventional atmospheric measurements, floating buoys, ships, submarines, and airplanes of opportunity, and earth satellites are necessary both to document the evolution of the present state of climate and to provide a data set that can be used to construct and verify the predictions of the mathematical models of climate that are necessary to evaluate the climatic impacts of human activities. Therefore, it is necessary to improve considerably the state-of-the-art of mathematical modelling of the climate. These needs have been laid out in the National Academy of Sciences report "Understanding Climatic Change" that was issued in 1975. Furthermore, the National Oceanic and Atmospheric Administration took the lead in preparing a plan to create a national climate research effort; their document on this plan was submitted to the domestic council and ultimately rejected because of budgetary priorities in 1974. Later on, after the administration had repeatedly turned its back on increasing climatic research (despite the difficulties the nation experienced in food production in 1974 because of bad weather) Congressman Phillip Hayes introduced the National Climatic Research Act (HR10013) in the spring of 1976. Hearings were held in the third week of May, 1976 in Congressman George Brown's Subcommittee on the Environment and the Atmosphere (my testimony at those hearings is attached). To date, lack of administration interest has continued and the bill remains obscure.

Finally, since most of the issues of climatic change and its impact on society are interdisciplinary, much of the work needed to shed light on the problem will have to be done in an interdisciplinary context--and both academic institutions and government funding agencies are ill-equipped to handle this kind of problem oriented research.

It must be understood that while it cannot be stated with certainty that increased effort and resources in the field of climatic studies will provide immediate payoffs in terms of forecast capability, it must be said that the costs of our ignorance and knowledge of the workings of the climatic system may already unacceptibly high, and that while assurance of success cannot be guaranteed, the value of obtaining a better understanding of climatic system makes this scientist comfortable with the thought that support for climatic research is an inexpensive and worthwhile hedge against potential climatic crises (see attached testimony for more details).

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RECOMMENDATIONS FOR PUBLIC POLICY MEASURES

Paralleling the policy issues, it is clear that short-term policy with regard to climatic issues requires A) that we restore an adequate food reserve to hedge against precedented climatic variability and B) that we engage in discussions with the international community to set up international food reserves to provide ample relief to those countries that are threatened with crop disasters from weather variability; however, such a food bank must not be merely a transfer agency to facilitate the feeding of chronically deficient nations, but rather, coupled to negotiated plans between developing and developed countries to build some stability into the agricultural system of the developing country. This effort requires direction of our foreign policy towards what has been called "planetary bargaining", a concept that recognizes both the risks and benefits of global interdependance, but proceeds on a negotiated basis to create a stable long-term world order; C) we must improve our ability to analyze and, ultimately, forecast climatic fluctuations through expansion of research efforts, and D) we need to build into academic and government granting agencies mechanisms to permit interdisciplinary research to flourish. For example, the reviewers of an interdisciplinary proposal submitted to the NSF would generally give such proposals low grades, since the review structure still uses peers who value disciplinary originality much more than problem importance. Substantial revision of academic and granting agency peer review and evaluation processes for interdisciplinary work must be undertaken if the vast array of existing scientific talent is to be brought to bear on crucial problems.

We need, E), greater understanding of the potential human impacts on climate to help determine what "acceptable risk" may be with regard to climatic modification. Of course, the acceptability of risk is truly a value judgment, not a scientific determination, and thus F) we need to devise better mechanisms to separate out implicit value judgment from scientific expertise in the testimony of scientists before government bodies with regard to the recommendations for policy actions from these scientists. No scientist has expert credentials on how the society should take risks in the future, and a serious deficiency in the input of scientific facts to public policy remains, since most scientists make implicit value judgments as to the acceptability of risk, and the structure is not yet very adept in separating a scientist's implicit values from his technical expertise.

The far reaching implications of the existance of the potential climatic barriers to energy growth suggest that Americans, and perhaps most of the world's people, must recognize the finiteness of our planet and the fragility of its ecosystems, and the exterme risks of continued unsustainable economic and population growth rates. We may have to begin to develop --if only in our consciousness at first--an "ethic of prudence" in the face of terrible uncertainty and future risk. This will require inspired leadership to ask the people to begin to gear up for the inevitability of life style changes. Perhaps government involvement to regulate the rates for which potentially polluting activities are allowed to grow is the most obvious first step, but this must be coupled with the public understanding of the needs for the new ethics of prudence.

The costs to the next generation of an irreversiably damaged climate

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could be measured from billions to trillions of dollars. Unforturnately, in present economic accounting systems these uncertain costs are "externalized", therefore, not included in the cost/benefit analysis over issues such as pollution controls or growth rate limitation regulations. If the potential costs to the future were internalized in present accounting, perhaps through the use of "next-generation environmental impact statements", then we would sustain less risk of doing irreparable harm to the world of our children and grandchildren.

APPENDIX I, ADMINISTRATION SHORTCOMINGS

With regard to climate and public policy issues, it is my opinion that the present administration has subjected both the United States and the world at large to great risk through its fear of surpluses more than shortages, a policy tantamount to putting profits for grain traders ahead of the risks of global convulsion (not to mention the moral compunction) from regional starvation in the face of not unlikely weather-induced reductions in crop yields. The horror of the drought in the Sahel in Africa and perhaps the collapse of some national governments can be attributed in part to the priorities of Mr. Butz and the administration (as pointed out by the now infamous "CIA Report" on the climate). Furthermore, the USDA has argued on technical grounds that reserves were less necessary, a point that was clearly proved false by both the analysis of many scientists who warned them in advance and the events of 1974 and 1976 in the grain belts (see attached for more details). When Mr. Butz was once challenged that the United States food policy was risky and that some form of reserves rationing might be necessary, he was quoted as responding that one can "ration with prices, you know". I believe, that the American consumer should hold him accountable for this philosophy of his administration.

With regard to improving our understanding of climatic change in order to reduce the uncertainty surrounding the issues listed in the previous pages, the administration rejected a carefully worked out plan to coordinate and accelerate national efforts on climate research. The relative priority they demonstrated by holding back the budget on an item of tens of millions of dollars while making room on the budget for certain hardware projects costing tens of billions of dollars, certainly deserves to be considered by the voters. I believe the Task Force should contact Congressman George Brown of California, who is trying to revive the hope of a national climate plan through his Subcommitte on the Environment and the Atmosphere. Congressman Brown can trace the political history of the administration's "cold shoulder" to climate research in detail.

Since the potential climatic threats of technology will be proportional to the size of the technological insults on the environment, the general unwillingness of the administration to recognize that limits to industrial, economic, and population growth will one day exist, and thus, we must begin our march toward a smooth transition towards a sustainable world, makes it that much more difficult to work toward a catastrophe-free transition over the next few decades. The need for energy conservation and the beginnings of a consciousness of holding back our insults on both the physical and social environment until we have better understanding of the long-term consequences of our short-term policies is an ethic that can and should be raised in the political arena.

Finally, the United States' refusal to support the proposal before the United Nations to ban the military uses of weather and climate control cannot be interpreted by most nations as a sign of our desire to create "a generation of peace".

Please note the attached material for more detail, or refer to my book (with Lynne E. Mesirow): The Genesis Strategy: Climate and Global Survival (Plenum, New York, 1976) 419 pp.

(3) B

9530 La Jolla Shores Drive
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8 September 1976

Mr. Michael Michaelis
Suite 513
1735 Eye Street, N. W.
Washington, D. C. 20006

Dear Mr. Michaelis:

I was out at sea last week and have just received the comments of Stephen Schneider on "Climatic Change: Implications for Science Policy." I had been somewhat familiar with his position on the basis of his recent and very comprehensive book, THE GENESIS STRATEGY: CLIMATE AND GLOBAL SURVIVAL. I would like to add the following comments:

1. I agree with Dr. Schneider that a national climate research program has a large potential payoff, both short-term and long-term. He has presented the arguments in great detail.

2. Among Administrative shortcomings, Schneider writes "refusal to support national climate research programs (costing tens of millions of dollars) needed to narrow uncertainties while approving tens of billions for new exotic military hardware." I would go easy on that; it is one of the lesser shortcomings of the Nixon-Ford Administration. There has, in fact, been quite a renaissance in climate studies in the U. S. during the last five years. I believe we are more limited by brain power than anything else. The forecasting capability of climate remains in doubt, as stated by Dr. Schneider.

3. Schneider has given a very general discussion on energy, population, and food. These are indeed the major problems where climate is an important factor, but by no means a decisive factor.

4. I do fully agree with Schneider's criticism of the Administration's refusal to support a United Nations proposal to ban military uses of weather and climate control.

As a whole, I think we can do better than to push Mr. Carter for a policy that puts more money into each of our fields of interest. I have always wished that the scientist could play a more responsible part in apportioning national support for research and being willing to assign priorities.

Sincerely yours,

Walter H. Munk

WHM:cg

cc: Dr. Lewis Branscomb
Dr. Stephen Schneider

CLIMATIC CHANGE AND THE WORLD PREDICAMENT*

Statement of

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presented to:

Climate Hearings of the House Subcommittee on the Environment and the Atmosphere

May 18, 1976

* Much of this statement is excerpted from the book The Genesis Strategy: Climate and Global Survival, by S. H. Schneider with L. E. Mesirow (Plenum Press, New York, 1976, 419pp).

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I. Climate Change: No Longer a Subject for Small Talk

Considerable concern and attention has recently been focussed on the prospect of a world food/climate crisis. Its concern was heightened by the disturbing weather events of 1972, which resulted in a halving of global food reserves and more than a doubling of some food prices. Fluctuations in world food production are the most obvious manifestations of climatic variability, yet despite the clear message from the events of 1972 the potential seriousness of a world food/climate crisis is still a controversial issue. For example, Reid Bryson of the University of Wisconsin has stated that there is climatic change in process, and if the trends continue perhaps as many as half a billion people could starve in the next few decades. On the other hand, U.S. Secretary of Agriculture Earl Butz has intimated that such statements are at best without scientific basis and at worst apocalyptic nonsense. As we explore in this testimony some of the issues which lead to this controversy, one element becomes abundantly clear: that issues of climatic change are both fraught with tremendous uncertainties and it is crucial that those uncertainties be narrowed as quickly as possible if we are to avoid potential disasters. It is my hope that these hearings can contribute to the latter goal, and I appreciate the opportunity to offer my views.

In addition to the obvious connection between climatic changes and food production, climate problems are deeply implicated in other aspects of the "human predicament" (i.e., problems of world population, resources, environment, and the condition of human kind). It is important to study climate-related aspects of these problems for a variety of reasons:

(1) Climate change can be both a global and potentially irreversible consequence of human indifference to natural systems.

(2) The climatic system does not conform to the prevailing concept of "national sovereignty"; thus, the possibilities of climatic shifts in one area being connected to changes elsewhere provide an opportunity for international cooperation; these possible relationships could even serve as a symbol of global interdependence to encourage greater world unity and movement away from the often selfish and short-sighted goals of nation-states. On the other hand, the interconnections of the climatic system could also provide a cause for international conflict.

(3) Climatic processes are not well understood, yet potential climatic changes could be serious; this case exemplifies dilemmas that will arise with increasing frequency over critical political issues that contain an important, but uncertain, scientific component. That is, the climate may well be understood "enough" to begin immediate and perhaps extensive actions to prepare for possible but uncertain dangers that present knowledge suggests may be ahead.

(4) Considering their immediate importance, problems of climatic change have been given relatively little detailed attention in most of the debates on the world predicament.

Let me emphasize at the outset, however, that I am not forecasting the "end of the world." I do not think it likely that the next ice age will be upon us before the end of the Bicentennial, nor do I anticipate, on the other hand, that the polar ice caps will soon melt and cause flooding of our coastal cities, permanently curing the problems of urban decay. While these climatic doomsday extremes cannot be completely ruled out as possibilities even as early as the next century, my greatest concern for the next few decades is for seemingly much less dramatic fluctuations in the climate--variations that are not unprecedented in the climatic history of the past few centuries. What is unprecedented, I believe, is the dangerous

vulnerability our global food producing systems face from even seemingly small variations in climate. This increasing vulnerability is not so much a consequence of the expectation of a continuously deteriorating climate, but rather a manifestation of our inability as a global society to build into our means of survival sufficient flexibility and reserve capacity to hedge against even the highly precedented variations in climate that have been documented in history. Of course, the wisdom of building a safety factor into our food producing systems is not a new concept. In the Biblical Book of Genesis, Joseph issued a long range climate forecast with a skill far beyond the best efforts of modern science: he warned that seven fat years would be followed by seven lean years and counseled that Pharaoh save up grain in the good years to ensure Egypt's survival in the inevitable lean ones. The Pharaoh, unfettered by the idealogical constraints of the "free market philosophy" or the political imperatives of inefficient agricultural collectives, took Joseph's advice and implemented the first recorded example of the principle of prudence I call "The Genesis Strategy": to build sufficient diversity and margins of safety into the means of our survival to insure our ability to sustain some adversity--be it bad weather, an attack of pests, or an embargo from an oil cartel--without catastropic consequences. Food is the most obvious material with which to practice the Genesis Strategy, so I will take a brief look at some of the reasons I believe the world may be facing a serious food/climate crisis in the next few decades.

II. The Potential for a World Food/Climate Crisis: The Short-Term Phase

Considerable concern and attention has recently been focused on the prospect of a world food/climate crisis. This concern was heightened by the disturbing weather events of 1972, which, as I said earlier, resulted in a halving of global food reserves and more than a doubling of some food prices. Let us examine this world situation briefly, for the demand for U.S. grains will depend not only on the production in the United States but also on the stability of the food supply outside of the U.S. (Much of what follows is excerpted verbatim from the book The Genesis Strategy: Climate and Global Survival, by S. H. Schneider with L. E. Mesirow, Plenum Press, New York, 1976, 419 pp, from which additional details and references to other work can be obtained.)

The year 1972 was a bad one for crops in many places outside of North America, and some weather experts think it could well presage a return to times of higher climatic variability and the attendant likelihood of severe food disasters. In that year a coincidence of climatic disruptions occurred in many parts of the world, among them damaging floods in the American Midwest and elsewhere; the warming of the coastal waters of Peru, which results in a near collapse of the economically and nutritionally important anchovy catch; the continuation of drought in the Sahel, with the consequent migration and starvation of some of its population; a few-weeks delay in the onset of the life-giving monsoon rains in much of India; and a drought in the Soviet Union so serious that it led directly to the infamous Soviet wheat purchases from the United States and Canada.

In view of these adverse conditions, it is not surprising that in 1972 world food production was reduced by roughly 1 percent from the previous year, the first such reduction in nearly a decade, a period during

which total food production increased by nearly 3 percent per year. The variable weather of 1972 reduced grain reserves from enough to feed the world for sixty-nine days to about only a month's supply by mid-1974, according to food expert Lester Brown. The price of wheat also rose dramatically because of its short supply, making additional purchases more difficult than ever for the poorer countries of the hunger belt, a term referring to the belt of highly populated relatively poor nations spanning the globe in mostly tropical and subtropical zones.

There is considerable debate among climate researchers as to whether the unusual events of 1972 were coupled with the occurrence of a "cooling trend," which has been documented mostly in the middle to high latitudes of the northern hemisphere. However, because of the slowness with which climatologists are able to assemble and analyze the world-wide collections of climatological data, climatologists often find themselves in the ironic position of knowing very little, statistically speaking, of the five-year period they have just lived through. Furthermore, many areas of the northern hemisphere are uncovered by thermometers and much of the southern hemisphere remains unobserved. Therefore it is not yet possible to tell whether, in fact, the globe has been experiencing a cooling trend in recent years, although it is certain that much of the middle and higher latitudes of the northern hemisphere was cooling during the 1960s and early 1970s. Thus, we cannot be certain whether the celebrated cooling trend has continued beyond 1972 or 1973, even in the northern hemisphere. On the other hand, the kinds of temperature fluctuations that have been observed in the past few hundred years are not unusual in the perspective of climatic history and should not be considered as guaranteed omens of a continuously deteriorating climate. The main point here is that one should not glibly assume that the climatic conditions of the very recent past will be maintained indefinitely, rather the climatic events of the past several

centuries are quite likely to recur. (In fact, in the absence of an adequate theory of climate with which to predict the future such an "actuarial" approach to climatic prediction is the only viable option.) This uncertainty over the likelihood for increased climatic variability is particularly damaging today, with world food stocks dangerously depleted and population growth maintaining its inexorable onward march.

Let us take a closer look at the influence of weather variability on cereal grain yields in the North American granary.

Consistently high crop yields depend on many factors: water, good seed stock, maintenance of genetic variability of crops, fertilizer, high productivity of the soils, pesticides, the pest-control services of natural ecosystems, good management skills of the farmer, capital to acquire and maintain technology, and stable climatic conditions. The major technological input is chemical fertilizers, especially on fields planted with high-yielding crop strains. Figure 1 shows crop yields up to 1973 for the case of corn in Missouri. The dramatic increase in yield per acre since about 1950 is coincidental with the dramatic increase in fertilizer, a coincidence that is not accidental.

The actual annual yields of corn do, however, vary considerably from one year to the next. The scatter of individual annual yields away from the long-term trend line (the solid curve on Fig. 1) indicates that before the mid-1950s the deviation of yields from the long-term trend was considerably larger than for the two decades after the mid-1950s. That is, after about 1956 the actual values of yields per acre each particular year (represented by the dots or squares on Fig. 1) are closer to the trend line (the solid line drawn through the middle of the dots). Thus, we can see that after the mid-1950s not only did yield per acre go up dramatically, but the <u>percentage</u> variability of yield per acre went down (represented by the

diminishing scatter of the dots away from the trend line). It is tempting to conclude that improved agricultural technology has also accounted for the reduced percentage variability in corn yields since 1956. In fact, there are people who have pointed to the reduced yield variability since the 1950s as an implicit justification for the policy of reducing our government's food reserves holdings. These people argue that since technology has reduced the vulnerability of crop yields to weather variations, large food reserves are now less necessary than in the past. However, this argument fails, as we shall see, to consider that weather played a significant role in the almost 20-year period of high crop yields and low yield variability.

Since the U.S. is the principal grain exporting nation in the world, and since U.S. agricultural exports provide not only an important economic benefit to the U.S., but an essential backstop against famine elsewhere, it is important to inquire as to what might be the outlook for drought in the U.S. plains.

III. Droughts in the High Plains: A Precedented Event

With some exceptions, such as the recent half dozen years of drought in the Sahelian zone of Central Africa, most of the years between 1956 and 1972 were blessed with remarkably favorable climatic conditions for agricultural production, particularly in North America. For example, in the five midwestern wheat-belt states in the United States, data compiled by Donald Gilman of the U.S. National Weather Service, Extended Forecast Branch, show that the period from 1955 to 1973 was marked by summer rainfall generally greater than the long-term average and summer temperatures slightly lower than this average, precisely the optimum conditions for high crop yields in this important agricultural region.

The darkened parts of the graph in Fig. 2 indicate above- or below-normal values of temperature or rainfall, depending on their location about the midline. The most obvious feature is the nearly unbroken ten-year streak during the 1930s, which was characterized by above-normal temperatures and below-normal rainfall. That period marked the great American drought that eventually caused that previously fertile area to be called the dust bowl. Literature and history are filled with accounts of the devastating effects of the drought, how blowing sand and endless streteches of dry, hot, dusty summer days ruined crops, wiped out family farms, and spawned massive migrations--from Oklahoma to California, for example. The reinforcing coincidence of the dust bowl and the Great Depression of the 1930s created as menacing a threat to the stability of the American democracy as any since the American Civil War, and although the unfavorable climate did not cause the depression, it undoubtedly aggravated an already grim situation.

Other droughts (i.e., periods characterized by below-normal summer rainfall and above-normal summer temperature) have occurred in the 1910-15 period and the early 1950s (Fig. 2). In fact, longer records indicate evidence for a periodicity of about twenty to twenty-two years for high plains droughts over the past hundred years or so. Dr. Walter Orr Roberts, who has long studied these seemingly cyclical droughts, suggests that they may be connected to sunspot cycles observed on the face of the sun. Unfortunately, a physical theory explaining such a hypothesis is still not available. The main point, one he often repeats, is that high plains droughts see to recur at regular intervals and thus, regardless of their cause, we should be prepared for them and their effect on crop yields, soil erosion, and food security. (He also points out the next such drought is "due" in the mid-to late 1970s!)

Now, we can compare the remarkably high yield and low yield variability period of the late 1950s and 1960s shown on Figure 1 with the weather in the high plains shown in Figure 2. Returning again to Gilman's findings (Fig. 2), one more important feature must be recognized. That is, directly following the 1950s drought the next fifteen years or so in the wheat belt saw nearly uniform summer climatic conditions: slightly higher than normal rainfall and below-normal temperatures--conditions that are ideal for high crop yields in the plains. Thus, we can see that the period of massive technological improvements in agriculture (when crop yields rose steadily and at the same time the variability in crop yields per acre from harvest to harvest decreased) was also one where the weather was abnormal, that is, abnormally good for growing. Until recently, nearly everyone has overlooked the fact that the weather during this period was also unusually favorable.

A study by Dean Louis M. Thompson of Iowa State University and Dr. James McQuigg of the National Oceanic and Atmospheric Administration at Columbia, Missouri has shown just how critical the fifteen nearly consecutive good growing years were to the maintenance of high yields and (particularly) to the low variability of yields. This study suggests that the chances of enjoying such a favorable growing climate for another fifteen years are quite low. Food reserves may not have seemed necessary in the recent past because some believed that technology had significantly reduced the chances of weather-related crop failures, thus rendering the need for reserves, at least by implication, somewhat superfluous. I believe this to be a dangerous assumption.

IV. The Interim Phase: Increasing Agriculture and Decreasing Population Growth Rates

Although I have argued that variations in the climate occurring at times of depleted food reserves could produce serious fluctuations in food production which, in turn, could lead to price rises in well-fed countries and famines elsewhere, the fundamental future threat to global stability is not so much climatic, but rather the classical difficulty: food production might increase at a slower rate than the rate of population growth.

It is often argued that population growth in developing countries will become self limiting as their standard of living increases--the so-called "demographic transition." Thus, rather than putting the brakes on development, advocates of this theory call for more development, which is often translated into calls for increased food production, industrialization and energy consumption. Let us take a look at the role of energy in food production through the case of U.S. agriculture.

In an article Science, John and Carol Steinhart of the University of Wisconsin have traced the energy component in the U.S. food system. Their study demonstrated how farm output in the U.S. has risen with increased energy use and how, in recent times, there has been a leveling-off of that food output despite still increasing energy inputs. This relationship is shown in Figure 3. Thirty to forty years ago only a few calories of energy input to the U.S. food system could buy a calorie of food output, whereas in 1975 it took more than 10 calories of energy input to get the same result, as seen on Figure 4. This suggests that in energy terms, at least, the U.S. agricultural system is no longer efficient but rather approaching a law of diminishing returns. The U.S. agricultural system is, of course,

highly productive, but it is not clear that U.S. farmers will be able to increase their productivity in the future at anywhere near the same rate that productivity increased during the 1950s and 1960s, without technological breakthroughs that cannot now be guaranteed.

Fortunately, most nations in the world, particularly those poorer nations in the hunger belt, do not have energy inefficient agricultural systems, but rather very unproductive ones. Therefore, there is much room for optimism that global world food productivity could be raised significantly since many nations have energy inputs to their agricultural systems well below the levels of energy input to the U.S. and other highly technological, energy-intensive agricultural systems. In fact, much of the optimism expressed by those who claim the world can support many more than its present population of four billion people, comes from the fact that global energy applications to agriculture in poorer countries are still well below that of the technological countries, and thus the hope exists that other nations could increase their productivity along the lines of the U.S. system or other developed agricultural systems.

Unfortunately, the application of technology, particularly energy, to improve the human conditions is also accompanied by a disagreeable by-product we call pollution. This, of course, leads to the now classical conflict between "environmental" interests, who wish to abate pollution, and economic and development interests, who are willing to accept pollution as an unfortunate but unavoidable by-product of development.

V. Theory of Climatic Change

Before describing some of the theories of climate change, let me first review how climate works. Weather in our latitudes is directly related to conditions elsewhere on the earth. Sunlight hits the earth with more of it intercepted in the tropics than in the poles. Some of that sunlight is reflected from air molecules, the earth's surface, dust, and clouds, and thus cannot be absorbed to warm the planet. At the same time, the remaining 70 percent of the energy which is absorbed causes the temperature of the planet to increase. Like any object, the earth gives off infrared radiation proportional to its temperature. Warm air rises in the equatorial regions, which are heated in excess of their outgoing infrared radiation, and travels toward either pole. As the earth rotates, the equator is spinning around faster than the poles; consequently, when the warm air moves outward it takes with it this momentum, this speed of equator, forming westerly winds in our latitudes.

The amount of air that moves toward the poles from the heated equator depends on the differences in temperature between the equator and the poles. If the poles are cold relative to the tropics, then the vigor of the circulation system is stronger; as a result in winter we experience more storm systems and the jetstream is very fast. As many of us are aware, in the winter, the flight from the East to the West Coast takes much longer than the return trip, whereas in the summer the flight time is almost the same.

To some extent one can say that virtually everything in the climate system is coupled to everything else; any large-scale push in one place causes a bulge somewhere else, but these are not all equal in magnitude. It is the task of climate theory to determine what those magnitudes are.

Since the sun is our major energy source, an obvious theory of climate change concerns fluctuations in the output of the sun. At the present time, fluctuation at very low and very high wavelengths has been determined but we do not know to better than about one percent what the total output of energy from the sun is and how it varies. Therefore, it is very difficult to determine if previously observed planet warmings and coolings are directly caused by changes in solar output. Some attention is now being directed to efforts to develop methods which will yield more accurate measurement; this task requires a difficult development process but it surely can be done if given impetus comparable to its importance.

Another theory is related to the fact that the earth's orbit varies slightly with respect to the sun; for example, the relative location of the poles changes from summer to winter over periods of 10,000 to 100,000 years. This theory has been used to explain long-term ice ages, but it certainly cannot account for climatic fluctuations like the "little ice age" and the short-term variations which wreak havoc with our crops. In addition, changes in atmospheric dust and carbon dioxide as well as changes in the land have been postulated; the continents have drifted around for millions of years, clearly causing a climate change, but that factor is not very important for climatic changes over less than a million years.

The oceans are a critical component of climate. They have vast capacity for energy storage and they can release their energy on time scales of days to hundreds of years. This process may very well be responsible for short-term fluctuations. Internal oscillations in the climate system (consisting of the atmosphere, oceans, land, and glaciers) have also been postulated:

whereas one might perceive short-term climate changes as being forced by external causes, they could, in fact, represent redistributions of energy among glaciers, oceans, and atmosphere.

In addition to natural causes, the effects of human activity must be considered in relation to recent climate changes. Some of these are discussed in the next section.

How does one judge the relative effect of these factors on climatic change? It is a difficult task to separate out quantitatively the cause-and-effect linkages from the many factors of comparable magnitude tending in opposite directions. As with any science, the process of developing a quantitative theory of climate begins with observations from which hypotheses are generated. The next step is to design experiments. Only a limited number of experiments can be carried out in the atmosphere. Moreover, it would be nearly impossible to devise a laboratory simulation of the complex, nonlinear interactions which produce the earth's climate. One can learn a good deal about individual processes from studying other planets which obey the same laws of physics as the earth. Without a twin earth, however, the only way to simulate the earth's atmosphere and oceans effectively is by means of mathematical models.

There are many different kinds of models ranging from simple one-dimensional forms that focus solely on the vertical part of the atmosphere to highly sophisticated representations of the atmosphere and oceans. Any analysis of long-term climate variations requires coupling of models of the atmosphere, the oceans, and even the cryosphere. In addition, while many processes are included in such models, there is no certainty that they have been included correctly. To the extent that we can define which processes are represented correctly, these models might have some utility for climate studies in the near future.

VI. Climatic Barriers to Long-Term Energy Growth

Industrialized peoples, with their higher standards of living, rapidly became dependent on the extensive use of energy to turn their wheels, heat their building, produce their electricity, and grow, store, and transport their food. Most of the energy liberated is derived from fossil fuels--coal, gas, and oil--whose burning is accompanied by a variety of atmospheric pollutants. One form of such pollution that affects the entire atmosphere is the release of carbon dioxide (CO_2) gas. Even though it makes up a small fraction (less than one one-thousandth) of the gases that comprise the atmosphere, CO_2 is crucial in determining the earth's temperature because it traps some of the earth's heat (to produce the so-called "greenhouse effect"). Human activities have already raised the CO_2 content in the atmosphere by about 10%. Figure 5 shows two estimates made of this phenomena. In Figure 5a the projection made by Dr. Lester Machta of the National Oceanic and Atmospheric Administration in 1971 is shown. This is a good example of the consequence of the exponential growth in the use of energy. The figure shows that over the past 110 years, the time in which the industrial revolution took off on a world-wide basis, atmospheric carbon dioxide has risen by about 10%. Theoretical arguments suggest that such an increase might increase the earth's surface temperature by several tenths of a degree Celsius. In fact, the earth's temperature did warm by about 0.5°C to about the middle of the 1940s. However, it is well documented that the northern hemisphere temperature, at least, cooled significantly since the 1940s. Therefore some people have argued that the CO_2-greenhouse warming theory could not be correct. However, the rise in temperature to the middle of the twentieth century was only about half a degree Celsius and therefore not at all unprecedented in climatic history. Whether the effects of the carbon dioxide were contribut-

ing to that trend, and were, therefore, bucking a natural cooling period after 1945, or whether the theory is wrong and the carbon dioxide-greenhouse theoretical estimates are too high, is not a determination that can yet be made for the simple reason that the fluctuations in climate that have occurred to date could either be a result of natural causes or influenced to some extent by human activities (such as the injection of carbon dioxide). Since there is no precedent in climatic history for such increasing carbon dioxide from which we could look at the response of the real atmosphere system to an increase in CO_2, we have no alternative but to attempt to estimate the potential effects of this pollutant from theoretical models of climatic change, mathematical constructs built to augment the limited ability of our physical laboratory to understand and model the actual climatic system. Notice from Figure 5, that although the first 10% increase in carbon dioxide took place in about 110 years, because of the exponential nature of the consumption of energy and the burning of fossil fuels we can see that the next 10% increase will take only about 20 years and the next 10% increase beyond that only about 10 years. By this time the climatic impact of the carbon dioxide should (according to the model calculations) cause a climatic warming of about 1°C--a warming as large as any that has occurred in modern climatic history. Whether such a warming would influence the extent of ice and snow at the polar caps or influence the level of the world's oceans cannot be said with certainty. Neither, can it be said whether such a warming would push the grain belts of the world northward by several hundred miles thereby disrupting the present patterns of agriculture. These, of course, are possibilities, but climatic theory is yet too crude to be certain. The most perplexing aspect of this dilemma is that the only certain proof that the carbon dioxide-greenhouse theory is correct, will come when the atmosphere itself "performs the experiment" of proving present estimates too

high--or too low. If the present rates of fossil fuel energy use continues, the climatic system will perform this experiment within a generation.

The estimates that Machta made in 1971 were based on a very limited sample of data, and therefore no one could be sure how reliable his projections would be. In fact, more recent data suggests that his inadequate data base was reflected in the fact that his more recent estimates were different from his earlier estimates. Figure 5b shows Machta's estimate of the CO_2 content in the atmosphere, an estimate he made in 1974, several years after his earlier estimate shown on Figure 5a. Notice that the uncertainties in the earlier data did not automatically reduce his estimate, as some people believe uncertainties will always do, but rather his new estimates suggest that the CO_2 concentrations of the atmosphere will be larger than orginally thought based on the uncertain data base several years earlier. Perhaps, the next increment in our knowledge will bring the answer back the other way, but the important point remains: uncertainty in present scientific estimates of potential climatic consequences of increased energy use is not biased toward optimism. The sword of uncertainty cuts in two directions, and thus we must face the uncomfortable reality that the only estimates we can make of potential human impacts on climate generally involve the use of uncertain mathematical models of the climate, models that must rely on tentative physical theories whose verification comes very slowly because of a limited data base of atmospheric and oceanic variables.

Figure 6 shows the considerable complexity involved in constructing one of these models. The figure shows the so-called "feedback loops" that exist between various processes in the climatic system. For example, if carbon dioxide increases really would lead to a warming of the surface, would that not evaporate more water, thereby creating more cloudiness, which in turn would

block some of the sunlight from reaching the earth's surface, thereby mitigating the warming effect of the CO_2? Such a "negative" feedback mechanism would lead to a dampening of the CO_2-induced warming. On the other hand, if the CO_2 warmed the earth's surface, it would melt some ice and snow near the polar caps. This region that was previously covered with ice or snow would then be darker than the white ice or snow it replaced. This darker region would absorb more sunlight thereby enhancing the CO_2 warming effect. This "positive" climatic feedback mechanism could act to destabilize the climate if perturbed by some human influence, such as CO_2. Unfortunately climatic theory is still incapable of resolving even the direction of the total sum of all atmospheric and oceanic feedback mechanisms, and thus the best estimates we are capable of making generally relate one variable, such as an increase in carbon dioxide, to a single response, such as an increase in earth's surface temperature. Whether the collective "soup" of all atmospheric and oceanic feedback mechanisms will ultimately render our present estimates high or low is too soon to tell, but it is urgent that the error bars in our estimates be narrowed so that society will be better able to make judments as to the timing and magnitude of potential climatic changes caused inadvertently as a consequence of human activities, activities often designed to improve the human condition.

Carbon dioxide is not the only by-product of the burning of fossil fuels. Another form of atmospheric pollution results from the introduction of dust and smoke particles, which, when suspended in air, are called atmospheric aerosols. The word "aerosols" is merely a term used to describe the suspension of any kind of particle in a gas. These particles can be solid like dust, sand, ice, and soot. Or, they can be droplets like the water particles in clouds and fog or the liquid chemicals that are dispensed as droplets from aerosol spray cans. The air contains

trillions upon trillions of aerosol particles, which, like CO_2, comprise only a minute fraction of the total atmospheric mass. Despite their relatively small volume, aerosols can affect our climate, primarily by absorbing and scattering back to space some of the sunlight that could have otherwise reached the earth's surface. Industry is not the only human activity that causes aerosols. They are also produced in great quantities by the widespread primitive agricultural practice of slash-and-burn, where large quantities of vegetation are purposefully burned to clear land.

A consensus among scientists today would not be forthcoming as to whether an increase in aerosols would result in a cooling of the climate or a warming of the climate, for aerosols will cool the climate if they are relatively whiter than the surface over which they lie, or, alternatively, they will warm the earth, if they are relatively darker than the surface over which they are floating. The dust that exists in the earth today, is highly nonuniform in both geographic distribution and relative brightness as compared to the underlying surface. Therefore, we cannot yet be sure whether dust contributes to climatic warming or, alternatively, has been implicated in the recent cooling.

My own feeling is that climatic theory is still too primitive to prove with much certainty whether the relatively small increases in CO_2 and aerosols up to 1976 have been responsible for the observed climatic changes we have recently documented. I do believe, however, that if concentrations of CO_2, and perhaps aerosols, continue to increase, demonstrable climatic changes could occur by the end of this century, if not sooner; recent calculations suggest that if present trends continue, a threshold may soon be reached after which the effects would be unambiguously detectable on a global basis. Problematically, by that point it may be too late to avoid the

dangerous consequences of such an occurrence, for as I have said, certain proof of present theories can come only after the atmosphere itself has "performed the experiment."

The climatic disruption from energy consumption is proportional to the total amount of energy used, which is equal to the population size multiplied times the per capita energy-consumption level. Thus, a greater level of consumption per capita is possible (with no additional enviornmental risk) if the total population size is smaller. Delay in achieving reduced population growth rates might just mean that there would be too many people on earth to achieve a high per capita energy-consumption level world wide without the risk of severe climatic changes; in that case the world would face increasingly intense pressures for the redistribution of wealth at a time of fixed levels of energy consumption. The unstable political climate that situation implies is most ominous indeed. The price of ignorance can indeed be very high.

VII. Decision Making: Can We Wait for Scientific Certainty?

Perhaps the greatest threat to our future security lies in a common misinterpretation by many citizens and decision makers of the loud and confusing debate among experts over the technical components of many public policy issues of future survival; that is, uncertainty in science suggests merely that we study more before we worry--or act.

Many people probably don't know whose opinion to trust on the bewildering issues of climate change, technology, and human survival. Unfortunately, the remaining choice is to trust no one, thereby avoiding the issues, a course of action that inevitably translates into maintenance of the status quo. Since measures designed to enhance the likelihood of catastrophe-free, long-term survival can be as expensive as they are uncertain of efficacy, it

is tempting to rationalize postponement of action on these perplexing matters until the scientists, economists, moralists, politicans, or other leaders of the debate are unanimous, or at least seem more certain, about what they are saying. At the same time, we often become preoccupied with more immediate crises--inflation, recession, taxes--and lose sight of the more distant calamities ahead. Unhappily, most democracies, like the United States, are in general responsive to relatively short-term concerns; and mechanisms must be devised immediately to encourage elected representatives (or even hard-fisted leaders in more totalitarian states) to place first priority on longer-term issues of human survival (perhaps by adopting some form of disaster insurance at an international level). A change in political consciousness, and ultimately political process, is essential.

But such forward-looking consciousness is a rare commodity. Returning to the case of climatic variability and a safe level of food reserves, I recall an incident in June, 1974, that I am fond of repeating, when Reid Bryson of the University of Wisconsin and I were arguing for just such a margin of safety with an Agriculture Department official before an audience of White House policy-makers. We pointed out that there has been over the past hundred years or so a drought of some significance in the Great Plains of the United States roughly every twenty to twenty-two years. Some researchers claim that these droughts are related to sunspot cycles, and others dispute this thinking as unfounded. We stressed that, regardless of possible causes for the droughts, the important consideration is that the next such drought is "due" in the mid-1970s, and thus prudence suggests that we be prepared with adequate food reserves, soil conservation practices,.... But food reserves are expensive and depress future prices for farmers and grain traders, we were told by the offical at the briefing. We agreed. However, he went on to repeat Agriculture Secretary Butz's belief that the government should nonetheless stay

out of the food reserves business regardless of the climatic risk. We protested that no one besides the federal government would voluntarily build up enough supplies to hedge against weather variability such as the twenty-two year drought cycle. Then a voice from the back of the room taught us a lesson. "Around here," he said sarcastically--referring to the terms of office of the U.S. congressional representatives, president, and senators--"the only cycles that count are the two-, four-, and six-year cycles."

This points out an apparent mismatch in time scales that could be one of our greatest threats. Whereas the climate can fluctuate over decadal periods or the adverse environmental and social consequences of premature deployment of large-scale technologies often are felt on the time scale of a generation, the political process is most effective in dealing with problems on yearly time scale. As the threats to our long-term survivability grow, this mismatch becomes, I believe, increasingly more serious.

VIII. Understanding and Predicting Climatic Change: The Need to Reduce Uncertainty

This difficult situation is made even more trying by the inability of present climatic theory and observations to provide more than order of magnitude estimates of the possibilities for climatic variability and their effect on food production on the one hand or the influence of technologies that create atmospheric pollution to affect the climate on the other hand. Therefore, it seems prudent that attempts to decrease the wide range of uncertainty about these climatic issues can go a long way toward helping decision makers choose policies that will both hedge against dangerous possibilities and at the same time minimize wasteful inhibition of needed development. In the short run we need to take a careful look at

the kinds of climatic fluctuations that have occurred in the past. This actuarial approach to climatic forecasting can help to tell us the kinds of food production fluctuations that could occur in the future if the weather of the past recurs. In the absence of forecast ability that is the best forecast that can be made. The notable efforts of Dr. James McQuigg and his colleagues at Columbia, Missouri of the National Oceanic and Atmospheric Administration in conjunction with the U.S. Department of Agriculture to look at food-climate relationships in the U.S. plains should be extended to other major granaries, not only in the United States and Canada but elsewhere in the world. At the same time studies aimed at determining the feasibility of predicting average weather in major granaries a month to a season in advance should be strengthened, but it must be recognized that this is a very difficult problem, one that has both observational and theoretical difficulties. Nevertheless, the value of such a forecast would seem to me to justify enhanced efforts at determining, at the least, the likelihood that such prediction is possible, let alone determination of factors that would permit such a prediction.

On the other hand, a second kind of predictive skill is needed: the ability to predict a change of the long-term average climate from human-induced changes in environmental conditions, such as the carbon dioxide level or heat released from power plant electricity generation. This predictability would not tell us the chronological way the climate would change from one season to the next or one year to the next, but rather would provide the mean or average picture of how the long-term statistics of the climate could change with external forcings like CO_2 increase. Considerable optimism is justified, I believe, that such prediction is feasible, since a very large externally changing forcing function, namely the seasonal march of the sun through the sky, causes a very large and predictable climatic

signal, namely, the seasons. Thus, we have demonstrable evidence that large-scale changes in the forcing of the climate system will cause detectable and reasonably predictable responses. As the impact of human activities grows in magnitude, it will be easier for us to demonstrate their influence on the climate and to predict them. This task requires further development of mathematical models of the climate, since these are the only tools that can test the response of the system to forcing functions for which the system has no previous experience. The difficulty we encounter at the outset is that verification of these models is often based on their ability to reproduce the known variations in the atmosphere such as the seasonal cycle. Therefore in order to verify these models for a problem such as determining the effect of carbon dioxide on the global climate, we must make these models reproduce known, but different, variations in the climate, such as the seasons. In order to gain confidence in their veracity, we must test any such models predictions against observations not only for atmospheric temperature, but also for variations in precipitation, radiation fluxes going up into space, changes in the reflectivity of the earth, and winds. Therefore, a companion observational program capable of providing data sets that are needed to verify the fidelity of the predictions of climatic models must be undertaken if we are to improve our confidence in the predictions of these models for problems of human impact on climate. Such a data set is necessary in its own right, to perform actuarial analyses of climatic variability.

Let me conclude by pointing out that many of the difficulties in predicting climate will require increased understanding in order to bring about improvements. The problem does not necessarily lend itself to quick "engineering solutions," whereby a large influx of effort and resources for a short time will provide a quick payoff. Rather, the commitment, I

believe, is to a continuous and perhaps expanding level of effort, where that level is determined in part by the progress at previous stages. Unsolved scientific problems like climatic predictability are best pursued through the market place of ideas, and thus I would prefer to see the effort spread among many independent research centers rather than accumulated into a central command. On the other hand, centralized tracking of progress at various remote institutions could help considerably by increasing cross-communications and insuring that important aspects of research do not fall between the cracks.

In conclusion, while it cannot be stated with certainty that increased effort and resources in the field of climatic studies will provide immediate payoffs in terms of forecast capability, it must be said that the costs of our ignorance of the knowledge and workings of the climatic system may already be unacceptably high, and that while assurance of success cannot be guaranteed, the value of obtaining better understanding of the climatic system makes this scientist comfortable with the feeling that support for climatic research is a worthwhile hedge against potential climatic crises.

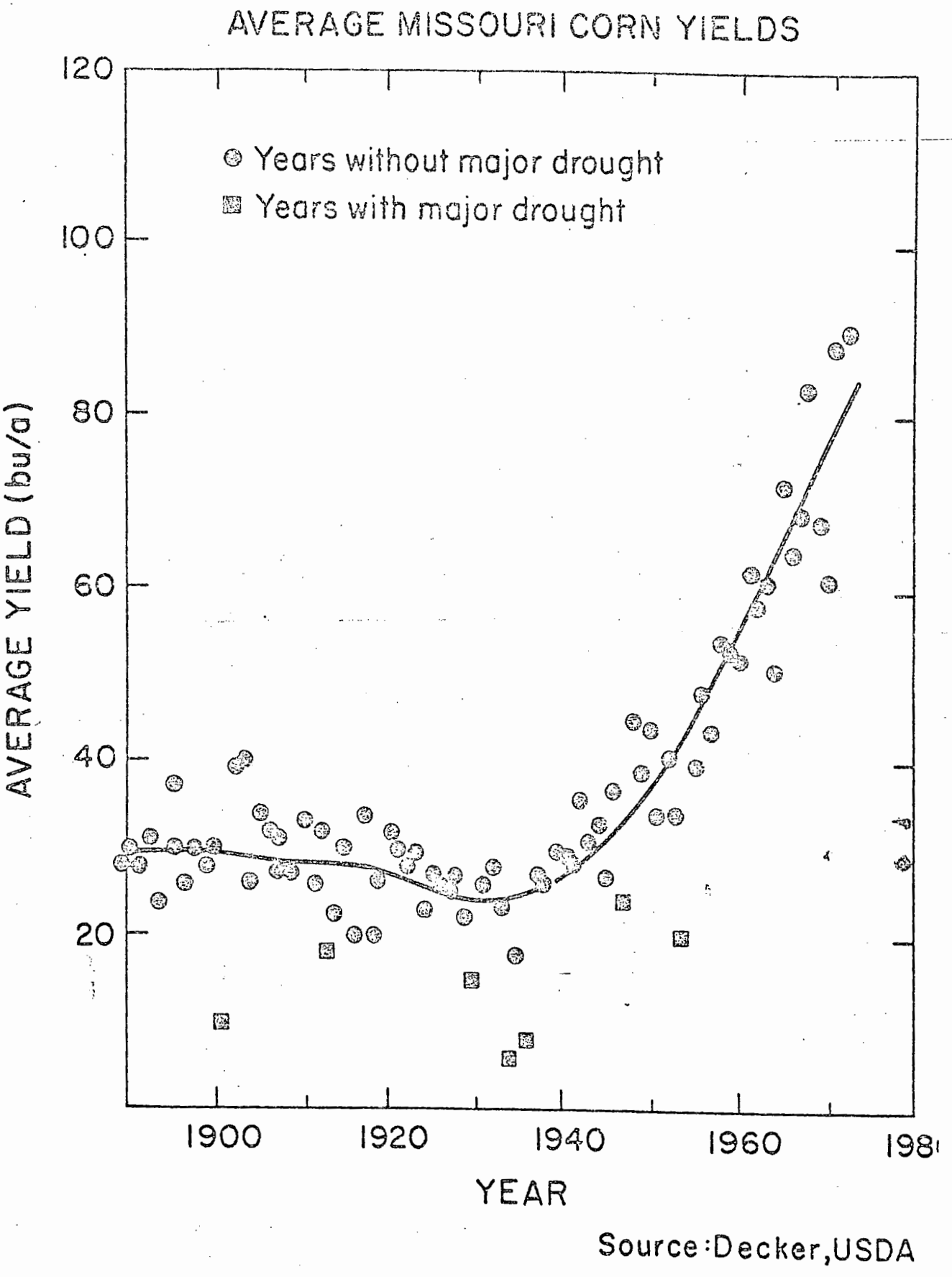
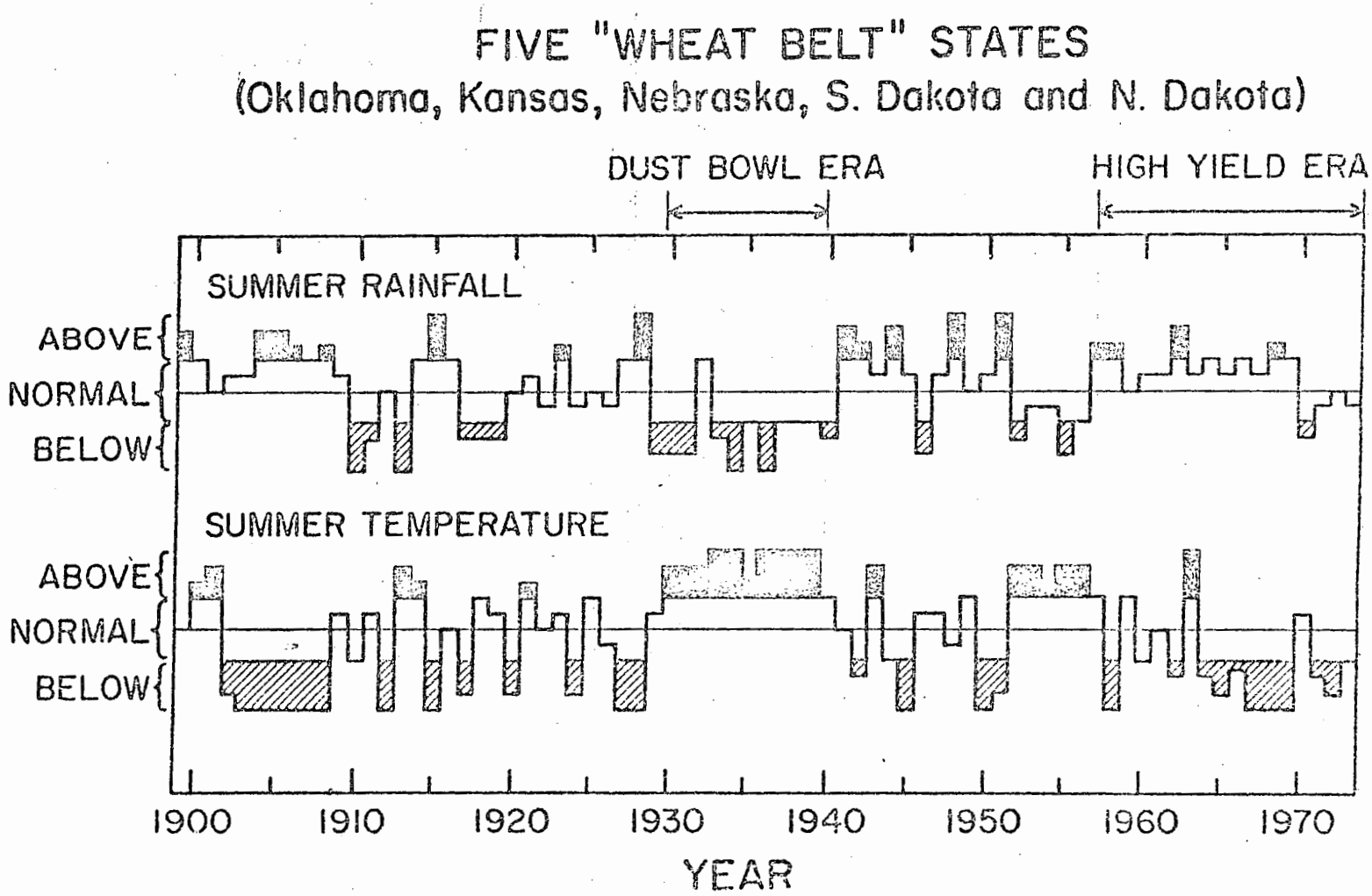

AVERAGE MISSOURI CORN YIELDS
Years without major drought
Years with major drought
AVERAGE YIELD (bu/a)
120
100
80
60
40
20
1900
1920
1940
1960
198
YEAR
Source: Decker, USDA

Fig 1



Source: D. Gilman, NOAA

F-12

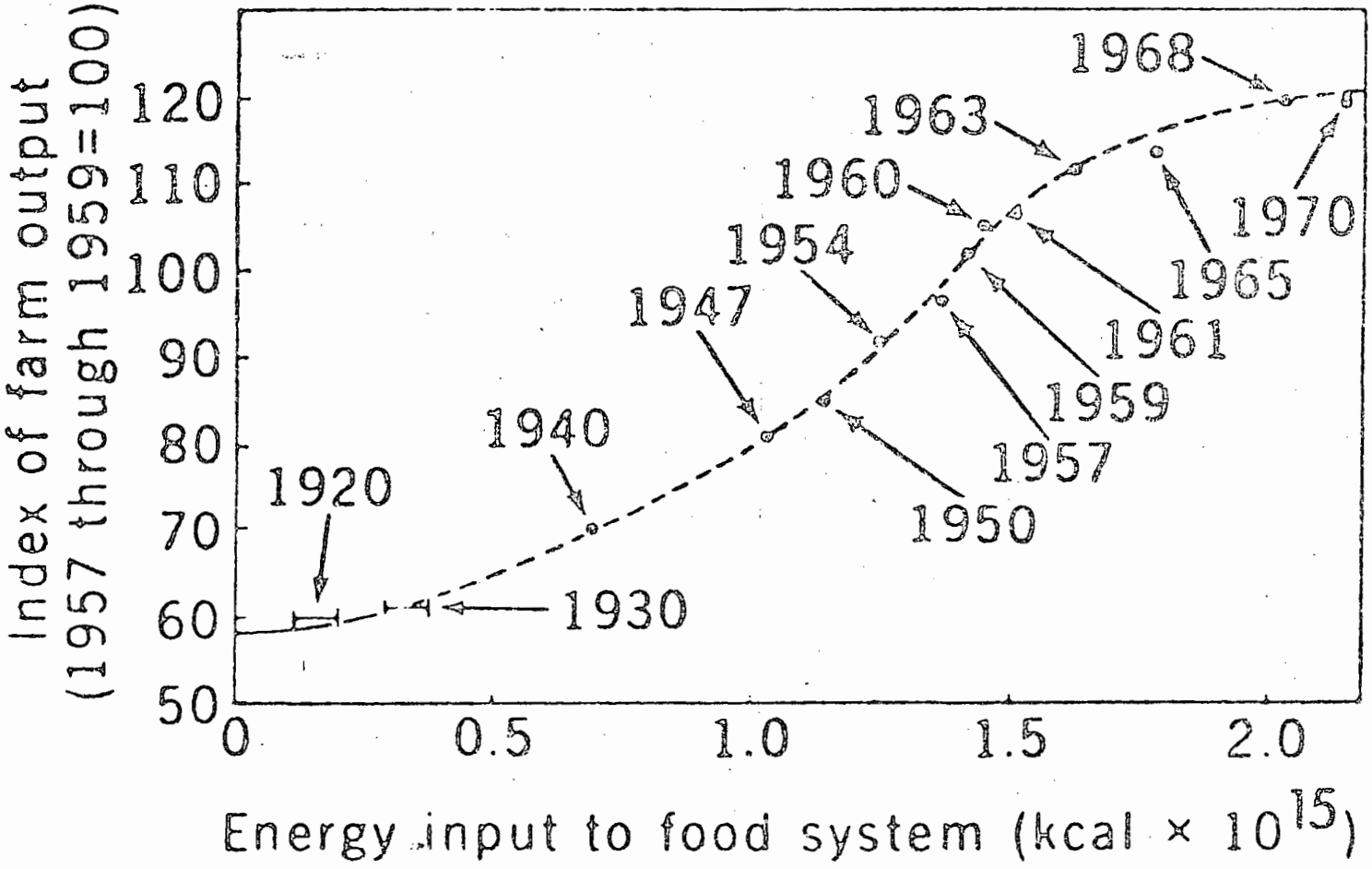


Fig. 3. Farm output as a function of energy input to the U.S. food system, 1920 through 1970.

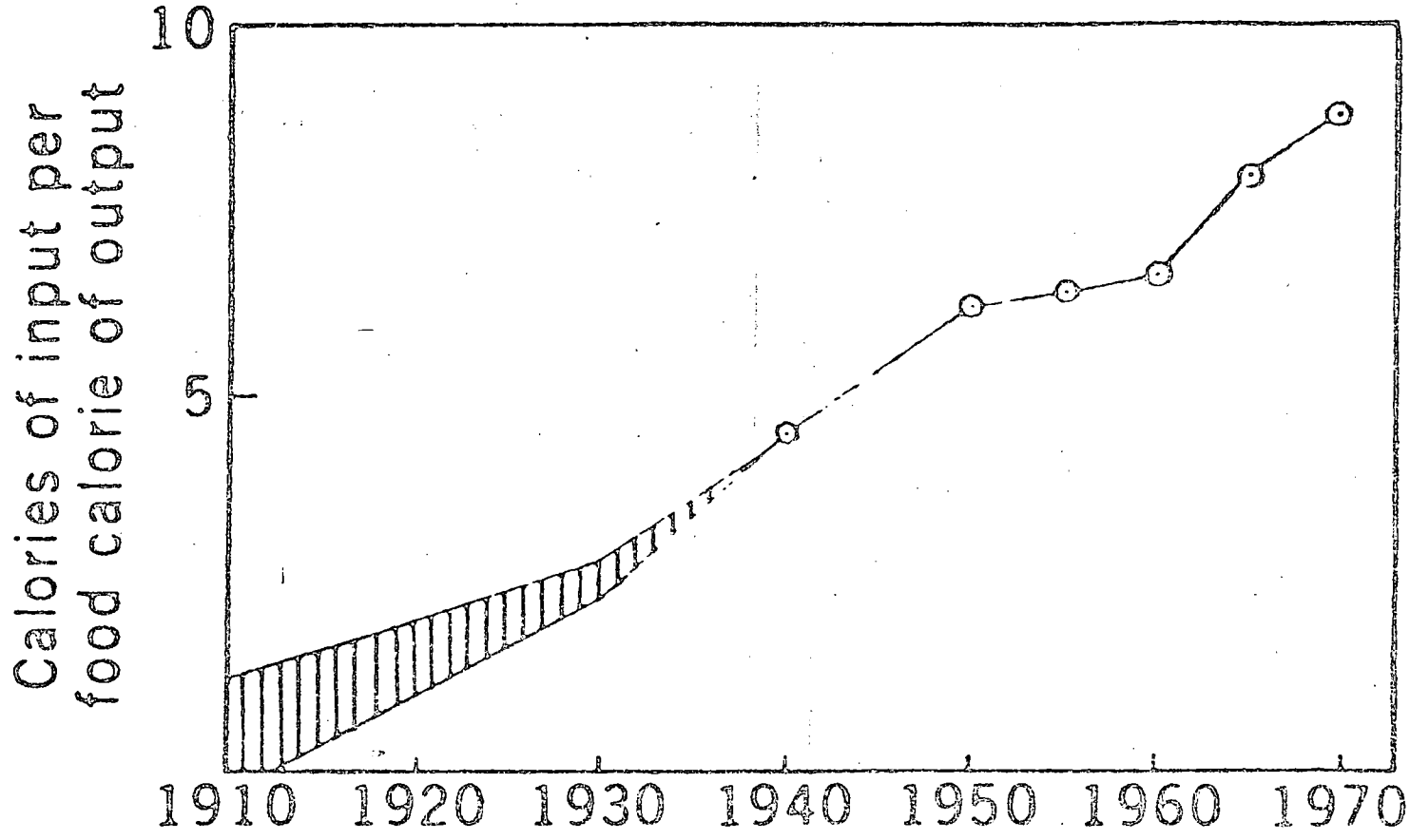


Fig. 4. Energy subsidy to the food system needed to obtain 1 food calorie.

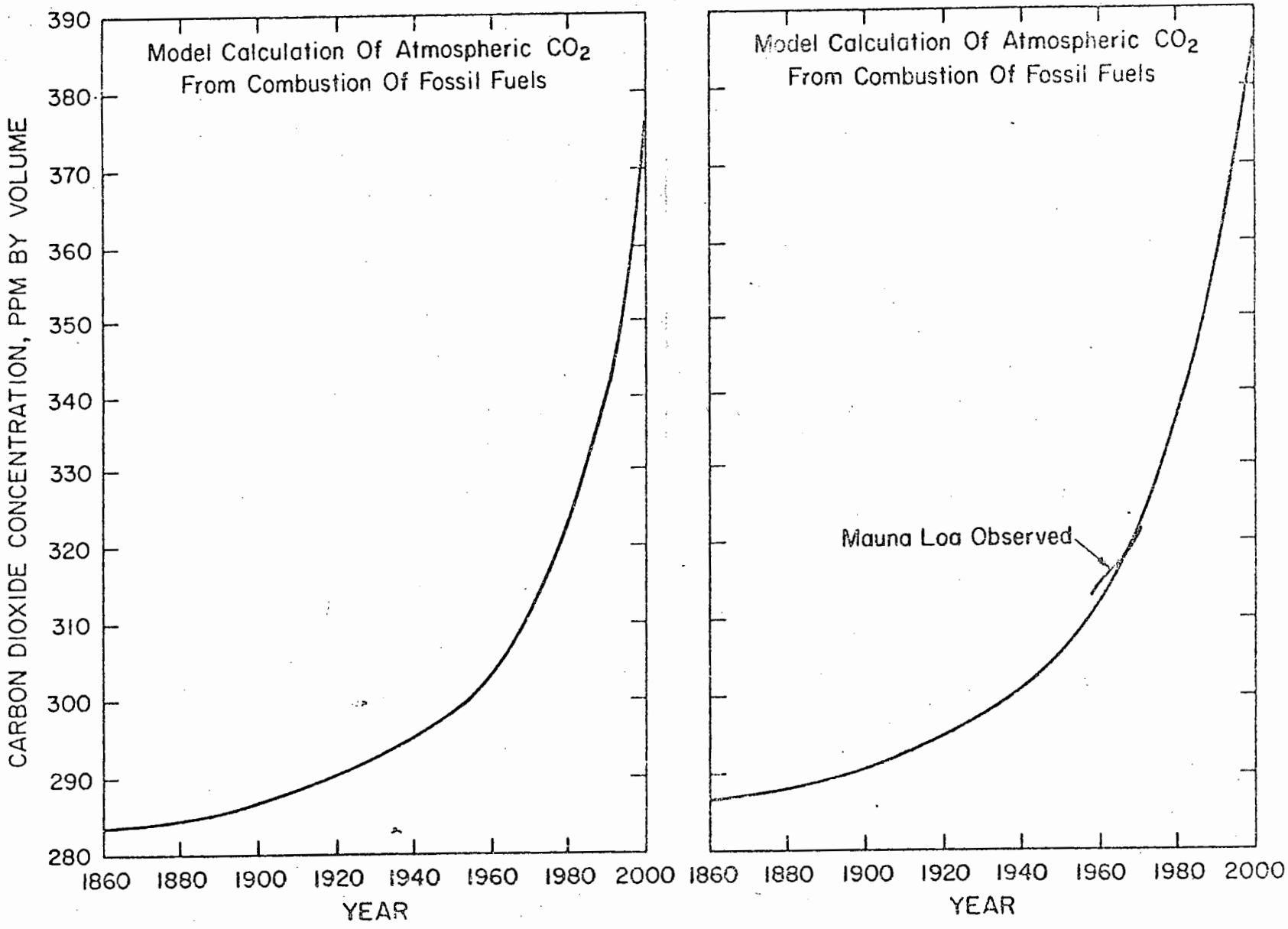

Model Calculation Of Atmospheric CO_2
From Combustion Of Fossil Fuels
CARBON DIOXIDE CONCENTRATION, PPM BY VOLUME
390
380
370
360
350
340
330
320
310
300
290
280
1860 1880 1900 1920 1940 1960 1980 2000
YEAR
(a)
Source: Machta, 1971
Model Calculation Of Atmospheric CO_2
From Combustion Of Fossil Fuels
Mauna Loa Observed
1860 1880 1900 1920 1940 1960 1980 2000
YEAR
(b)
Source: Machta and Telegadas, 1974

Fig 5

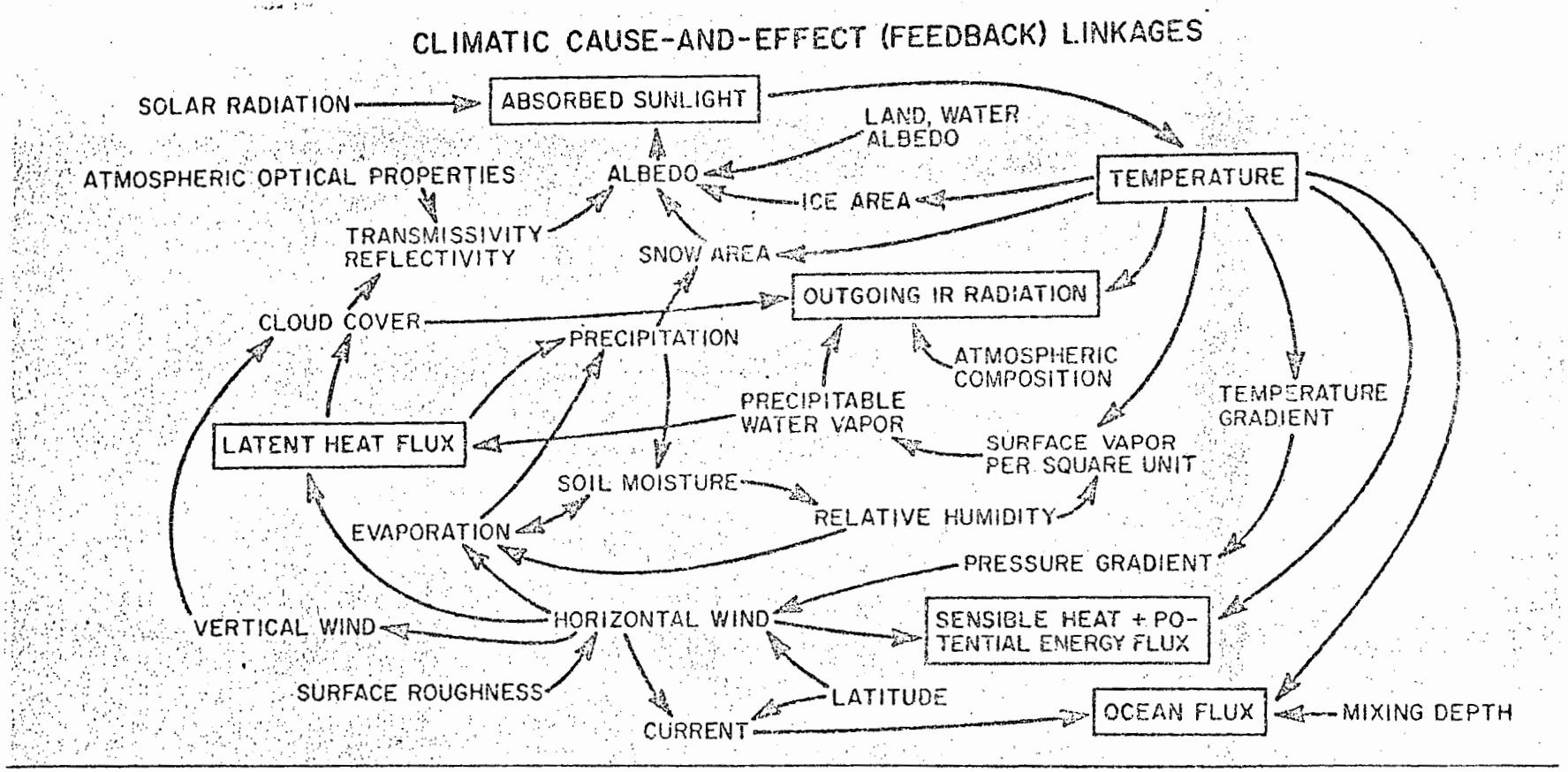

CLIMATIC CAUSE-AND-EFFECT (FEEDBACK) LINKAGES
SOLAR RADIATION
ABSORBED SUNLIGHT
LAND, WATER ALBEDO
ATMOSPHERIC OPTICAL PROPERTIES
ALBEDO
TEMPERATURE
ICE AREA
TRANSMISSIVITY
REFLECTIVITY
SNOW AREA
OUTGOING IR RADIATION
CLOUD COVER
PRECIPITATION
ATMOSPHERIC COMPOSITION
TEMPERATURE GRADIENT
PRECIPITABLE WATER VAPOR
LATENT HEAT FLUX
SURFACE VAPOR PER SQUARE UNIT
SOIL MOISTURE
RELATIVE HUMIDITY
EVAPORATION
PRESSURE GRADIENT
VERTICAL WIND
HORIZONTAL WIND
SENSIBLE HEAT + POTENTIAL ENERGY FLUX
SURFACE ROUGHNESS
LATITUDE
CURRENT
OCEAN FLUX
MIXING DEPTH

FIG 6

Will Congress Do Something About the Weather?

by Judith Randal

That the Nixon White House should have had a scientific mission and that a Democratic Congress should take it up where that White House left off may seem a strange state of affairs—even more so as the Central Intelligence Agency was involved. But in fact "A Study of Climatological Research As It Pertains to Intelligence Problems"—supplied by the CIA to the President's Domestic Council in August 1974—may turn out to be the impetus needed to launch a major publicly funded research initiative.

The situation two years ago was this. The United Nations World Food Conference was to be held in Rome in November and Secretary of State Henry Kissinger was eager to have the highest reaches of government explore in advance the political as well as the humanitarian ramifications that had caused him to call for the conference the previous fall.

In this context, it had come to the CIA's attention that Reid Bryson and his colleagues at the University of Wisconsin's Institute for Environmental Studies were predicting that anyone who thought agricultural productivity could be maintained—let alone improved in the Green Revolution tradition—was, in effect, living in a fool's paradise. The Wisconsin group, along with others, had detected what it perceived as a global climatic shift back toward weather conditions that had prevailed, in the words of the CIA report, during "the neo-boreal era of 1600-1850—an era of drought, famine, and political unrest in the western world." The CIA, of course, could not be sure that Bryson, et al., were correct. Nonetheless, it was so sobered by their forecast and by world population projections that it felt safe in concluding that "the politics of food will become the central issue of every government."

Indeed, had the Domestic Council been able to act on the agency's assessment, a National Climatic Research Plan—with inputs from the National Science Foundation, the National Academy of Sciences, and the National Oceanographic and Atmospheric Administration—might already be under way. Because of Watergate, however, the council lost whatever influence it had wielded to the Office of Management and Budget, and at OMB the entire matter fell to the bottom of the priority heap.

There it might still be had not the report become public in May and drawn the notice of Indiana Democrat Philip H. Hayes. Hayes, a member of the House Science and Technology Committee subcommittee, whose particular concern is the environment, had in 1975 introduced a bill (H.R. 10013) calling for the creation of a national climate program that would authorize the expenditure of $156 million over a three-year period for a variety of research objectives directed toward forecasting climatic changes as much as a year ahead. Now, he convinced the measure's co-sponsors—the subcommittee's chairman, George Brown of California, and Republican Larry Winn, Jr., of Kansas—was the strategic moment to hold hearings on the proposal and so give it a credible legislative history. The matter could come to a vote as early as the end of this year. More likely, however, definitive action will await 1977 when a new Congress may be in the mood and the position to boldly strike out on its own.

Whatever the legislation that emerges (several congressmen have other bills in the hopper), the hearings made it clear that there are two things scientists want most to see incorporated—besides, of course, adequate funding. One is an emphasis on the upgrading of climate sciences and career development for them, since the number of people in this country with advanced degrees in this field is now extremely small. Presumably this would entail not only the support and development of more university research centers, but also the awarding of postgraduate training grants.

The other is a long-range commitment to the gathering of more information and to its analysis and coordination in and out of government. Witness after witness told the hearings that a crash effort directed toward technological quick fixes would be inappropriate both because the present knowledge base is meager and because what are needed far more than spectacular attainments, like deliberate weather modification, are the means to factor considerations of climate into virtually every aspect of public policy. "Climatic changes can make the difference between the prosperity of a society and its misery and decline," said Charles L. Hosler, Jr., president of the American Meteorological Society and dean of Earth and Mineral Sciences at Pennsylvania State University, whose sentiments were typical of those expressed. "We must build flexibility into our social and economic strategies."

Weather modification technology, for example, carries with it the risk that rainmaking in some areas will create droughts in others, a potential source of international tension if there ever was one. Of equal international significance is the fact that nature seems to have dealt the Soviet Union a highly variable climate that lately has become highly

JUDITH RANDAL, Change Magazine's science policy editor, is science correspondent in Washington for the New York Daily News.

susceptible to drought and a shortened growing season. Most Americans assume that the massive Russian wheat lures of the early and mid-1970s are a passing phase. According to the experts, quite the opposite is true. Russian climatology, they say, is at least as sophisticated as ours and that nation's leaders are well aware that its food supply will probably be indefinitely precarious, undoubtedly a crucial element in their commitment to détente.

In addition, then, to considerations of the world's burgeoning population, the United States may have an ongoing stake in further wheat sales to the Russians if what it wants is stability and peace. It was the consensus of witnesses at the hearings that the U.S. would be well advised to better plan for such contingencies in advance.

The 1972 Russian wheat purchase, for example, meant less grain here at home for livestock feed and so led to an embargo on the export of soybeans, which in turn strained U.S. relations with Japan. And because grain reserves for relief and concessionary sales purposes were at an all-time low, millions in sub-Saharan Africa, Ethiopia, Bangladesh, Pakistan, India, Sri Lanka, and elsewhere either went hungry or died of starvation as a result of widespread crop failures during the 1970s in those countries. Improved climate assessment and prediction, therefore, are essential not only for dealing with emergencies but also for minimizing their domino effects.

The prospect of ever more mouths to feed on distant shores is having its effects at home, too—bringing under cultivation in this country more marginal land, with what precise consequences for the water table, soil erosion, and other variables no one really knows. Two years before his death in 1826, Thomas Jefferson expressed his concern that the conversion of much of his young country from forest to fields might not be entirely advantageous and hoped that studies leading to a theory of climate would be made. Today when the face of the land has changed so much that Jefferson might hardly recognize it—and though we have behind us the object lesson of the 1930s Dust Bowl—there has been surprisingly little progress toward that goal.

Walter Orr Roberts, for example—who upon his recent retirement as director of the National Center for Atmospheric Research in Boulder, Colorado, decided to devote his remaining years to the population-food-climate issue at the Aspen Institute for Humanistic Studies—told the hearings that he believes that a prolonged drought is in the offing for the nation's breadbasket stretching east from the Rocky Mountains. Roberts is among several scientists who share this conviction and who have suggested that sun spot perturbations may be involved. But neither he nor they have any plausible, detailed explanation for the hunch and this is the rule whenever most such predictions are made.

Another controversial theory maintains that the world is undergoing a cooling trend that may presage the onset of a new mini-ice age like that which decimated Iceland in the nineteenth century. But other scientists believe that what may be in store instead is a warming of the earth that would melt the polar ice caps and cause massive coastal floods in 50 years or so.

Incredible in a world amply supplied with computers to keep track of statistical data, where mathematical simulations and technology are kings? Not really. Such concerns have long had low priority and in many parts of the globe thermometers are so scarce that not even daily temperature readings are routine. Yet without constant and conscientious measurements of small fluctuations, reliable assessment of whatever larger trends are in the making becomes guesswork at best.

Furthermore, the capabilities of technology are uneven and not always as far along as some people may suppose. The lack of tools for the remote sensing of climatic conditions in the ocean is illustrative. Satellite measurements penetrate only a few millimeters below the surface of the water, and while the observations can be made by instruments and men deployed from buoys or oceanographic vessels, this is so costly that it has rarely been attempted on a global scale.

The price of such neglect may already have come high. Apparently temperature and other changes that result from air-sea interactions taking place on the water's surface have an enormous bearing on the abundance of fish and the plankton and other elements of the food chain on which fish and crustacean populations depend. While the 1950s demise of the California sardine and the more recent disappearance of the anchovy off the coast of Peru, for example, have been popularly chalked up to overfishing, many scientists believe that shifting climatic conditions were depleting these species anyway. Had this been reckoned with in advance, it might have been possible to seek out other fishing grounds, to turn to other species, or both. More comprehensive monitoring and analysis of the ocean's temperature patterns and shifting currents are vital for other reasons, too. Submarine warfare, deep-sea mining, and the ocean disposal of atomic and other wastes are some that come immediately to mind.

Scientists, students of climate, and politicians like Hayes also have their antennae tuned to various phenomena that strike or could strike closer to the backyards of everyday citizens. Intensive field studies of the 1,500 square miles east of St. Louis, for example, have revealed that average summer climates bring 80 percent more hail and 50 percent more heavy rainstorms than are visited on surrounding areas, a phenomenon almost certainly related to urbanization since it has been observed near other cities as well. And had L. Frank Baum written the Oz books in the 1970s instead of the 1900s, Dorothy and her dog Toto would probably have started their adventures in Indiana rather than Kansas since that is where most of the nation's tornadoes now occur.

Similarly, although no major American city has experienced a shortage of potable water since New York had to rationalize it in the 1950s, hydrologists have nightmares about what might happen if a serious drought imposed itself on the heavily populated corridor that has come into being the length of the eastern seaboard from Boston to Washington.

Such eventualities, Pennsylvania State University's Hosler pointed out at the hearings, call for regional storage and transport arrangements made in advance. Yet, to his knowledge, all officials have, if they remember the New York situation at all, treated it as a historical accident unlikely to recur.

Last but hardly least among policy concerns is that the climate issue and the energy issue are inextricably intertwined. Like those aerosol spray cans and the Anglo-French jet Concorde, nitrogenous fertilizers derived from petroleum may be weakening the blanket of ozone (tri-atomic oxygen) that shields the earth against too heavy a bombardment of ultraviolet rays. Far less publicized, however, is another trend whose implications, to hear the witnesses tell it, are fully as grave as the possibility that the destruction of the ozone layer could unleash a worldwide epidemic of skin cancer.

(*Continued on page 64*)

THE CIA AND THE ACADEMY

(*Continued from page 42*)

works to prejudice truly fruitful exchange between the two institutions, but it sees little wrong, it would seem, with academics engaging in agency work. It calls for "trust and confidence" between the CIA and the academic community, but not for an end to the relationship itself.

The rationale for a continuing CIA-university association bears strange resemblance to the defense offered at Nuremberg by those German academics who served the SD, the elite Nazi intelligence agency that became an autonomous branch of the SS under the command of Reinhard Heydrich. In a fascinating study published in 1975, George C. Browder of the State University of New York has examined the psychology of SD members. The SD intellectuals—an academic degree was almost a necessity for an SD career—viewed themselves as separate from those sections that engaged in terrorist police work and illegal dirty tricks. They saw themselves as part of "an idealistic intelligence service," not of a body that took part in unthinkable actions. Just as John F. Devlin could tell assembled historians that he finds agency covert spying within the United States reprehensible and claim to have known nothing of it, SD leaders "vainly sought to separate themselves from the unpleasant and distasteful activities of the Gestapo and from much of what the total SD implied." But, as Browder writes, "try as they might, they were members of the *total SD*."

While Nazi leaders sometimes forced reluctant SD officials to become involved in acts of mass murder, spying, and informing, CIA officials generally realize that erudite American academics prefer simply to do the research that professional operatives will put to practical use. Because of this separation of function, American professors working for the agency can maintain the fiction that their effort is separate from that of the total CIA. Dirty tricks may be viewed as unpleasantries quite apart from their own scholarly pursuits.

The CIA, of course, is not the SD, but structural parallels exist. Like these German intellectuals, American professors who rationalize their involvement with the agency try to separate their roles from its total operation, thus disclaiming their share of responsibility for such activities as the massive programs undertaken to overthrow the legal and democratic socialist government of Salvador Allende in Chile. That academics should have served the agency in the mistaken belief that they were engaging in disinterested research is simply evidence of the illusions sincere scholars harbor about those who offer them employment.

As AAUP President Van Alstyne makes clear, working for the CIA undermines the integrity and independence of institutions of higher learning. But despite the accumulated evidence of how the agency manipulates information and scholarship, it is now experiencing some success in re-entering academia and recruiting scholars. Perhaps this reveals how little American academics understand the role they play and the uses to which their research is put once they decide to do work for the agency. If the American university is to be restored as a sanctuary for learning and scholarship, it simply cannot be used either for covert operations or for contractual work undertaken on behalf of the Central Intelligence Agency. ■

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Science Policy

(*Continued from page 51*)

Since the onset of the industrial revolution roughly a century ago, the burning of fossil fuels has increased the amount of carbon dioxide in the air by about 12 percent. Although the levels vary somewhat—they fell, for instance, during the economic slowdown of the depression—there is evidence of a steadily accelerating upward drift. The fear, therefore, is that as the increased energy demands of the near-term future not only step up the use of remaining petroleum reserves but also bring on line coal gasification and oil shale, plant life and the oceans will reach their limits in handling the excess.

Again, climatologists cannot with any precision weigh what the effects would be. But they are reasonably confident that the global distribution of climate patterns could be so drastically altered in relatively short order as to plunge man into an alien world. And what really concerns them is the time scale. According to even conservative estimates, the point of no return might easily be reached early in the twenty-first century, whereas it is thought that at least two decades would have to elapse before any alternative to fossil fuels could be expected to take hold in any major way.

All in all, the old saw seems no longer to apply, if it ever did. Man not only talks about the weather but influences it, whether by slash and burn agriculture in the third world, which sends huge quantities of dust and smoke particles into the atmosphere, or by the industrial combustion of fossil fuels. From the sounds of it, furthermore, to count on technology to come to the rescue at the last minute may be naive in the extreme. Now is the time to begin to resolve the uncertainties. But only further developments will tell us whether these concerns will ultimately strike a sufficiently responsive chord either among the public or in Congress. ■

For a lucid and more comprehensive discussion of these matters, see The Genesis Strategy *(Plenum Press, $14.95), written by Stephen H. Schneider of the National Center for Atmospheric Research, with L.E. Mesirow. Schneider was among the witnesses testifying in favor of H.R. 10013.*

Answered,
KPS 8/2/76

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SPECIAL DELIVERY

July 16, 1976

Mr. Orin Kramer
National Task Force Director
Jimmy Carter Presidential Campaign
Post Office Box 1976
Atlanta, Georgia 30301

Dear Mr. Kramer:

In reference to your letter of July 1st, and my response of July 8th, please find enclosed both a draft position paper or speech on science, technology and society, and various background materials. You of course realize that we had but a few days and only one person at work--not a task force. Hence, the work is very sketchy. If additional work is desired, I would be happy to discuss it with you.

Sincerely,

Amitai Etzioni
Director

AE:sb
encs.

SCIENCE, TECHNOLOGY AND SOCIETY

draft position paper/speech

background material

Prepared by

Amitai Etzioni

The
CENTER FOR POLICY RESEARCH, INC.
475 Riverside Drive
New York, New York 10027

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SCIENCE, TECHNOLOGY AND SOCIETY

PREAMBLE:

A vigorous, thriving, well-nourished science and technology is not only vital to our nation's defense, economic growth, and culture; it is, more broadly, vital to our capacity to anticipate and respond creatively to the many opportunities and challenges the future presents. A nation is no longer measured just by the size of its territory, by the tonnage of its ships, the steel it produces, or the coal it mines. We look now to its number of scientists and engineers, the number of patents registered, the proportion of its resources dedicated to research and development, the number of its Nobel Laureates. It is no longer just the number or height of the smokestacks, but the square yards of laboratories, which measure the stature of a nation.

To the extent that ignorance is at the source of many of our national problems, science and technology will be indispensible in helping to arrive at solutions, from finding a cure for cancer and other illnesses to new sources of energy, to further enhancing our production of food.

A free society is free of dogma; it allows its citizens to be informed, form and express their own views, and act on them. Science embodies the freedom of inquiry, the incessant, unsparing search for truth. Hence, a free society is the only one in which science can truly thrive, and the endorsement of the scientific approach enhances the foundations of a free society. The questing, self-bettering spirit of a free society and science's unceasing search for truth support each other.

To look upon science and technology with hope and expectation of their contribution to a better world, and to invest in them accordingly, is not to view them as modern magic which can in short order make our problems disappear, nor ignore potential negative side-effects. Without demanding immediate payoffs at every point, we must nurture basic scientific research both because it is an end in its own right, and because in the longer run seeds of knowledge planted now will ultimately yield a rich spiritual and material harvest on which we and future generations will feast. Applied research and technological developments must be supported because basic research, by itself, cannot provide the tools and techniques we all require.

To ensure that the fruits of new scientific and technological advances are carefully evaluated and applied to purposes compatible with the national needs and priorities, their potential impact must be assessed openly and with public involvement. Thus, just as the voice and advice of science and technology are to be heard in the nation's highest councils, freely and unincumbered, and scientific and technological advice is to be made more readily available to our states, cities, and citizens--the people of America have a right to know where scientific and technological work is headed, what its effects might be, and to what extent the people would rather delay or do without some of the applications of science and technology, to reduce the risks to their lives, those to their children, or to the environment in which we all must exist.

A TRI-SECTOR PARTNERSHIP

A larger investment in basic as well as applied research and technological development will be most effectively and economically achieved not by making science and technology rely on government subsidies and grants, but via a combined three sector strategy encompassing the voluntary, private and public sectors. Thus, we must create a more encouraging climate for voluntary gifts and contributions to universities, colleges, and foundations which sponsor higher education and research, greater incentives for private sector investments, and--within the limits of overall budgetary constraints and priorities--increased government allocations.

(1) Voluntary Gifts and Contributions: As a national tradition, Americans have voluntarily contributed more for higher education and research, through direct individual donations and by establishing foundations, than people of all other nations combined. Government should take care that its actions not displace or distort such spontaneous initiative and involvement in support of science on the part of citizens and corporations. Several recent changes in the tax laws and proposals for other such changes--for instance, in the area of the sizes of gifts to members of one's family and inheritances that are tax free--may, unwittingly, sharply reduce future philanthropic contributions. The new Presidential administration will set up a task force to scrutinize specific proposals for changes in tax laws to examine and take into account their effects on voluntary contributions to higher education and research,

to encourage rather than undermine this tradition.

(2) Private Sector Support: Too much of our total Research and Development budget used to be government-supported, reaching nearly two-thirds in the mid-Sixties. By the mid-Seventies, the proportion of the government-support Research and Development was still above 50%. And, following the energy crisis, the call is for more federal support for Research and Development.

Basically, it would be best if the government did not have to involve itself at all in these matters, and if research and development were to be fully carried by the voluntary and private sectors. However, past experience shows that often these sectors cannot be exclusively relied upon.* First, we should study what hinders these sectors from conducting the needed Research and Development. A task force should examine to what extent excessive government regulations and guidelines curb business or universities from taking on the needed research work. According to testimony provided by Jordan D. Lewis, the Director of Experimental Technology Incentives Program, "regulation appears to have severely inhibited any form of innovation in railroads, caused over-investment in service innovations and underinvestment in price-reducing innovations in airlines, inhibited certain forms of innovation while encouraging others in electric utilities, and discouraged the growth of CATV in order to "protect" TV broadcasters from competition."

Second, we should examine whether the hindrances lie in an unpredictable economic environment caused by government actions such as changes in import/export policies and price subsidies (e.g., in the case of oil.)

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* See enclosed document from Business Week, February 16, 1976.

There can be no doubt, though that even after such hindrances are removed by striking hobbling regulations, providing a regulations ombudsman (to which those who are caught up in regulatory cross-fire, "Catch-22," and ambiguous meaning, can turn), and securing a more predictable environment (e.g., providing expeditious advance ruling on regulatory matters; refraining from zig-zag policies on oil price regulation)--that the government will still have to support scientific and technological Research and Development. However, the more the government moves from supporting the relatively inexpensive research toward the more expensive development of new technologies, the more it is vital to ensure that there is a genuine need or market for them. Too often in the past the federal government has subsidized not only the Research and Development work but also the capitalization of the new product, which either no one wanted; e.g., the Nixon administration gave high priority to the development in Morgantown, West Virginia of an automated high-capacity transit system using four- to six-passenger vehicles that would travel on special guideways--a project in trouble basically because it is not marketable. In other instances, federal capitalization has led to a whole industry becoming a sort of ward of the state, as with aerospace and nuclear energy.

Wherever possible the government should rather rely on incentives to the voluntary and private sector to do the work the public good requires, be it through federal guarantee for loans (rather than outright grants or loans), accelerated write-offs for capital Research and Development costs, and issuance of interim

patents. The government may use its own procurements to provide the initial orders or to guarantee a minimum market for a new device, e.g., a more energy-economical bulb, when such support is necessary and justified.

(3) Government Support: While "Uncle Sam" should not and cannot afford to behave like the proverbial rich uncle to whom all come whenever they have a need or shortfall to ask for an increased share of the taxpayers' dollars, it must be recognized that science and technology are believed to have suffered over the recent years. According to a 1975 report of the natural science board of the National Science Foundation, the proportion of the GNP spent on Research and Development has declined over the last decade in the United States while growing substantially in the USSR, West Germany, and Japan. The number of scientists and engineers per 10,000 population declined in the United States after 1969 but continued to grow in both the United States' main adversary, the USSR, and main competitors, West Germany and Japan. The fraction of the GNP dedicated to Research and Development in the United States declined from 3% in 1964 to 2.3% in 1974, representing about $10 billion less allocated to Research and Development today than would have been had the proportion held steady. At the same time the number of science engineers in Research and Development fell from 558,000 in 1964 to 528,000 in 1974.

While studies suggest that scientific productivity at the main centers has not fallen off, this may well yet prove to represent a false security due mainly to a long lead time before the true effects are felt.

In particular, as financial shortages force universities to limit and cut back the size of the faculties, more and more positions are being reserved for older, already tenured scientists, and younger scientists find fewer opportunities open to them. The resulting career uncertainties cause some to leave science, and discourage ever more promising students from pursuing scientific careers in the first place. National Science Foundation figures show that between 1968 and 1974 the proportion of young investigators decreased significantly in relation to the total number of faculty investigators--for example, by more than half in physics and about 40% in chemistry. A study by Professor Bruce L.R. Smith shows that "research opportunities for outstanding young scientists will be scarce until the normal pattern of retirements beginning around 1985 eases the situation." But young scientists will not wait that long. The vitality of science depends on the steady influx of young talent, and it is the young scientists who make many of the breakthroughs. To forestall the current trend and ensure the continuity and renewal of the scientific profession is a matter which requires our urgent attention.

Rather than paying universities to hire or retain young scientists, thereby intervening in their internal policies, a more flexible alternative is possible: to make available a large number of 5 to 10 year fellowships for senior scientists 5 or 10 years from retirement. By taking over the universities' remaining financial obligations to a portion of senior tenured faculty, the fellowships would free existing university resources to hire members of the upcoming scientific generation, or other promising scientists, as the univer-

sities deem wise. The fellowships would enable the senior scientists receiving them to engage full-time in research, teach outside the major science centers (as they no longer will be tied to them) or serve on a Science Peace Corps overseas or as science advisors to state and local governments--and participate in various kinds of activities to expand the general public's understanding and appreciation of science.

AN EARTH-NASA: AN AGENCY FOR DOMESTIC POLICY DEVELOPMENT

All new government programs should be carefully "R&D'd" before being launched, and old ones should be reevaluated. Relevant existing federal government capacities should be pulled together for greater efficiency and effectiveness into a domestic policy development agency--a kind of earth-oriented NASA.

We have learned from the social programs of the Sixties, the campaign against drug abuse, crime and cancer, and the recent drive to develop new energy resources, that in trying to use national resources to overcome our social problems, highly ambitious projects have often been attempted without a sufficient knowledge base or back-up. Multi-billion dollar programs, conceived in Washington, were introduced based on verbal concepts and with little testing or prior research. We cannot afford in human or financial terms the expensive wrecks that result. We need fewer but better researched and developed government programs.

It is fairly standard practice in the engineering of new space craft, weapons, airplanes, even toys, to move systematically from a theoretical concept to a pencil-and-paper design, to a small scale model, which is subject to various tests, leading to the

production of one or a few full-scale prototypes, all before mass production is authorized. Normally at each stage modifications are made on the basis of experience gained precisely because as a rule we cannot anticipate, reason out, all reactions and developments. New government programs need to go through as full and as careful a process of Research and Development as new technologies. The effectiveness of this approach is illustrated by studies in New Jersey which have shown, in actual field experiments, that the fear that people's motivation to work would be undermined if they were entitled to a secure minimum income are basically unfounded; by experiments with housing allowances which have suggested the advantages of letting people select their housing in the marketplace rather than providing them with subsidized housing; and by still other experiments which have cast doubts on the value of performance contracting in teaching (in which the teachers are paid according to how much the pupils learn)--before this idea was widely applied.

The scientific and technological research needs of our domestic programs are now being served by Research and Development efforts dispersed widely among scores of federal agencies and literally hundreds of subdivisions, bureaus, and offices within them, as well as outside the government under contract with universities, research corporations, and private industry. To some extent this arrangement is both inevitable and desirable. Most agencies have some specific research needs of their own that they themselves can probably best serve. The existence of a multiplicity of Research and Development centers in the voluntary and private sectors helps to insure that a given approach will not monopolize the funds and prematurely drive out others which may prove to be more productive in

the long run. However, the existing pattern is very long on pluralism but too short on coordination, cooperation, and often quality. It amounts to a fragmented, often chaotic approach to Research and Development.

Without subscribing to simplistic analogies between the space program and solving social problems, NASA does provide an administrative prototype since social programs are akin to the space effort in requiring a management structure capable of linking in partnership the universities, industry and government. And the concentration at one agency of scores of disparate programs such as the Experimental Technologies Incentives Programs, now in the Bureau of Standards, Research Applied to National Needs now in the National Science Foundation, the National Institute of Education, now on its own, research on crime prevention in the Law Enforcement Assistance Administration, domestic Research conducted in the Departments of Agriculture and Defense and in the National Institute of Aging, and scores of other such programs, into one agency, would give applied social Research and Development the proper visibility and support (leaving the support of basic research to the National Science Foundation and National Institutes of Health.) The concentration would provide the critical mass necessary to create a distinguished community of researchers, often not attracted to small programs which tend to lack in intellectual community and protection against undue bureaucratic and political intervention and will provide the cross-disciplinary vantage points good policy research surely requires.

Among the many reasons for favoring a domestic policy development agency which would bring together existing fragmented activities

are the following three. First, in many domestic-oriented agencies research is an administrative stepchild. Because research is neither the primary mission, nor the primary means of fulfilling the major missions of these agencies, only a small fraction of their budgets are devoted to it. Only rarely are its special needs adequately understood either by the agency heads, whose backgrounds and training tend to be neither in research nor in technical development, or by the civil servants who stand between the technological division and the agency heads.

Second, the fact that many of the numerous agencies engaged in the domestic areas now have Research and Development facilities of their own, leads to waste and duplication. While some of these facilities are area-specific, others--such as computer centers and testing grounds--are not. Establishment of a federal Research and Development agency specializing in domestic missions would seem more economical than support of Research and Development in each of the numerous agencies and subagencies with a domestic mission.

Finally, many domestic program efforts and their research needs are interdisciplinary and interdependent. New transportation systems, for example, are often designed without sufficient regard for housing problems, housing projects are designed without recognition of the problems of crime control, and so on. To the extent that various specialized efforts are placed under one administrative roof, the likelihood will be increased that both the negative and the positive "side effects" of new approaches and their place in domestic programs will be more fully taken into account.

TO INTEGRATE SCIENCE AND TECHNOLOGY IN THE CONTEXT OF OUR VALUES:

(a) Have the voice and counsel of science on the highest policy level--in the White House. There are few matters of public policy in which scientists cannot help shed light and which their expertise does not touch, whether it be a matter of energy, population, land use, space, defense or whatever. Hence, under the new administration science and technology will again be represented in the White House in the form of a science advisor to the President, backed up by four deputies, a staff, and a policy council. Their endeavors should encompass both bringing order, coherence, and coordination to our science and technology policy, and establishing and advancing the contributions science and technology can make to other policies and programs. That is to say, they should be both a voice speaking on behalf of science and technology, and contributing to other national policies. Here there is a special place for the social and policy sciences to develop their contribution because of their special concern and evolving expertise in system-linkages which bridge science, technology and society.

(b) We need to ensure that the development and especially the application of science and technology is in harmony with our social priorities and basic values. Public Law 94-282 (94th Congress H.R. 10230, May 11, 1976) goes a long way toward providing for mechanisms to establish Research and Development priorities for federal investments and coordinating government policies in this area, but the Ford Administration has not implemented many of these, nor has the White House used the discretionary power the law provides it. The voice of science and technology in the White House was silenced for a good part of the Nixon-Ford administration years.

A 1975 American Association for the Advancement of Science White Paper criticized the federal government's current approach to Research and Development investments as more tactical than strategic, and characterized the reliance on a tactical crisis-type of scientific and technical response as "wasteful and disruptive of human and material resources." As one of its conclusions the White Paper notes: "Our view of [the] future persuades us that the country's goals and objectives are linked closely to science and technology, and that the arrangements for policy analysis, planning, resource allocation and management should reflect that linkage."

After reviewing carefully, as part of the reorganization of government, the procedures outlined in Public Law 94-282, a new drive will be launched to put these mechanisms to work, to ensure that the priorities of support for Research and Development are compatible with the nation's priorities and to make order out of the chaos of scores of agencies, each pulling the Research and Development program in its direction.* As Dr. Edward Wenk, Jr., of the University of Washington, asked, does it make sense for us to spend $30 billion annually for Research and Development, but less than .5 percent for study of delivery systems, despite repeated reports that programs often fail not because of inadequate scientific and engineering input, but due to weaknesses in system design and implementation? Is it proper for us, as Senator Edward M. Kennedy asked, to spend $4.8 billion on Research and Development in nuclear power, but only $331 million on coal research and only $67 million on solar energy research? Should we spend less on research on

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* For details, text of the law is enclosed.

far-away planets? Have we neglected agricultural research? Are the social sciences able to provide us more clues as to how to deal with crime, poverty, alcoholism? What are the lessons of our efforts of the past several years to fight cancer more directly by focusing on applied and clinical research as opposed to the preceding basic research emphasis? And, what are the lessons of our recent efforts to focus research on energy needs? These questions have not received their due attention and require urgent answers as we seek to align our Research and Development priorities with our national ones.

(c) To help evaluate the impact of new scientific and technology developments, a Presidential Commission will be set up, composed of scientists, engineers, social scientists and humanists, to review these matters in public hearings. As a distinguished committee of scientists and scholars, members of the American Association for the Advancement of Science Committee on Scientific Freedom and Responsibility, pointed out: "Those for whom the advancement of knowledge is a supreme value might believe that, in basic research as distinct from applied science and technology, no subject should be declared off limits. Yet there are clear inhibitions on some kind of research involving human beings, indeed animals. Today we are increasingly conscious of the need for informed consent in studies of human physiology and behavior that may involve risk to the experimental subject." The report goes on to explore the problems in conducting experiments involving children, other experiments which might be "morally degrading or psychologically

damaging," or even ending life. Some significant progress was made in this direction by the appointment of a Commission for the Protection of Human Subjects and its work. However, the Presidential Commission suggested would have a much wider scope. Its province will not be limited to those directly subject to experiments, e.g., inmates used for drug research, but to the potential impact of scientific breakthroughs and technological developments (such as experiments with changing the structure of DNA and exploring the behavioral meaning of XYY chromosomal patterns) on all of us. At stake is not just the lives, safety, and psychic well-being of a few hundred persons studied (not to be taken lightly) but those of all members of society which might perish if genetically modified bacteria for which there is no known antibiotic run wild, a nuclear chain reaction is unleashed, or the protective atmosphere is stripped away. The purpose of the suggested Commission is not to restrain the freedom of scientific inquiry--its free spirit is essential for a free and vital society--but to alert policy makers, citizens, and the scientific community itself to the broader social and moral implications and consequences of the applications contemplated for new scientific discoveries and technological innovations, so that proper use can be assured and abuse avoided. (For details see the Mondale bill, enclosed.)

(d) Public openness: Science and technology need to be protected from crippling political interference, but need not and should not be cloistered. Scientific freedom need not violate other basic ethical values or the common good. Ethical values and the community well-being in some instances call for intro-

ducing safeguards on the conduct of research as well as on its applications. Nor can all technological developments be welcomed, in the name of science; their impact on the environment and on our society and personal lives must be carefully assessed and evaluated.

For science to flourish in a free society it must enjoy public appreciation and understanding of its missions and means. Open discussion and open decision-making regarding ethical issues involved in certain forms of scientific experimentation and application can further these aims. Except where genuine issues of national security or individual privacy are at stake, secrecy is as out of place in the conduct of science as it is in the conduct of democratic government. Thus, as the distinguished professor Paul Ramsey of Princeton University pointed out in his book, The Ethics of Fetal Research, guidelines concerning experiments to be conducted on fetuses were developed in closed sessions rather than open ones and following public hearings. Professor Amitai Etzioni of Columbia University made the same point concerning the uses of amniocentesis. Similarly, Congress passed a welcome amendment to the National Science Foundation FY 1976 authorization bill, H.R. 4723, requiring that all instructional material used in connection with any National Science Foundation funded program be available within the school district for inspection by parents of children engaged in such programs.

Among the initiatives in public involvement the new administration would seek to promote and extend is the National Science Foundation's program of Science for Citizens; in particular,

its efforts to enable non-profit citizens' public interest groups to acquire technical expertise to assist them in dealing with scientific and technological aspects of public policy issues.

The next administration will seek to apply the "sunshine" policy of openness to such significant decision-making regarding science policy while protecting the privacy of individual scientists involved, for instance, in peer review proceedings.

Along with opening up the processes involved in initiation and conduct of research, greater efforts must be made to ensure that findings and developments made at great expense reach those who may be able to use them. Scientific findings or technological developments achieved in government labs or supported with government funds in particular should be accessible to the business community unless such access violates national security, property or individual privacy rights. State and local governments should be helped to develop their own offices of science and technology so they will be more able to absorb such findings and developments and adapt them to their own needs.

THE INTERNATIONAL COMMUNITY

Our scientific and technological resources are among our best means of helping other nations in ways they may welcome as constructive and non-interfering. Hence we should focus on developing means of employing our great scientific and technological capacities for greater international welfare. The United States cannot and should not seek to be either the world's policeman or its provider.

While we should extend a helping hand to other nations, to aid the victims of earthquakes, floods and other natural disasters, encourage our young men and women to do volunteer work abroad, and make contributions to other nations' development efforts--we realize we cannot carry the world's burden on our shoulders and should not make them dependent on us.

One of our greatest opportunities to contribute to the world lies in the realm of science and technology. Our breakthroughs in the development of new medical knowledge (e.g., the polio vaccine), instruments (e.g., computers, photocopying), communication (e.g., satellites), and scores of others, have already benefited citizens of all nations. It is of the essence of scientific riches that unlike economic resources they can be given, shared and used everywhere, and yet not be depleted or lacking in our own home. Thus, if we should find a cure for cancer, a cheap and efficient way to milk the sun, or to desalt the ocean's water, these would serve all mankind and we should not be lacking.

Special care should be taken that when we carry out scientific and technological studies in other nations, their scientists and engineers and other personnel are as fully involved as is practical, to help them develop their own capacities and to counter any charges of exploitation.

The bill for several of our scientific and technological programs runs into hundreds of millions, even billions. Collaboration with other nations, be it on space work or combatting disease, will both tie us closer together in a peaceful pursuit and reduce

our costs. Science is by its very nature an open, international enterprise and should be pursued in this manner.

Finally, in a small number of areas scientists themselves have widely urged that certain lines of research be delayed until their safety can be assessed, and adequately insured, be it study of modification of DNA, experiments with "test-tube babies," exploring the significance of XYY chromosomes for criminal behavior, or of subliminal advertising. Clearly such "moratoria" will be effective only if we can gain the cooperation of the international scientific community. We should thus do all we can to promote that community's development, through sponsorship of international exchange of scientific and technological information, sponsorship of international conferences and meetings, and participation in international scientific agreements to promote--or if deemed necessary to postpone--particular lines of research.

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