Research Policy as an Agent of Change

Workshop Report

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About the Cover:

“A view down the middle of a boron nitride nanotube,” by Vin Crespi, Penn State Physics (1997).

A team led by Vincent Crespi, associate professor of physics, has simulated carbon nanotubes that are smaller and stronger than any other nanotube. Using supercomputers in California, Michigan, and Texas to model the electronic states and total energies of various carbon molecules, Crespi and his colleagues discovered a tetrahedral carbon atom that creates tight and stable bonds to form tiny tubes only six atoms across--the smallest diameter theoretically possible. Crespi believes they may prove very useful in nanotechnology applications.

Research Policy as an Agent of Change

Decision, Risk, and Management Sciences Program
Economics Program
Science and Technology Studies Program
Societal Dimensions of Engineering, Science, and Technology Program

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I. Executive Summary

In October 2003, an NSF-sponsored workshop on research policy as an agent of change was held in Tucson, Arizona, under the auspices of the University of Arizona. The workshop explored the role of research policies in a time of significant scientific, technological, and social change. Scholars from a wide range of relevant disciplines, as well as a number of NSF staff, met for two days to discuss what is, and what is not, known about how research policy contributes—in both intended and unintended ways—to major societal transformations.

This report is intended to capture the central themes of the workshop discussions. It begins with an executive summary that presents the participants' main conclusions. The body of the report describes major issues addressed in the discussions. These issues have been grouped under the headings infrastructure, benefits of research policy, unintended consequences, and critical research needs. The appendices present the workshop agenda, the short statements that participants wrote prior to arrival in Tucson, and brief descriptions of the small group discussions that took place on the second day of the workshop.

Participants reached three main conclusions:

1. A focused effort to study research policy as an agent of change (RPAC) is urgently needed.
2. Studies of RPAC will require the use of diverse research methods informed by a range of disciplinary, interdisciplinary, and multidisciplinary perspectives.
3. NSF should explore ways to encourage research in this area.

The next section elaborates on each of these themes in turn.

1. A focused effort to study RPAC is urgently needed.

Science and technology are integral to major social, political, economic, and environmental transformations, with significant implications at local, national, and global scales. For this reason, understanding the processes that shape developments in science and technology is a critical goal for the social sciences today. Because research policy influences these processes in myriad intended and unintended ways, the study of research policy and its role as an agent of change merits sustained attention.

The term *research policy* is subject to different interpretations. In its most general form, research policy can be thought of as "a strategy for achieving developments of new knowledge, new forms of expertise, and new infrastructure." [1]The term may refer exclusively to the formal policies of governmental science-funding agencies. Participants at the workshop agreed, however, that a more encompassing concept of research policy is needed to understand the forces at work

[1] See paper by D. Johnson, Appendix C.

in contemporary research systems. These systems feature the activities of a diverse mix of public and private organizations that use a wide range of mechanisms to pursue goals related to resource allocation, implementation, and evaluation of scientific research and technological change. Accordingly, this report employs the term research policy to designate a multitude of strategies for developing knowledge, expertise, and infrastructures that constitute the frontier of scientific inquiry:

- Research policy encompasses a range of substantive areas pertaining to public and private investments in R&D. These include efforts to create research infrastructures; influence the exploitation and commercialization of research products; govern the conduct of research (e.g., as it relates to human subjects, environmental concerns, and accountability issues); and shape institutional dimensions of research systems, including the organization of scientific inquiry and its reward systems.

- Research policy includes not only governmental actions aimed directly at influencing R&D, but also encompasses the activities of such organizations as scientific advisory bodies, regulatory agencies, university administrations, standards setting and professional bodies, and courts—all of which also shape the production, use, and diffusion of knowledge.

- Research policy is shaped by a range of actors from all branches of government, industry, universities, foundations, venture capital firms, professional associations, non-governmental organizations (NGOs), and civil society. These operate and interact on national, state, local, transnational, and international levels.

- Research policy involves a range of mechanisms, including budget allocation, legislative authorization, industrial policy, non-state policies (such as university intellectual property rules), public-private partnerships, consortia, R&D tax credits, etc. Explicit, formal policies and informal policies, embedded in patterns of practice, are both important.

Research policy is frequently treated as a "black box" that is not systematically examined. But because research policy plays such a significant role in contemporary research systems, understanding its operation is of critical importance for informed decision making. Far too little is now known about precisely how research policies are implicated in social and scientific change. A multidisciplinary effort to address this gap in our knowledge would aid policy makers and inform the public debate on a host of issues.

A variety of important intellectual and practical concerns fall under the RPAC rubric. RPAC research can contribute to improving strategies for directing and regulating the production, use, and uptake of knowledge. To achieve this end, we need to better understand both the impact of research policy and the processes that shape it. Thus, RPAC should encompass studies that treat research policy as an independent variable and studies that treat it as a dependent variable. Studies are needed that move beyond linear models of policymaking (which typically progress from agenda setting, to decision making, to implementation, to evaluation) to capture the complex ways that governmental, industry, and university policies interact.

The study of research policy should not limit its focus to decisions and mechanisms that are actually put in place, but should also pay attention to roads not taken and counterfactual examples. There is a critical need for studies of agenda setting, of the implications of non-decisions, and of additional ways that institutional structures and organizational practices contribute to the neglect of potentially important research. Identifying how policies contribute not just to reducing but also to producing gaps in knowledge can have important practical implications, for it can suggest new ways of achieving social goals.

Beyond governmental and non-governmental policies, RPAC research should illuminate how institutions, culture, and politics shape the environment in which knowledge is created and put into use. Changes in the ecology of knowledge making have far-reaching effects, but their influence can be hard to discern because they can arise in many different organizations in geographically dispersed locations. Media coverage, accountability rules and structures, popular culture and mass media, legislative and legal decisions, and norms regarding commercialization all may influence this ecology. RPAC research should address how explicit and implicit policies, as well as historical contingencies, alter the environments and institutions where research takes place.

2. Studies of RPAC will require the use of diverse research methods and disciplinary perspectives.

Research in the RPAC domain is challenging. Studies using quantitative methods are often hindered by a lack of data. Workshop participants extensively discussed the need to improve the kinds of data that are available for research on research politics and their implications. Strategies to create improved databases, with broad coverage of government, corporate, and university R&D, would be an essential aspect of an RPAC program. In addition to databases, the research infrastructure should include archives of policy documents and other materials relevant to case studies and historical analysis of research policy. For both quantitative and qualitative studies, access to data that illuminates RPAC issues is often limited, owing to proprietary or political concerns. Beyond databases and archives, there is also a need for better measures of the effectiveness of research policy.

Ethnographic and qualitative studies are also needed to enrich and deepen understanding of RPAC complexity. For example, developing a detailed understanding of how policies interact with research practices requires *in situ* studies in specific local sites. Regulations, guidelines, and other policies are often adapted and transformed as they are implemented, and qualitative research is needed to examine such processes. In addition, qualitative research can shed light on the formation of research policy discourses, illuminating the ways that even subtle changes in categories, concepts, and analytic frameworks can have far-reaching impacts.

A recurring theme in the conference discussions was the importance of comparative research on RPAC topics. Variations in the ways that different nations approach policy making offer important opportunities for developing insights of both practical and intellectual importance. The need for historical studies was also highlighted repeatedly.

RPAC issues can only be addressed by an ongoing effort employing a variety of research methods and disciplinary perspectives. Research policymaking, not to mention the social processes that shape its development and affect its outcomes, cannot be fully understood when analyzed from the perspective of any single discipline. RPAC research should include a variety of quantitative and qualitative approaches, and should engage scholars trained in such fields as economics, sociology, science & technology studies, political science, history, law, and ethics. Often, RPAC research will benefit from collaborations between these scholars and natural scientists and engineers.

Building a diverse research agenda in RPAC will require finding ways to support graduate students, postdoctoral associates, and faculty who seek to work in this area. There is also a need to encourage cooperative efforts among researchers in social sciences, on the one hand, and natural sciences and engineering, on the other. Strengthening links among these communities should be a priority. Finally, there may be a need for specialized centers devoted to aspects of RPAC research.

3. NSF should explore ways to encourage research in this area.

Given the importance of the RPAC domain, workshop participants agreed that NSF should encourage research in this area. Doing so poses some challenges, because the community of researchers with relevant skills and interests remains somewhat fragmented. Even so, the workshop demonstrated the existence of a variety of interested scholars, and suggested that it would be possible to attract considerable talent to the area. At this juncture, NSF can play an influential role in building capacity among this community. Accordingly, the participants concluded that a significant effort should be made to inspire interest in the RPAC area. In the very near term, a series of workshops on carefully chosen topics should be held to build networks of researchers. Ultimately, steps should be taken to create a program to ensure that this important area is not neglected.

The participants agreed that follow-up workshops could help stimulate interest in this area. Three directions for future workshops were discussed:

- *Infrastructure*. Efforts to build infrastructure for RPAC research would provide resources for the community of scholars, circulate information that would allow the better utilization of NSF investments in data collection and facilitate research that addresses public policy issues related to privacy, conditions of access and the ownership of data and intellectual property. This workshop would assess the current infrastructure, compare U.S. efforts against those of other countries, and make recommendations and offer policy to augment the RPAC infrastructure and increase use and accessibility.

- *Universities and research policy*. This workshop would explore the influence of research policies on universities and the role of universities in formulating research policies. How do governmental research policies affect research universities? How do the institutional policies of universities (e.g., regarding university-industry relations, intellectual property, fundraising initiatives, composition of faculty, and graduate and postdoctoral programs) affect research agendas, practices, and outcomes? How do research policies affect the character of the university as an institution in intended and unintended ways?

- *Comparative studies of research policy*. The organization of scientific and engineering research differs considerably nationally and, within countries, among different agencies. In addition, transnational organizations, such as the World Health Organization, the International Panel on Climate Change, or the World Trade Organization, are increasingly influencing research agendas. This workshop would use comparative analysis of research policies to shed light on a number of questions: In what ways do research policies vary cross-nationally and with what effects? How do research policies fit into the broader politics of different societies and sites? And how do political cultures, institutional structures, and social movements influence the formulation and impact of research policies?

During the workshop, participants suggested a wide range of research topics that investigators interested in this area should be encouraged to explore. A brief sampling follows:

- Studies of how government and institutional policies affect the composition of the scientific and engineering laborforce, define career paths, and shape the opportunity structure for scientists and engineers.

- Studies of discourses of evaluation. What are those discourses, including but not limited to peer review, and how have they changed over time?

- A re-evaluation of the research university, one that is more reflexive and sensitive to institutional issues than evaluations done in the past. This could include examining specific institutional adaptations to RPAC issues, such as the creation of technology transfer offices, as well as considering broader questions of the effects of corporate funding or classified research on the culture or practices of the university.

- Studies of research policy and civil society. What role do influences from civil society play in shaping research policies? How has the "democraticization" of research, through greater input from citizen's groups and patient organizations, influenced research policy?

- Studies of research policy formation in different political cultures. Research that takes advantage of opportunities for comparison can gain analytic leverage on agenda setting and related topics.

- Research on the changing nature of knowledge production. Knowledge is being produced not only in laboratories and universities but also in sites such as law, health, and media. This complex process involves an ever-increasing number of social actors such as NGOs.

- Examinations of interdisciplinary research, e.g., focusing on the formation of new modes of inquiry through interdisciplinarity.

- Research on earmarked funding and its impact on competition for funding and the distribution of benefits.

- Studies of efforts to build research on social and ethical issues into scientific research programs (as in the cases of genomics and nanotechnology). What do such programs achieve, and how do they fit into various policy cultures?

Finally, workshop participants suggested a number of specific ways that NSF could encourage development of this area:

- NSF should alert investigators that studies of research policy will be eligible for consideration under the Agents of Change rubric within the initiative on Human and Social Dynamics. This is a natural place for RPAC research.

- NSF should encourage researchers to look at RPAC topics within the SDEST program.

- NSF should investigate whether there are ways to work with professional societies, other federal agencies, such as NIH, or journals to stimulate research in this area.

II. Issues Discussed at the Workshop

A. Infrastructure

Since the publication of *Science the Endless Frontier* there has been increased recognition of the role of scientific research as an agent of change. Moreover, throughout the industrial world the past twenty-five years have witnessed a period of great experimentation with the organization of scientific and technological research; the principles employed for the allocation of R&D resources in the public and private sectors; the incentives provided to individual scientists; and the mechanisms for translating scientific discoveries into innovation, economic growth, and increases in the quality and standard of living. Scientific research has created new industries such as biotechnology, nanotechnology and telecommunications. Understanding RPAC issues in this context requires an effective research infrastructure.

The United States was formerly the undisputed world leader in scholarship and research on science and technology policy. Unfortunately, the investment of public resources in "research on research" has not kept pace with the growing salience of science and technology policy. The United States has abdicated its position of international leadership in this important field to scholars from other nations, notably the European Union countries. European initiatives have funded both the collection of data on science and technology (S&T) indicators and social science research projects to study these issues. A series of international changes in the funding and incentives for research that are not recognized and appreciated in the United States have important implications for future international economic competitiveness.

Important questions related to how societal needs are measured and articulated, how businesses and industries respond to those needs with technological innovations, how politics, markets and legal institutions encourage or impede technologies, and how society employs technology and addresses its unintended consequences are all components of research policy. Empirical work on these topics often relies on original data collection, which may be funded by a variety of federal and state agencies or private foundations. These efforts are often uncoordinated. In addition, federal government agencies may lack objectivity, owing to their role as research sponsors.

The current situation is unfortunate. Studies of research policy are undersupported at a time when Congress has made a significant commitment to establishing accountability in federal agencies through the Government Performance and Review Act (GPRA). Implementing GPRA requires greater accountability on the part of government agencies and commits the U.S. government to expanded formal evaluation of the formulation and realization of the "strategic goals" of public agencies, including the major government funders of research in the United States. Effective implementation of these processes requires a critical mass of capable researchers. More than mere irony is implicated here: a naïve or unsophisticated approach to the evaluation of S&T strategies, programs and priorities could prove harmful; for example, by shifting attention to short-term outcomes to the detriment of long-term goals.

The NSF HSD Agents of Change program could mobilize the community of S&T scholars and create a research agenda that would enhance understanding of the innovation process. Three infrastructure initiatives were mentioned at the Tucson Meeting involving data collection, community building, and training the next generation of scholars. Each of these is described in turn.

1. Data, Methodology, and Metrics

One component of infrastructure is data resource development, specifically the development of web-based resources and project archives that would provide access to quantitative and qualitative data to support RPAC research. While NSF funds many projects that collect data that might be useful to RPAC, there is limited dissemination of information about the types of data currently available and how these data may be accessed. The costs of research projects to analyze such data are significantly less than the costs associated with the original effort to collect them.

A compendium cataloging S&T policy and research data could help catalyze the community of scholars. There have been other efforts that attempt to inventory data. While these efforts provide a good baseline to build upon, they lack an evaluative component that highlights the limitations of the data. Most notably, the existing surveys tend to focus on governmental data sources and do not mention data sources created and made available to scholars through NSF funding. In addition, existing data compendiums do not cover privately collected proprietary data which are increasingly used in the literature.

The European Union is supporting the Community Innovation Survey (CIS) with the purpose of strengthening the empirical basis for policy related to innovation in Europe. Launched in 1991, CIS is a collaborative project of the Member States and the European Union. The survey collects data on commercial firms at the enterprise level. The time series is the basis for a large number of academic papers. There is no equivalent or comparable data source in the United States.

Some of the most interesting current work links different data sources to provide a more integrated temporal picture. Often these data come from different federal agencies. This is a new research frontier only made possible by advances in computing and matching algorithms. There are also a set of privacy laws, which although intended to prohibit commercial firms from exploiting personal data, may limit the ability of academics to analyze these data. Scholarly research would benefit from a set of standards, policies and procedures regarding access to such data. Currently, access is negotiated on an individual basis, which is inefficient. Moreover, access to data is often limited even though scholars may be able to file Freedom of Information Act (FOIA) requests. Significant public resources are spent collecting these data and their analysis could yield information to benefit society. The lack of access to data frustrates researchers, and the time delay and uncertainty in securing data limit scholarship, especially for young scholars facing tenure pressures.

There is also a need to develop new statistical techniques to provide better measures of research output and to better conceptualize and measure policy outcomes. The need to promote activities to advance the effective discovery of knowledge from data was mentioned repeatedly by workshop participants.

An NSF program of S&T policy research should include assessment and research on mission agency R&D programs, including those of DoD, NIH, NASA, and DoE. These mission agencies account for far more federal R&D spending than does NSF and in many instances, mission-agency R&D programs have relatively clear objectives. Some of the most important basic research advances, as well as technological innovations produced in the postwar United States (e.g., the Internet, biotechnology, the discipline of computer science), owe a great debt to mission-agency R&D funding.

2. Community Building Activities

The diverse disciplines involved in studying RPAC topics could form a community of common interest and mutual respect. Towards this end, activities that could foster community include a set of thematic conferences that would incorporate interdisciplinary perspectives, promote collaboration, and diffuse new ideas and methodologies. Similar efforts are underway in Europe. For example, more than 100 delegates representing 42 research centers participated in the first meeting of the Policies for Research and Innovation in the Move towards the European Research Area (PRIME) Network of Excellence in Madrid on January 8-10, 2004. The objectives are similar to the RPAC. Network activities are funded under the European Union Sixth Framework program for five years.

Community building efforts should extend beyond the immediate community of RPAC scholars to include other stakeholders in the scientific community. The topics considered under this new initiative would benefit from cross-directorate collaborations. While many programs call for social science evaluation, these efforts are often not integral to the project. Scientific professional associations also have concerns about RPAC issues. These efforts would provide a closer connection between RPAC research and those who might put it to practical use. In addition, the participants mentioned outreach to other stakeholders, such as university administrations, politicians, and the press, about RPAC research questions and capabilities. These stakeholders affect resource decisions and public opinion. Inviting them to conferences or short courses to promote a dialogue would help to build awareness of RPAC issues.

3. Training the Next Generation of Scholars

The final infrastructure item is the systematic encouragement for research on these and related topics by Ph.D. students from a range of relevant disciplines, including the history of science, sociology, political science, economics, and public policy. NSF programs typically provide dissertation enhancement awards as a special programmatic category and there was support for having this mechanism become a component of RPAC. In addition, additional funding to support graduate student travel to conferences could be included as a budget item.

One mechanism to encourage new scholarship in this field is an annual conference focused on research presentations by Ph.D. students who have been advanced to candidacy but have not yet completed their theses. Such conferences have been highly successful in other interdisciplinary fields, supporting the development of networks of students who subsequently become important figures in academia and other spheres. In addition, this annual conference could also award prizes for best student paper as a component of the RPAC program.

B. Beneficiaries of research policy

To mobilize support, policy makers usually identify broad benefits for the policies they seek to enact. The benefits described in the policy enactment phase are often sweeping. During the Cold War, the discourse on military research emphasized the societal benefits of national security. After the Cold War, the discourse around American competitiveness in global markets emphasized the importance of research in discovering new technologies, creating jobs and improving the economy, benefits that created a prosperous citizenry. The discourse around NIH funding emphasized the health benefits brought by research. Alongside the broad mission agency programs are efforts, such as the Experimental Program to Stimulate Competitive Research (EPSCoR), to broaden research capability in the several states. The states themselves increasingly support academic research, often through research programs aimed at economic development. But these discourses about benefits from research, however well developed, tell us little about concrete benefit distribution through the policy process.

Initially, workshop participants suggested that we might begin to study beneficiaries of research policy by looking at mechanisms that were already in place. For example, we might study how researchers and agencies comply with GPRA. In the same vein, "criterion two," which requires faculty seeking NSF funding to address the broader impacts of proposed research, could be studied systematically. Pursuing the mechanisms already in place for collecting data about research beneficiaries (GPRA, broader impacts) undoubtedly would repay investigation, but a broader approach to beneficiaries is even more important to pursue. Workshop participants considered beneficiaries of research policies from a number of viewpoints. These are grouped under the headings **patrons**, **mission agencies**, **institutions**, **politics**, **people**, and **policy**.

1. Patrons

The primary patrons of research are the federal government, corporations, and foundations. The federal government provides the lion's share of funding for basic research through mission agencies and NSF. As several of the participants noted, earmarking is increasing rapidly. Earmarking shifts funding to fields, programs and institutions that may not have previously benefited from funding. Universities are recipients of earmarks as are mission agencies. Corporations have increased their research funding, but only a few areas, such as biotechnology, have increased dramatically. Research on the complex interactions among patrons might increase Congressional and administrative understanding of the economic and social benefits of research to their constituents.

2. Mission agencies

Mission agencies are beneficiaries of research policy as well as patrons of institutions and individuals engaged in research. The mission agencies themselves should be studied. Although the mission agencies dispense funding, they often seek to increase their own budgets and the funding they dispense to create stronger, more powerful agencies that provide more benefits and opportunities for those who staff them.

3. Institutions

Many of the participants saw research universities as important beneficiaries of research funding. The small groups that discussed the possibility of an RPAC program agreed that research universities have undergone significant changes that call for careful evaluation. Institutional adaptations to changes in research policy, such as the creation of technology transfer offices, need to be studied. While research universities are beneficiaries of research policy, these benefits may have far-reaching and unintended consequences. Some of the questions raised by participants were: What advantages and disadvantages accrue to universities that engage heavily in research? How does research funding interact with internal institutional resource allocation? For example, does involvement of public universities in research diminish institutional resource allocations to undergraduate instruction, as current National Science Board data indicate? Does concentration of research funding in specific institutions over a long period yield better results—in terms of articles, patents, start-up corporations—than lesser rates of funding spread across more institutions?

Government laboratories and corporations are also beneficiaries of research policy. While there has been a great deal of scholarly work on the costs and benefits of innovation related research at universities, there has been less at government laboratories and corporations. To understand fully how research policy benefits institutions we need to study corporations and government laboratories as well. Moreover, universities, government laboratories and corporations are not the only institutions that produce science and benefit from research policy. We should broaden our study to look at civil society, in addition to the market and the state.

4. Politics

Many of the participants thought that general discourses about research beneficiaries—American competitiveness, job creation, economic growth, improved health—were political discourses useful in increasing funding for mission agencies. However, these discourses do not focus on which specific groups and institutions benefit from which research policies. There is difference between job creation, which politicians say is a benefit of research, and wealth creation. Large corporations in specific sectors, such as pharmaceuticals and defense, are often the beneficiaries of wealth creation. A number of participants argued that the distributional dimensions of the benefits of research policy need more attention, and some suggested that benefits should be widely dispersed.

5. People

A program that examines research policy as an agent of change should consider the variety of actors who have a stake in research policy. However, the stakeholders' model has some limitations in that only the persons "already at the table" are included, leaving out many others who may have legitimate interests. How do individuals and various groups benefit from research? Are they best served by economic growth, new technologies and public health, or are there many other benefits that can be identified? What are the roles of people and organizations that are not conventional science actors? For example, some NGOs are producing a kind of "paraknowledge" about science research. Are they beneficiaries of science policy, or could they be? Should they be? How do investments in research by NGOs differ from investments in research by other institutions?

6. Policy

A central concern of participants in the workshop was that the benefits of research policy not be considered solely in a narrowly instrumental fashion. It was pointed out that human institutions are difficult to engineer, and what some groups perceive as benefits are not seen in the same way by others.

In studying the beneficiaries and benefits of research policy, we should move beyond the broad benefits often attributed to science and technology and focus on a more specific question: What organizations, in what circumstance, are most effective in bringing the benefits of science to society: public institutions (i.e., government health programs, educational institutions), private non-profits (citizens groups, environmental alliances, health groups), or for-profits (market mechanisms)? We also need to know much more about how the policymakers and organizations that perform science assess its benefits. We need to know more about how they interact in deciding what to support, and respond to voices promoting or indicating concern about the direction and results of science.

The following outline highlights some research questions that an RPAC program might address. Unless we understand the processes through which benefits from research are distributed, and identify its direct and indirect beneficiaries as well as the costs others pay, we cannot craft policy that serves the citizenry well. As we move toward a knowledge society, in which research is increasingly important, the need to understand the benefits of research becomes more urgent.

I. How does research funding benefit the individuals and institutions that perform it?
   - A. Research universities.
     - i. What advantages accrue to universities that engage heavily in research; what disadvantages?
     - ii. How does research funding interact with internal institutional resource allocation?
     - iii. Does research funding stratify universities internally? For example, how do current patterns of research affect postdoctoral populations? If post docs do not attain faculty positions, where do they go? Will following their networks reveal how the benefits of scientific knowledge are dispersed across economic and social institutions?
     - iv. What are the implications of concentrations of research funding in a limited number of specific institutions?
   - B. Government laboratories
   - C. Corporations
   - D. NGOs

II. How does knowledge/discovery travel from research agencies to the broader society?
   - A. Examination of dissemination ideas in NSF proposals
   - B. Examination of how networks and mechanisms channel knowledge/discoveries
     - i. Patenting
       - a. Selection of patents to promote
       - b. Selection of corporations to license

c. Numbers of jobs created
d. Follow up that evaluates the social utility of the patent
e. Distribution of products and processes throughout society

ii. Know-how

III. What organizations are most effective in bringing the benefits of science to society? Public institutions, non-profits, for-profits?

IV. How do the policy makers and organizations that perform science receive feedback about benefits?
A. From what organizations?
B. Through what mechanisms?
C. What role do programs like GPRA play in feedback? What happens to the feedback; how is it monitored; how is information deployed?

V. What happens when there are no benefits; what happens if there are more costs than benefits; what happens if there are unintended consequences?

C. Unintended consequences of research policy

As previously noted, one workable definition of research policy is "a strategy for achieving developments of new knowledge, new forms of expertise, and new infrastructures," where infrastructure is understood to include not only material objects like satellites and supercomputers but also training programs and curricula. After recognizing the variety of groups, both public (e.g., courts, regulatory agencies, advisory bodies—at all levels of government) and private (e.g., for-profit firms and not-for-profit foundations as well as other institutions of civil society) that pursue such strategies, the workshop participants noted that not all strategies explicitly include attention to each component of knowledge, expertise, and infrastructure. Moreover, the participants recognized that research policy is often a consequence not explicitly formulated but is a resultant of other policy activities.

The breadth of research policy goals and its focus on new innovation, the diversity of effective actors, the often narrow cast of their agendas, and the interaction with other policy domains creates a policy environment with enormous potential for unintended consequences. This section offers a discussion of the unintended consequences of research policy, drawn from the discussions of the Tucson group and grouped under a list of five "P's": **people, programs, patrons, politics, and policy**. This list is encompassing but not exhaustive, and one could easily offer additional categories; but it captures many of the important elements discussed at the workshop. It also demonstrates the variety of levels of aggregation on which research policy has its impacts.

1. People

Research policy has actual and often unintended consequences on the individuals who perform research. The current system of emphasizing individual principal investigators has led to a number of unintended consequences, including the staffing of labs by postdoctoral fellows who receive modest compensation, the offering of training opportunities with sparse upside potential, and the increasing use of foreign nationals in such positions (a consequence that has newly salient policy dimensions in an era of heightened security concerns). Simply increasing the pay to fairly compensate for poorly paid post-doctoral associates is likely to exacerbate other problems by continuing to attract young researchers, both domestic and foreign, to traineeships that still may not have full career potential.

Discussion of the role of foreign nationals in the U.S. science and engineering enterprise often relates to discussion of the "pipeline" of U.S. students and so-called "leaks" of students who do not emerge into science and engineering careers. Such "leaks" may have positive unintended consequences, as students trained to some degree in science and engineering bring that form of literacy to other careers in which such expertise is valuable, or even simply bring it to informed citizenship. We do not, however, track such "leaks" well.

Another kind of unintended consequence of research policy is on people who do not perform research, but who are the users or consumers of the products of research. Although a leading rationale for the public support of R&D activities is economic growth and job creation, these are indeed two separate phenomena and research may be more about wealth creation than job creation. The distribution of the benefits of research policy—both within the US and between the US and other nations—is rarely considered when policy makers make priorities between civilian R&D and military R&D or among particular strategies or approaches to public health and disease, but such priorities have profound impact on the way individuals live their lives.

There are unintended consequences of research policy for the subjects of scientific investigations as well. Human subjects protection, although relatively settled conceptually in the US for some time, has become unsettled recently with instances of financial conflicts of interest— an unintended social impact of research policies that encourage the use of financial incentives to spur innovation and technology transfer. More profound, possibly, are the potential consequences of the globalization of clinical research, perhaps stimulated by US human subjects requirements that move research to settings that allow experimentation to occur on more vulnerable populations. A proposed response, applying US rules to non-US sites, means that various experiments and drug trials may go undone.

2. Programs

Research policy has unintended consequences for the meso-level units of knowledge creation like disciplines and broad research agendas. At the workshop, some analysts emphasized the under-scrutinized influence of funding patterns on the organization and development of scientific disciplines and in the differing conceptions of disciplinarity, often associated with the lone principal investigator, and interdisciplinarity, often associated with larger centers. Some participants at the workshop also expressed the concern that interdisciplinary training could draw off talented people and prevent disciplines from retaining their strong intellectual bases.

Centers have economic, as well as intellectual, implications; because they provide a space for broader, inter-sectoral collaboration, they have a strong appeal for economic development. Other funding mechanisms beyond investigator-originated grants and center awards, e.g., prizes, may motivate R&D in different directions with a different set of intended and unintended consequences.

Similarly, funding mechanisms such as earmarking have an impact on the way research programs develop, particularly for individual research institutions that look to earmarks for institutional and infrastructural support. Other policies, especially those for anticipating or evaluating research outputs and outcomes (the NSF evaluation criteria concerning broader impacts and the federal legislation (GPRA) mandating assessment of federal R&D programs, respectively), may change the style of research or reorient research programs into directions that are perhaps more relevant but also plausibly more short-term and less productive over the long haul.

Often implicit in the discussion was the idea that research programs—both because of the economic orientation of policy makers and the cultural orientations of all involved—are largely aimed at national audiences in the wealthiest countries, leaving global concerns and the social needs of nations that cannot afford large-scale research programs neglected. Several participants at the workshop lamented the lack of institutions for debating and making research policy with a view toward its global consequences.

3. Patrons

It is widely recognized—and celebrated—that patronage for R&D in the US is highly pluralistic. That is, financial support for R&D comes from a wide array of private and public actors, and even within the public sector from a large number of agencies. What is less understood is how the patrons of R&D adjust to one another. For example, have foundations played a role in creating new fields of science where government funding has been more conservative? Workshop discussions also alluded to the question of what happens to private R&D spending when public spending moves in particular directions. Important issues also center on venture capital, an increasingly significant patron in the innovation system about which too little is known.

The consequences of attempting to exert political direction over public patrons are not well understood. Do we really know the effects of the Mansfield amendment, by which Congress restricted the Department of Defense to supporting only mission-related research and not basic research? In the contemporary funding environment, the emphasis of political direction over public patrons often involves issues of bioethics, as in the case of stem cells. But, if research patronage is now a global phenomenon, what is the hope of forbidding or controlling certain types of research?

4. Politics

Research policy is political through and through, and it has consequences for politics that range from its influence on the distribution of goods and services in societies to its influence on inquiries into human nature. The very success of research in promoting economic change, for example, has meant the creation of a politics in which every state and every university wants a share—putting increasing political pressure on peer review and other distribution schemes designed to insulate science from politics. But the upside of the inefficiencies of departures from strict peer review may be political support for the broader R&D enterprise, though this is sometimes purchased at the price of earmarks and carve-outs (or Experimental Program to Stimulate Competitive Research (EPSCoR) or Small Business Improvement Research (SBIR)). In either event, research institutions are now more enthusiastic political actors, the consequences of this activity for knowledge creation and other goals of research policy need examination.

Policies such as the Government Performance and Results Act, not initially designed specifically for R&D, change the politics of research policy by shifting emphasis to certain measured outcomes of research or the research funding process. Even those measures specifically designed for research, like the new NSF broader impacts criterion, can develop politics around the articulation of the standard and the ability of funding agencies and peer reviewers to evaluate such articulations. Arguably, the role of the broader impacts criterion is to get researchers out of their internalist arguments and connect their research beyond the narrow (academic) laboratory—in effect, creating a different kind of research politics that includes users, stakeholders, and others, and not just readers of scientific papers. Whether this policy works and whether it comes at the cost of less funding for ultimately more important but immediately less beneficial science are questions for research.

Another political consequence of how research gets funded is secrecy. Secret processes related to weapons research, particularly nuclear weapons but also new security research at national laboratories and on some campuses, may have troubling consequences for the general advance of science, including the training of graduate students, as well as for democratic politics. But the trade-offs between secrecy and scientific advance are unclear. There are some kinds of research that societies might not fund unless they could be kept secret. The implications of science secrecy for a well-functioning democracy are similarly unclear and the consequences for greater democratization of research policy are uncertain.

Research policies create different kinds of politics in the global context as well, as knowledge is produced not only in laboratories across the globe but in institutions of civil society, including the media, advocacy groups, and indigenous groups. Institutionalizing different conclusions about the nature of knowledge, expertise, and credibility in different places makes a different politics, with characteristics that are not easily foreseen.

5. Policy

The literature distinguishes between two types of uncertainty: aleatory uncertainty, which results from natural complexity and randomness, and epistemic uncertainty, which results from shortcomings in knowledge and processes of and capacities for inquiry. The discussion above included consequences for people, programs, patrons, and politics that were unanticipated because of both types of uncertainty.

The participants at the Tucson workshop recognized the difficulty in engineering human institutions and the uncertain outcomes that can occur when such attempts are made. However, the group did not believe that uncertainty should become an excuse for inaction—especially because the future benefits of research are not forecast with any more precision or certainty than the future costs. Predictions about the impact of research are made all the time, but prediction is not really what the inquiry is about. We should be willing and able to examine how research policy interacts with other social institutions so the credit or blame is, appropriately, not placed on the shoulders of science alone.

Workshop participants found it troubling that programs for envisioning future policy and other social outcomes, such as the Office of Technology Assessment, have been cancelled. The ethical, legal, and social implications (ELSI) research that has gone along with genome research, and now is a companion to nanotech research, has been important but arguably has only been partially successful and has not brought about a strong critical capacity within the community that studies research policy.

To summarize, a program to explore research policy as an agent of change needs to reduce epistemic uncertainty broadly across the dimensions of people, programs, patrons and politics discussed above.

D. Agenda setting

Research agendas are influenced by a wide variety of events, cultural trends, mass media framings of problems, and economic conditions. Because agendas foreshadow outcomes many groups attempt to set agendas for research policy. Usually they try to influence the federal government because they seek funding for research. Sometimes groups seek long-term funding in a general area (computer technology, biotechnology); at other times, they seek support for specific projects. Frequently, groups try to shift policy, as did a segment of the American business class that was against "dual use" (DoD/commercial) policies because they impeded U.S. global competitiveness. Biomedical policy provides numerous examples of different kinds of groups influencing and attempting to influence policy.

Among the types of organizations that try to shape federal policy are think tanks (e.g., Brookings Institution, American Enterprise Institute); "blue ribbon" commissions (such as the President's Council on Bioethics); political parties (the Democratic Leadership Council under Clinton); organizations of scientists (American Association for the Advancement of Science); lobbyists (from defense firms, from organizations seeking earmarks, from research universities); and a wide array of grassroots and social movements (Science for the People, anti-nuclear groups, anti-cloning groups, anti-globalization groups, pro-solar groups). The White House, through the Office of Science and Technology Policy, and a number of Congressional committees are involved in setting the research policy agenda, as are many executive branch agencies, including OMB, DoD, DoE, NASA, NIH, and NSF.

There are a number of studies of how such groups lobby or otherwise seek to influence research funding. The role of Congress in shaping the national agenda for research policy is, however, understudied. Generally, we know relatively little about the interactions of the different branches of the federal government in agenda setting for research policy. Understanding how various parts of the federal government work together is important, especially given the expansion of efforts to coordinate science across agencies, as the example of the National Nanotechnology Initiative dramatically demonstrates. Nor are there many studies of the interaction among various lobbying groups, think tanks, and commissions, or of how the work of multiple groups intersect with the federal government's many policy arms. Understanding the part these groups play in agenda setting for research policy becomes more important as science becomes ever more integral to our everyday lives.

A large number of groups are interested in science policy, at least in specific areas. A cursory search on the Internet yields many hundreds of non-profit groups and social movements with such concerns . The role of these groups, who stand outside bureaucratic understandings of the policy process, in agenda setting merits more attention. Although well-established organizations may enjoy more power than grassroots organizations, social movements also influence agenda settings, though when and how is difficult to predict. It appears that grassroots and social movement groups can sometimes exercise what amounts to a "veto" on policy, as may have occurred in the case of nuclear energy. They are also capable of pushing investments in science, as evidenced by the apparent successes of some "disease lobbies." As public reaction to scientific developments (e.g., GMOs) assumes more importance, understanding the role of grass roots organizations and social movements becomes crucial.

Science policy researchers often see the most important agenda-setting issue as promoting funding for basic research. This focus misses many important impacts, such as the effect that research policies can have on universities and other research institutions. For example, the bipartisan competitiveness coalition in Congress that has operated since the 1980s passed legislation designed to make America more competitive in global markets. The Bayh-Dole Act, which was part of that legislation, was designed in large part to stimulate small businesses, which were seen as engines of economic recovery. Yet the Bayh-Dole Act had an enormous impact on research universities' capacity to develop intellectual property and perhaps inadvertently shifted them toward entrepreneurial research. As the U.S. economy becomes a knowledge-based economy, many policies aimed at promoting economic growth influence national research agendas. To understand better how research policy agendas take shape, RPAC research needs to use a broad lens, including not only legislation specifically aimed at the research system but also other laws that directly or indirectly influence research policy.

The states also participate in setting research policy agendas. Beginning in the 1980s, states pursued economic development programs that often had strong research components. In many cases, they sought to emulate Silicon Valley and the Route 128 beltway in Massachusetts, creating a synergy among universities and large and small businesses, stimulating technology clusters, and connecting local development to national and world markets. Many states promoted entrepreneurial research agendas that were more focused and tightly articulated with regional and national business needs than was the federal agenda. Although such cases as Silicon Valley and Route 128 have been studied as examples of successful regional centers of innovation, the processes by which state agendas take shape are not well understood. How state research policy agendas interact with federal government agendas in setting goals and distributing funds has received even less attention. Given that one of the purposes of research funding is to create new technology that will stimulate economic development, there is a great need to understand these complex agenda setting processes better.

E. Conclusion

The discussion at the meeting ranged widely. It can be grouped into the four categories identified above.

Under infrastructure, one main topic of discussion was the need for better data, more easily accessed. Another issue was the need for research program assessment. Participants recommended thematic conferences on the topics, to develop a community of scholars and, in the long run, a broader group of interested stakeholders. The conferences could help in training a next generation of scholars, also viewed to be quite important.

The discussion about beneficiaries identified patrons themselves as beneficiaries of the programs they support. It noted that universities are direct beneficiaries. General discourse highlights economic and other benefits, that need to be disaggregated so that scholars and stakeholders can identify which individuals and groups benefit, in which ways, from which programs undertaken by which organizations.

Similarly, research policy as an agent of change should have the goal of reducing epistemic uncertainty and identifying unintended consequences on people, groups, programs, and patrons. It can examine the relationship of politics to unintended consequences for all affected parties. Research policies themselves need examination in light of the unintended consequences they may have.

Workshop participants discussed issues of agenda setting for research policy. Many, many different groups are involved in this process. Understanding the parts that significant actors play is of major importance to addressing the needs and research questions identified in this report.

III. Appendices

A. Agenda of Workshop

Research Policy as an Agent of Change
NSF Workshop, October 9-11, 2003
Tucson, Arizona

Location: Catalina Room, The Lodge on the Desert

Schedule:

Thursday, October 9th, 2003

8:30-10:00pm	Opening Reception

Friday, October 10th, 2003

8:30-9:00	Welcome and Overview
9:00-10:15	Speaker: Irwin Feller. Commentators: Jane Maienschein, Maryann Feldman. Discussion.
10:15-10:45	Coffee Break
10:45-12:00	Speaker: Sheila Jasanoff Commentators: Robert Hoppe, Susan Silbey. Discussion.
12:00-1:00 Lunch	
1:00-2:45	Speaker: Deborah Johnson. Commentator: Stephen Hilgartner, Judith Layzer. Discussion.
2:45-3:15	Coffee Break
3:15-5:00	Speaker: Edward Hackett. Commentators: Paula Stephan, David Guston. Discussion.

Saturday, October 11th, 2003

8:30-9:00	Introduction Comments from the graduate student rapporteurs
9:00-10:00	Small groups Each of the small groups defined yesterday should prepare a short statement on what a program on Research Policy as an Agent of Change should look like. Consider such issues as what should be included under the rubric "research policy" and why a program on research policy is important.
10:00 -10:15	Coffee break
10:15-11:15	Interest area groups Each person should self-select into one of the following three discussion groups: A. Measurement and Assessment B. Ethics and Values C. Critical and Democratic Perspectives Each group should prepare a short vision statement on its interest area. Issues to address might include: defining the area and its significance; examples of burning research questions; methods; infrastructure and capacity building; and concrete proposals for program design.
11:15-12:00	Reports of small groups and interest area groups (5 min. each)
12:00	Adjourn

B. List of Participants

Name	Title	Department	Institution
Invited Participants			
Baumgartner, Frank	Professor and Dept. Head	Political Science	Penn State University
Chubin, Daryl	Senior Vice President	Policy and Research	National Action Council for Minorities in Engineering
Feller, Irwin	Professor Emeritus	Economics	Penn State University
Gusterson, Hugh	Associate Professor	Anthropology and Science and Technology Studies	MIT
Hackett, Edward	Professor	Sociology	Arizona State University
Hoppe, Robert	Professor and Dept. Head	Political Science and Policy Studies	University of Twente
Jasanoff, Sheila	Pforzheimer Professor of Science and Technology Studies	John F. Kennedy School of Government; secondary appointment School of Public Health	Harvard University
Johnson, Deborah	Anne Shirley Carter Olsson Professor of Applied Ethics	School of Engineering and Applied Science	University of Virginia
Kahn, B. Zorina	Associate Professor	Economics	Bowdoin College
Laird, Frank N.	Associate Professor	Graduate School of International Studies	University of Denver
Layzer, Judith A.	Assistant Professor of Environmental Policy	Department of Urban Studies and Planning	MIT
Maienschein, Jane	Regents' Professor and Director	Center for Biology and Society	Arizona State University
Miller, Clark	Assistant Professor	Public Affairs, La Follette School of Public Affairs	University of Wisconsin-Madison
Mowery, David	Milton W. Terrill Professor of Business Administration	Haas Business and Public Policy Group	University of California-Berkeley
Silbey, Susan	Professor	Sociology and Anthropology	MIT
Stephan, Paula	Professor	Economics, Andrew Young School of Policy Studies	Georgia State University
Workshop Organizers			
Feldman, Maryann	Jeffrey S. Skoll Chair in Technical Innovation and Entrepreneurship; and Professor of Business Economics	Rotman School of Management	University of Toronto

Guston, David	Associate Professor	Department of Public Policy, Bloustein School of Planning and Public Policy	Rutgers, The State University of New Jersey
Hilgartner, Stephen	Associate Professor	Department of Science & Technology Studies	Cornell University
Slaughter, Sheila	Professor	Center for the Study of Higher Education	University of Arizona
Rapporteurs			
Lucas, Matthew	Graduate Student	Munk Centre for International Studies	University of Toronto
Mahajan, Manjari	Graduate Student	Dept. of Science and Technology Studies	Cornell University
Metcalfe, Amy S.	Graduate Student	Center for the Study of Higher Education	University of Arizona
Schwarz, Gretchen	Graduate Student	Bloustein School of Planning and Public Policy	Rutgers University
NSF Participants			
Benson, Keith	Program Director	SBE/SES	NSF
Bradburn, Norman	Assistant Director	SBE/OAD	NSF
Hollander, Rachelle	Program Director/ Cluster Coordinator	SBE/SES	NSF
Lempert, Richard	Division Director	SBE/SES	NSF
Newlon, Daniel	Program Director/ Cluster Coordinator	SBE/SES	NSF
O’Connor, Robert	Program Director	SBE/SES	NSF

C. Short Statements

Framing Research Policy Where Research Policy Does Not Exist

Frank R. Baumgartner, Professor and Head
Department of Political Science, The Pennsylvania State University

Prepared for "Research Policy as an Agent of Change" NSF Workshop, October 9–11, 2003, Tucson, Arizona

In the US government as in most, research policy is a concept most often honored in the breach. That is, there is no research policy, but there are scores of policies supporting research. If we think even informally of the greatest initiatives of the federal government in the area of research, the majority are focused on solving some problem, not supporting research because of its intrinsic merits. There is almost always a more specific policy goal, and research is the means to that end: Beating the Soviets, winning a "war on cancer," ensuring safe food and drugs, mapping the genome, enhancing our global competitiveness, whatever. In Congress, few oppose efforts to enhance our global competitiveness, but many are opposed to corporate welfare, waste, and bloated federal bureaucracies. How research policies are seen sometimes as being linked more closely to one of these than another is a key issue.

One of the themes of this workshop has to do with the degree to which areas of research are "captured" by those surrounding them. In fact, any policy subsystem may become isolated from the broader society, attracting only like-minded proponents of a given policy solution, and benefiting from congressional support from a few and apathy from the rest. Many powerful subsystems are apparent in various areas of public policy from defense to agriculture, and many support large and diverse research programs. On the other hand, capture is not the only possible outcome: healthy competition, diversity of views, and competing visions of future policies may also surround any given policy area. One relevant issue for scholars is whether isolated and likeminded policy communities produce better research than those in which substantial and core-belief conflicts are more common. One may imagine that scientific advance cannot come rapidly, or be supported efficiently, unless a clear and shared scientific paradigm has been identified. (Those working in such policy areas would certainly like us to believe so.) On the other hand, if that paradigm is uncontested, this is no proof that it will be correct, or even that it will produce policies or outcomes that will be acceptable to the public, the government, or to non-specialists if and when these lay-people ever become aware of them. Conflict, competing values, and contested scientific approaches may possibly produce more rapid scientific advance, or at least scientific advance that remains within the bounds of public acceptance. This may especially be true as we think of increasingly complex and global scale scientific questions.

In any case, there is great variance in levels of conflict surrounding scientific research issues. One element rarely explored is the degree to which the contestation is scientific, or rather pits scientists on one side with lay critics on the other. Over the past 50 years, scores of topics that were once relatively consensual have become more contested. This is sometimes seen as a sign that social mobilization has created opposition to progress or to scientific autonomy. But much of the controversy is now supported by science on several sides. To take a simple and well-known example, the environmental movement may have started with a number of general calls for greater sensitivity to Mother Earth. Today, however, the range of technical, detailed, highly scientific, and professionally based studies on environmental topics is huge. Similarly in many fields, we do not see only disputes between scientists on the one side and lay critics on the other; we see scientifically well trained communities of experts in disputes with each other. These disputes are sometimes hard for outsiders to evaluate, but as a policy process they are likely to guarantee fuller discussion of policy options than a consensus of any isolated group of scientists who share a single scientific paradigm and work in isolation from any broad public discussion. Scientific conflict rather than consensus may have important benefits to society. In any case, this would appear an empirical question well worth discussion.

As we think of how important issues of research policy arise on the public agenda, and how and why government may choose certain priorities for major research investments, it is worth understanding that no one outside of a research community sees research as a good investment in itself. Many public officials may agree in the abstract that scientific advance is too complex and unpredictable to be expected to follow a linear progression. All may know in the abstract that many important scientific advances have come from serendipity if not by mistake. On the other hand, government officials must justify their investments and there is little chance of support for a research policy that does not provide at least the possibility of solving some major public problem. As we think about framing research policies, then, it is worth considering that government officials are likely to find “research policy” too abstract, too indirect, too close to “corporate welfare,” and too much of a luxury in hard budgetary times. On the other hand, fighting terrorism, finding a cure for cancer, or increasing communications capacities so that the economy will grow again are all topics a political leader can find money to support. In sum, research policy, in the eye of the public official, is a means to an end. As there are scores of important problems we expect government to solve, there are scores of research policies. Understanding that few research policies are justified except by the potential solutions they may produce may take us some way in understanding why federal research policies are never likely to be coordinated, monitored, or discussed as a single whole. We have no research policy, though we probably have the most active research policies of any government in history.

What are the implications of my argument that research policy is a misnomer? For one, it means that basic infrastructure programs, such as education, are harder to justify that more applied research projects; these programs need special attention, or more creative framing efforts (as has often occurred; witness the National Defense Student Loan program). For two, it means that we should not expect research programs ever to be well coordinated. In fact, increased jurisdictional overlap, duplication of effort, and ambiguous lines of authority are increasingly a part of all areas of public policy over the post World-War-Two era, not just in research policy. There are some obvious inefficiencies that stem from these duplications. However, for many complex and poorly understood issues, such as global warming, that are the foci of many of our most important research policies, duplicative and overlapping jurisdictions of government may ensure that the issue will be approached from a variety of frames, and that experts with scientific legitimacy and authority will compete and contend with one another. The result, strangely enough, is that we may learn more from inefficient research programs, with their seeming duplications, than from more administratively “sensible” arrangements. This, too, is an empirical question; it may be truer in areas of limited scientific consensus than in areas of clear scientific understanding. But as an issue gets to that level of scientific understanding, there is not that much research left to do.

Comments on *Research Policy as an Agent of Change*
Daryl E. Chubin

September 16, 2003

At Rachelle Hollander's urging, I am posting my reactions to the *Research Policy as an Agent of Change* discussion paper. I do so as an outsider to the community that drafted it. I have been a full-time academic (and still an adjunct at two universities), served in two branches of the federal government (including NSF division director, OSTP staffer, and former Senior Policy Officer for the National Science Board), and am now an officer of a nonprofit organization.

This program idea is ambitious and potentially quite important. But I am repeatedly struck by the ability of intellectual communities to seal themselves off from human resources who are not their professional peers. What alarms me is that while the program is inclusive of topics, it is exclusive when it comes to participants. Academics have a maddening sense of monopoly over what and who matters. They are skilled at circumscribing their area of expertise – not unlike Members of Congress defining power into 535 individual domains (and numerous committee niches).

The sense of diversity projected in this paper is limited to "scholars with instrumental views of the research process" and "more critical scholars." (This is an artificial and incomplete distinction.) As academics consumed, in part by institutional demands, by the need for entrepreneurship, recognition, and reputation, they are engaged in this exercise to advise NSF. This is more than a trifle self-serving since the establishment of a program, if not an NSF priority area, will afford them a receptive place to seek support for the ideas that they have contributed to the program mission statement. Expertise breeds such conflicts of interest. It is inescapable in merit review and in science advising. Program officers live with it, but must try to control it.

My recommendation, therefore, is to seek as many boundary-spanners as possible – not only people but also writings that have addressed "research policy" in various guises. The academic literature is hardly the fount of all inspiration here. For example, NSF has published many reports ranging from merit review reports to treatments on "categories of research" to NSB documents that illustrate the issues cited. The Carnegie Commission a decade ago also, in retrospect, produced many reports relevant to the program's interests.

I would also challenge a couple other assertions in the paper. At the bottom of p. 2, "Research policy directs the funding of US science and technology in both academe and corporations." Certainly federal policy influences the former. When I was with NSB however, I was astounded by the comments made by corporate Board members that their companies' policy directions were set with almost no regard to federal funding. What does that suggest? On p. 3, if employment of scientists and engineers is really an issue, then the forthcoming BEST reports (following on the Morella Commission and in which I've been deeply involved for ca. two years) will have much research and evaluation-based practical guidelines for program implementation – a key resource for "agents of change" focused on science and engineering education and employment nationally and globally (www.bestworkforce.org).

As for the workshop agenda, themes #2&3 are old chestnuts, #1&4 are hot now. Are you hedging bets, being comprehensive, or is there a hierarchy of priorities that you would like to see emerge from these workshops? (By the way, OTA's *Federally Funded Research* report, 1991) contains all sorts of ideas, ranging from interdisciplinarity to controlling research costs, which warrant another look. So does the piece on peer review that Hackett and Chubin just completed for the Center on Education at NRC.)

Finally, I urge the planning group to seek out industry and NGO stakeholders as workshop participants. (Former NSB members, who understand NSF programs, would be a start.) Professional society representatives and journal editors, too, must be "changed." Why not get their views now, on the front end, rather than having to sell later an academic-centric view of what's needed after the program announcement has been framed?

I have little patience for academics – many of whom I respect and whose work is laudable – but who think they know it all. Once one leaves the academy full-time one's intellectual work (published in books and refereed journals) does not stop. No, it matures and changes. My colleagues in the government, corporate, and nonprofit worlds go beyond knowledge-production to applications that make a difference in people's lives, not scholars' careers alone. Sorry if that sounds harsh.

I appreciate Rachelle calling me about this. I hope she is not ahead of her constituency. This program could make a difference. I wish you all the very best.

Daryl E. Chubin, Ph.D.
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Research Policy as an Agent of Change: A Perspective from Economics

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Rotman School of Management
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Research policy, sometimes referred to as science policy, is one of the least understood, appreciated and studied areas of economic activities. This is difficult to understand if we start from the almost trite premise that we live in a knowledge-based economy. After all, the major economic inputs to knowledge creation are R&D and human capital. While we recognize that firms are responsible for productively organizing these resources, economists recognize that there are substantial market failures that limit private investment in knowledge creation. Firms will invest in R&D; however, the social rates of return to R&D are greater than the private rates of return, leading firms to under-invest in R&D. Individuals will invest in their own education, but education is regarded as an example of a public good where once again markets fail to allocate sufficient resources from a societal viewpoint.

These reasons justify government expenditures on research and education; however, there is frequent debate about appropriate levels of funding and types of programs. This debate is often politically and ideologically charged. Meaningful discussion is hindered by a lack of objective evaluation. In turn, evaluative efforts are limited by funding and the lack of data on programmatic outcomes. Many economists work on these topics, garnering funding from a variety of sources and engaging in original and innovative data collection. Overall, the discipline is hurt by a large volume of advocacy research which is not objective and frequently little more than thinly veiled public relations. To the extent that we believe that future economic growth and competitiveness are predicated on the efficient organization of knowledge creating resources, then this situation should be addressed. A National Science Foundation priority area would encourage scholars to work on these topics.

Science policy is at the hinges where social and behavioral research meets the hard sciences. There are repeated illustrations of the ways in which technology is endogenous to institutional and societal factors: a combination of economic and social factors shape the process of scientific advance (Rosenberg, 1994). Consider, as a case in point, the 1982 court decree which split AT&T into seven regional companies. Judge Greene observed that the telephone industry grew up in the copper wire days when it was a natural monopoly, and that when microwaves made it possible to bypass the wooden pole network, the monopoly was no longer justified. Microwave technology was largely developed through federal funding during the Second World War. The intention was to perfect the radar system to promote national defense. However, the commercial applications were significant and changed the nature of competition in the communications industry. As a result, the Department of Justice argued, AT&T used profits from the monopoly granted by prior technology to suppress competition in the emerging long-distance and telephone equipment industries. The resulting decree created greater competition and led to further technological change in the industry; a decrease in the pricing of telephone services; increases in service quality and new services; household telephone subscriber levels; and greater efficiency and productivity; and increased international trade (c.f. Cole, 1991). Thus, economic, technological and social factors have complex interactions in the process of change. The challenge for economists and other social scientists is to enrich their theories to capture the complexity of economic growth. Rather than study these effects *ex post* an initiative aimed to encourage understanding of research policy as an agent of change may enhance policy and institutional design.

There is a general realization that technology is part of a social context, that is, a context in which political, cultural, economic, historical, and environmental factors are at work and must be taken into account. The ability of a technology to realize economic and social benefits is determined by this context. Every technology creates winners and losers, and lives or dies at the mercy of myriad non-technical influences. Inability or refusal to consider context results in myopic decisions and outcomes in which technologies fail for extra-technical reasons. Blindness to context limits the ability to reap the returns to investments in science resources. While many NSF programs advocate a social science component, in reality this is sadly reported to be little more than a perfunctory end-stage evaluation rather than an integrated component of the project design and implementation. Understanding socioeconomic and historical phenomena are integral components of technological progress that unfortunately have few existing advocates. The nature of scientific work requires an intense focus. A natural side effect of this level of concentration is narrow-minded myopia about the technology. A manager may view a technology as a set of deadlines and resource constraints; a financier may view it as profit, loss, and risk; a customer may view it as benefit or cost, convenience or constraint; an environmentalist may view it as a threat to nature. There are few who regard the total impact of the technology and unfortunately there is little informed debate about the myriad alternative futures that any one technology may provide. The effectiveness of the economy and overall societal benefit may be enhanced if experts from the social and behavioral sciences, history and philosophy ask the larger questions. The question themselves require the types of multiple, interdisciplinary perspectives that defy the traditional programmatic structure of NSF. A new initiative devoted to Research Policy could overcome this limitation and work to develop the required body of knowledge.

References:

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Rosenberg, Nathan, 1994. *Exploring the Black Box: Technology, Economics and History*, Cambridge: Cambridge University Press.

Changing Research Policy

Irwin Feller
Senior Visiting Scientist
American Association for the Advancement of Science

Presentation to the Workshop on
Research Policy as an Agent of Change
University of Arizona
October 10, 2003

I. Research policy issues and research policy questions co-exist in the current search by federal science agencies and the academic research community for a new equilibrium between the dynamics of scientific inquiry and existing structures and practices for providing federal funds to support academic research.

National research policy discourse now speaks with two voices: first, academic research is becoming increasingly multi-disciplinary, collaborative, and capital-intensive (with the attendant increase in project costs); and second, the preeminent world position of the U.S. in science is in large part attributable to the post-World War II policy decisions that led the federal government to support basic research in universities and to use the mechanisms of (single) investigator-initiated, peer review, and competitive selection as the primary, although never exclusive, mechanisms for identifying research priorities and research performers, at least in non-defense and non-mission areas. Harmony between the two voices is achieved by a well-orchestrated blending of the knowledge creation and societal benefits generated by each mode of scientific inquiry.

We are entering a period in which these voices are becoming discordant. The competing demands for increased support along each line of scientific advance, combined with the prospects for decelerated rates of budgetary growth, increase the likelihood that federal science agencies, particularly the National Institutes of Health and the National Science Foundation, will have increasing difficulty reconciling differing perspectives within both the agencies and the academic research communities about the optimal blend of research priorities and funding mechanisms. Statements found in the almost assembly-line production of reports from esteemed science organizations and associations, as well as from federal agencies themselves, that the frontiers of knowledge are best explored in the intersections, interconnections, and interstices of existing disciplines, are increasingly at variance with other statements about the historic importance of the investigator-initiated mode of research funding, including the concluding assertion that this system must be "protected at all costs".

These statements are made analytically and empirically, not normatively or prescriptively. They are presented neither as a brief for either mode (Mode I/Mode II) of research nor as an algorithm for finding the optimally balanced portfolio. Rather, based on a review of recent reports, ongoing field research into the status of interdisciplinary research in federal agencies, foundations, and universities, and "walking about" (or sitting through) a number of science policy forums/

meetings distributed across a number of federal agencies and scientific fields, they are intended to (1) highlight the likelihood (but not inexorability) that the rhetoric of "balance" among alternative strategies and models for funding basic research now found in existing agency strategic plans and external program assessments is wearing thin, and (2) outline several conceptual and empirical research questions that need to be answered if whatever new balance may be defined is evidence based.

II. Challenges to the primacy of the investigator-initiated model of conducting research are evident both directly and obliquely in statements voiced by NIH, NSF, and Department of Energy-Office of Science officials about the increased importance of multidisciplinary research, and in any number of special reports prepared by NIH, NSF, and the National Academies about trends in selected fields of science.

To cite one recent report, consider the opening recommendation from the Institute of Medicine-National Research Council's report, *Large-Scale Biomedical Science*:

> NIH and other federal funding agencies that support large-scale biomedical science (including the National Science Foundation, the U.S. Department of Energy, the U.S. Department of Agriculture and the U.S. Department of Defense) should develop a more open and systematic method for assessing important new research opportunities emerging from the scientific community in which a large-scale approach is likely to achieve the scientific goals more effectively or efficiently than traditional research efforts (p. 4).

The traditional research mode is the single-investigator model. To make the point even sharper, although still shielded, the IOM-NRC also indirectly cites the recently published roadmap advanced by NIH's new director, Elias Zerhouni, as pointing to the need to rebalance modes of research support:

> Indeed, the director of the National Institutes of Health recently presented to his advisory council a "road map" for the agency's future that includes a greater emphasis on "revolutionary methods of research" focused on scientific questions too complex to be addressed by the single investigator scientific approach. He noted that the NIH grant review process will need to be adapted to accommodate this new large-scale approach to scientific investigation, which may conflict with the traditional paradigms for proposing, funding, and managing science projects that were designed for smaller-scale, hypothesis driven research (p. 2).

Reports issued under NSF auspices tend to be more circumspect in highlighting the implications that changes in the structure of scientific inquiry have for funding levels (and NSF's organizational arrangements), but they nevertheless contain similar sentiments. For example, the 2003 report of the NSF Advisory Committee for Environmental Research and Evaluation, *Complex Environmental Systems*, states that "New Instrumentation, data-handling, and methodological capabilities have expanded the horizons of what we can study and understand about the environment. These advances create the demand for collaborative teams of engineers and natural and social sciences that go beyond current disciplinary research and educational frameworks" (p. 1).

Another real-time example, "Educating Future Scientists" (Nancy Sung, et al.) in *Science*, 12 September 2002, appeared as this presentation underwent its final editing: "The most exciting science in the 21st century is likely to evolve among, not within, traditional disciplines….Yet the education of scientists has historically been constrained by disciplines, paralleling patterns of science funding" (p. 1485).

Not surprisingly to students of social change, organizations tend to respond to new pressures or opportunities by accretion, adding new missions or functions without necessarily displacing earlier activities and arrangements, and at the same time adapting their organizational vocabularies (mission statements, strategic plans, and the like) to assert the importance of both old and new and the consistency between them. Thus, current research policy in federal science agencies accommodates both research strategies by deploying annually enlarged budgets to expand support both while maintaining essentially stable (or static) relative shares between them. Changes in budgets, intra-organizational structures, and composition of review panels, to the extent that they occur, do so at the margins of an agency's operations.

(To introduce a dollop of data into this presentation, using the simplified dichotomy of single-investigator and center-based awards as a proxy for the complex set of issues raised above, NIH has estimated that in FY2003 it was spending $2.4B, or slightly less than 9 percent of its total budget [or 10–11 percent of its total extramural awards] to support 1,209 centers. In the same fiscal year, NSF is estimated to have spent $356M to support 294 centers; this total represents 14.0 percent of the $2,559M that NSF budgeted under its strategic goal, Ideas, and 7.1 percent of its total budget of $5,028M. Although similarities between NSF and NIH exist in the missions, objectives, and activities of centers as a mode of research support, enough differences exist in the rationales and scales used by each agency to justify centers, to make comparisons problematic.)

The dynamic stability of current activities to balance and blend alternative modes of research performance given the increased frequency of the types of statements alluded to above is open to question. For example, oft-made criticisms of the conservatism of NSF and NIH review panels seem to build to at least a parboiling if not boiling point. My own research and interactions with academic researchers has produced a growing number of cases in which "eminent" scientists have complained about their inability to course the review gauntlet on occasions where their proposals extend beyond mainstream disciplinary paradigms and methodologies or involve their efforts to engage in trans-disciplinary research. Evidence of this discontent is seen in NIH's recent establishment of Director's Innovator Awards. Modeled on DOD's DARPA program, the NIH program would provide awards to people rather than projects. As described by Elvira Ehrenfeld, director of NIH's Center for Scientific Review, "It is clear that we are losing groundbreaking proposals simply because of the conservatism built into the system" (quoted in *Science* [15 August 2003, Vol. 301, p. 902, "NIH Plans New Grants for Innovative Minds"]).

If, in fact, the trends in scientific inquiry towards multidisciplinarity, collaboration, and scale are as powerful and important as many recent statements indicate, changes in national research policy, including changes in funding priorities, intra-organizational arrangements, composition of review panels, and criteria and methodologies for assessing program and project outcomes well beyond those adopted in the past 10–15 years will be required. In the absence of "high" rates of increase in budgets, which raises all boats and softens points of trade-off, agency decision makers likely will have to make more explicit choices among modes of research support, develop more systematic criteria to guide them in these choices, be more systematic in collecting evidence to assess competing positions, and ultimately be better able to evaluate the effectiveness and efficiency of alternative funding mechanisms than they are at present. Given the power of prevailing beliefs about the historic potency of the disciplinary-based, investigator-initiated model of research (and graduate training), as well as institutional conservatism on the part of both federal science agencies and research universities, many of these changes, to the extent that agencies seek them, will occur either in advance of or in opposition to dominant views in the academic communities that form both the agencies' primary constituents and consumers.

III. Several research questions, both conceptual and empirical and necessary for the formulation of "evidence-based decision-making", are embedded in the above statements. To take one example of each, greater conceptual clarity is needed in analyzing the dualistic manner in which much of the contemporary dialogue is cast, including (purposefully, I should note) the casting of the above statements. In numerous settings I have heard the alternatives in funding strategies presented as consisting of two lists: single-investigator, investigator-initiated, discipline-based, and "small-scale" in one column; and collaborative, program (often center)-based, multi-disciplinary, and "big" science in the other.

The combinations among these elements, however, are far more numerous than suggested by simple dichotomies. Figure 1 offers a simple illustration of at least four combinations. Issues relating to the design and operation of the current research systems in NIH and NSF exist not only in choices between the upper left- and lower right-hand combinations, the paradigmatic opposing perspectives, but also in (a) treatment by peer review panels, as noted above, of initiatives of single investigators to extend the scope of their research beyond the limits of existing disciplines, (b) choices between single-investigator and center-based modes of research support within specific disciplines, and (c) the relative productivities of discipline-based and multidisciplinary centers.

The last question surfaces as perhaps the major unresolved empirical, and of course, policy question, namely, where are the highest returns (at the margin, of course) to knowledge creation, training of a future scientific and technical workforce, knowledge transfer, or whatever set of objectives are posited by the funding agency, the research community, or external constituencies, to be found? This question appears instantly and repeatedly in any discussion of modes of federal support of academic research. Answers to the question also are instant, taking on the character of "it's obvious" or "everybody knows", especially in terms of the post-World War II emphasis on single-investigator modes of research.

My own review of the relevant literature on questions of the comparative effectiveness and efficiency of alternative modes of research support, including participation in several such agency reviews and program evaluations, has led me to conclude that there is in fact little systematic evidence to use in answering these questions. Manifold problems exist here, both in the quality and policy relevance of existing studies and in working out the design of future such studies. The intent here is not to offer either a critique or a blueprint, but rather to highlight the importance of these questions and the need for federal science agencies to more actively and aggressively support external research on them.

Figure 1. Disciplinary Scope

		Disciplinary Scope	
		Single Discipline	**Multidisciplinary**
Funding Mechanism	**Investigator – Initiated**		
	Center		

IV. Except perhaps for emphasis, I take it as a given that much of the above discussion is familiar to participants at this workshop. Where I do see something new emerging from the intersection of the workshop's agenda and my ongoing research is the importance I have begun to assign to federal research policy in initiating and sustaining the development of new fields of knowledge within universities. Perhaps the more long-lasting but least well understood (or examined) aspect of the implications of changes in federal science agency research policies is how they affect the launching and sustainability of new academic fields of knowledge, departmental structures, professional affiliations, and training of students. As an example of what is at stake here, as noted in the Sung et al. article, the education of scientists has been discipline-based, "paralleling patterns of science funding". By implication, changes in patterns of science funding will lead to changes in the content of graduate student education, with follow-up implications for the structure of academic colleges and departments.

One leading scholar recently quipped that every interdisciplinary field is a disciplinary wannabe, that is, that all fields seek to acquire legitimacy and permanency within the university by gaining control of budgets, faculty hires and advancement, and space. These tendencies towards repeated mitosis of necessity are offset by prudent and "rational" academic administrators (not to forget the interests of faculty in maintaining dominance over pre-existing fields of study) who hesitate to commit funds to "hot" fields that may prove to be limited intellectual lodes, have limited appeal to students, or indeed are best set as subspecialties, easily accommodated within existing departmental or college structures.

The formation of new fields and their Darwinian struggle for survival, in terms of institutionalization within the university, are relatively unexplored research questions. To shift the unit of analysis here from federal agencies to universities, in my ongoing field research into the status of interdisciplinary research and degree programs at a cross-section of American universities, I have been struck by the number of new departments that appear to have emerged in response to funding and other forms of leadership provided by federal agencies and foundations. A notable example of this influence can be seen in the development of materials science as a field, following the needs of the Department of Defense for improvements in materials, an undertaking that required new combinations of physics, chemistry, metallurgy and ceramic sciences, to list only the most immediately involved disciplines. This growth took several forms—new departments, at times formed from an amalgamation of established departments; new departments formed by hiring faculties interested in interdisciplinary work; stand-alone centers or institutes; and other matrix-like arrangements. The key here was that the field was a distinctive field of knowledge and graduate training, not only as a subspecialty within a discipline or as a cross-disciplinary "program", beholden to the good graces of existing academic units for its faculty, budgets, and space. Similarly, early development of policy sciences as a discrete field of study and academic standing as a department or school involved support from the Ford Foundation and Sloan Foundation. The Sloan Foundation, likewise, is credited by some of its leading academic practitioners with launching cognitive sciences, defined in terms of assemblages of linguistics, computer science and psychology.

Indeed, one can observe these phenomena today in various stages of gestation. The recent emergence of "prevention science", a field that now has its own national association and journal, and where faculty (and graduate students) increasingly describe and market themselves as "prevention scientists", even though I know of no such academic department to date, owes much to the efforts of NIH program staff and funding. Developmental science may be an academic structure on the horizon—that is, if federal funding is provided. Does "vulnerability science", a field proposed by Susan Cutter in her recent presidential address, "The Vulnerability of Science and the Science of Vulnerability", to the Association of American Geographers, have a future as an academic program, or will it remain a subspecialty?

What unites all of these examples, and what differentiates them from other selected multidisciplinary, collaborative, and large-scale research initiatives undertaken by federal science agencies such as, say, NSF's Engineering Research Centers program, is that they lead to sustainable, organizationally grounded changes in new fields of research and education that diffuse through a system of universities. At issue, then, is the extent to which federal science agencies self-consciously see themselves not only as the sponsors of the best quality science that is proposed to them by the research communities but also as agents of change. Change here is understood not only in terms of the reallocation of agency resources to reflect evolving definitions of the coordinates of the frontiers of science, however imperfectly they may be measured or seen, but also in organizational arrangements and cultures within agencies and universities.

Research Policy as an Agent of Change

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The problem with policy-relevant scientific information in the United States is not so much a lack of volume as increasing suspicions regarding its quality and impartiality. I discuss this issue below with reference to two areas with which I am familiar: biomedical research and nuclear weapons research. In both cases there is a strong public interest, international as well as national, in the generation of reliable scientific knowledge. In one case the generation and dissemination of such knowledge is impeded by strong commercial interests, in the other by the dynamics of the national security state. Although derided by current practitioners of science studies, there was some merit in the view of an older generation of sociologists of science, such as Robert Merton, that scientific knowledge can have a particular robustness if it must survive adversarial debate and peer review. If scientific knowledge is to be an agent of change, we must reinvigorate adversarial debate at the intersection of science and society.

Recent years have seen an explosion of public commentary on the increasing influence of commercial interests over academic research, especially academic research in biomedicine (Angell 2000, Bok 2003, Eyal and Washburn 2000). There are two concerns here. First, the power of commercial interests responding to the logic of the market rather than public health needs determines which medical problems are ignored and which lavished with R&D attention. Thus we have massive drug development programs focused on erectile dysfunction and heartburn, but few resources to tackle a global scourge such as malaria. Second, the integrity of scientific research itself is threatened. A recent study by Krimsky et al (2001) found that 34% of 789 articles published in 14 different science and biomedicine journals were written by authors with a financial interest in the outcome of the research – and hence a conflict of interest that was often undisclosed. Numerous statistical studies have demonstrated that researchers with financial ties to pharmaceutical companies are significantly more likely to find those companies' products safe and effective than researchers without such ties (Krimsky 1999). In the most egregious cases, the studies are largely performed and written up by in-house staff at the companies, then edited, signed and submitted for publication by professors who receive a fee and another line on their vita for this. More disturbing still, there have been cases where pharmaceutical companies have been able to prevent publication of unfavorable studies through the enforcement of contract clauses giving them control over publication of research they funded (King 1996).

Nuclear weapons scientists constitute a closed community that is largely sealed off from the broader scientific community by rules of secrecy that have, surprisingly, intensified since the end of the cold war (Masco 2002). This community has attempted to institute a degree of peer review by having two separate nuclear weapons laboratories, at Los Alamos and Lawrence Livermore, review one another's work and by giving secret clearances to a select few academic scientists in the JASON group, which reviews the conduct of weapons science on behalf of the Department of Energy and the Department of Defense. This system of peer review worked well in the late 1980s when it brought to light the possibility that American nuclear weapons were in danger of exploding accidentally in some cases (Smith 1990). It worked less well in the same decade when scientists at the Lawrence Livermore National Laboratory were able to manipulate rules of secrecy to protect the X-ray laser, a key SDI technology, from scientific criticism for a surprisingly long time, even after Livermore's Associate Director for Weapons Development had secretly resigned in protest (Broad 1992). There is also increasingly compelling evidence to suggest that the independent judgment of external academic scientists on JASON review panels or other ad hoc committees is compromised over time as they are absorbed into the organizational culture of the secret world – in much the same way that the judgment of academic scientists contracting to pharmaceutical companies may be compromised (Gusterson, forthcoming).

The first Clinton Administration offers a rare and interesting example of nuclear weapons research policy conducted in the sunshine. Confronted with a consensus in the weapons laboratories that the reliability of nuclear weapons could not be assured without further nuclear testing, the Secretary of Energy Hazel O'Leary forced the weapons laboratories to debate their claims with academic scientists normally excluded from such discussions and declassified enough information to allow antinuclear NGOs such as the Natural Resources Defense Council and the Federation of American Scientists to participate in the debate as well. The Comprehensive Test Ban Treaty was the result.

One could give other examples of the importance of public interest science in the national security arena. Ted Postol's group at MIT, for example, funded by foundations and operating without security clearances, has had a major impact on national security policy by demonstrating the failure of the Patriot missile in the first Gulf War and, more recently, the cooking of ballistic missile defense tests. At a more local level, Tri-Valley CAREs, an NGO funded by an EPA grant, won the cancellation of a proposed radioactive incinerator in Livermore through careful review of flaws in its environmental impact statement.

In order to make scientific research an agent of change, we need to strengthen the adversarial debate over knowledge. In practical terms this means building an infrastructure that supports the conduct of science in the public interest in the universities and in NGOs. The MacArthur Foundation has recently undertaken a modest project in this vein by providing seed money for professorships in technical arms control at six major research universities. We need to go further. Foundations and universities could fund analogous faculty positions in a variety of areas at the intersection of science and public policy – on environmental policy, biomedical ethics, energy research and so on. They could also establish special fellowships, or even graduate degree programs, to bring staff from NGOs to study at universities so as to strengthen their scientific knowledge and judgment. MIT's Knight Fellowship program, which brings several science journalists to MIT each year, might serve as a model. Without a public interest counterweight to the national security state and the corporate sector, there will be little debate of their ability to set the research agenda and inadequate scrutiny of the lazy knowledge claims that scientific cronyism always facilitates.

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Toward a Political Economy of Research Policy?
David H. Guston

Preliminary material for the Research Policy as an Agent of Change workshop refers to the "political economy of research policy," although it does not clearly spell out exactly what is meant by the term. This ambiguity is understandable because of what we have called the problem of fragmentation – that the scholarly study of research policy draws on a wide array of disciplinary traditions (including political science, economics, sociology, policy analysis, management, science and technology studies, and of course knowledge from and about particular fields of science and technology that are the objects of inquiry) that have their own conceptions of what political economy is, let alone of its application to research policy. This short paper explores ways to refine our sense of the political economy of research policy with an interdisciplinary approach.

The New Handbook of Political Science (Goodin and Klingemann 1996) presents a short set of entries in a section on "Political Economy," all of which focus to some degree on the extent to which current political economic approaches in political science (and in part with sociology)

1. diverge from but still echo with the agenda of the political economy of previous centuries, which dealt more with national economic issues, the role of government, and normative rather than positive issues (esp. Atkinson 1996);

2. incorporate assumptions and techniques from economic methods, namely a complex set of independent variables generally called "endowments," a process of competition, coordination, or cooperation to pursue interests, individual rationality; and externalities and feedback, which help to understand eventually how endowments originate (esp. Offe 1996);

3. attempt to explain institutional and policy outcomes.

Thus, as Offe (1996, 678) writes, "The agenda of a full politico-economic analysis can thus be described as following a cyclical pattern….[in which] institutions generating actors who generate outcomes that cannot be accommodated within existing institutions, hence leading to the generation of new and conceivably 'better' institutional arrangements – is what political economists have contributed to the study of social change."

Political scientists also talk about national political economies and international political economy (IPE), which focus on the grounding, organization, and operation of national- and global-scale systems (e.g., capitalism, socialism) and how their component parts – particularly their "political" and "economic" institutions – interact.

Scholars in science and technology studies (S&TS) have used political economy to denote work that ranges from a Marxist account of scientific research and ideology (Rose and Rose 1976) to the neo-classical analysis of science, technological change, and development (Clark 1985). Other S&TS scholars have readily adopted economic metaphors or models, e.g., Latour and Woolgar's (1979) "credibility cycle" – which provides a Offe-like model of the internal dynamics of the market of science – and Rip's (1994) elaboration of it. This work revises in important ways the more Smithian market model of science that Polanyi described (1962).

Economists themselves have generally engaged in two types of work in research policy. First is the now large and robust field of innovation studies – both contemporary studies that range widely in scope and scale from national systems to regional development to particular innovation programs of government, and historical studies (e.g., Mokyr 2002) that increasingly identify a role for knowledge and its diffusion in the long view of economic development. The second is the less developed study of the organization and behavior of science, but more explicitly economic than Latour and Woolgar, Rip, and Polanyi. Mirowski and Sent (2002) collect representative work from both types, although their examples of the former are now more classic articles than current research.

A research agenda around "research policy as an agent of change" needs to accommodate all these aspects of political economic thought:

- Research policy is an agent of change for the organization and behavior of scientists, both through the creation of funding opportunities and programs as well as through the consequences of developing new research tools and technologies.
- Research policy is an agent of change for the delivery of innovative goods and services – both those that are easily priced and thus measured and those that are not – as new knowledge is organized, transferred, absorbed, applied, and developed.
- Research policy is an agent of change for the array of public and private institutions organized around the performance of research (universities, firms, government agencies, hospitals, NGOs, etc.).
- Research policy is an agent of change for larger-order national and global systems through the rise and fall of industries, innovations in the technologies of warfare, increased understanding of the global environmental change and vulnerabilities, the ability to intervene in human health and reproduction, etc.

There is a literature on most or all of these topics. But my sense is that this literature does not complete the full political-economic cycle that Offe is after. For example, as little as we understand about the dynamics of how researchers "follow the money," we probably understand even less about how that behavior cycles through scientific productivity, innovation, and demand for institutional change in the organization of research funding. As much as we know about the role of university-based research in regional economic development, we know far less and in a less systematic way about the influence of that role on political processes and outcomes in such regions and the subsequent changes on university priorities and internal operations. Even if we can understand how research institutions respond to the structure of and incentives contained in research policy, we do not fully grasp how they react to the consequences of the knowledge-based innovations they then produce. To the extent that we include global perspectives in the research agenda on research policy, we still face the challenge of fully accommodating the diversity of global contexts in our analysis and the feedback from global conditions in local politics.

We should also not forget the breadth of political economic methods to study research policy as an agent of change. Scientists often operate in institutions, e.g., advisory committees, that are not unlike legislative institutions, where political economic methods have had some notable successes. Scientists operate with substantial delegations of authority from political actors, and there is a small but developing literature on principal-agent studies of science policy (Braun and

Guston 2003). One could even hope to recover some of the grander scope and normative power of "old" political economic analyses – eventually (following Weber and Merton) writing for science what has been written for economics by Karl Polanyi (1957), or what has been written for political theory by Robert Dahl (1985). This type of understanding of research policy would greatly inform contemporary debates.

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Research Policy as an Agent of Change

Interdisciplinarity, Transdisciplinarity, and the (Re)Organization of Research

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Let's start with the reflexive observation that others have surely noticed, too: we are engaged in an RPAC activity, trying to create a program that will alter the activities of our own research community. In doing so we are implicitly taking stock of abilities, assessing the desirability of possible lines of inquiry, imagining how we and others might participate. We are designing RPAC to draw upon the STS literatures as we understand them, emphasizing the ideas and perspectives most congenial to our own. We must be wondering in what ways RPAC would advance our research agendas and in what ways it might divert them, and whether any redirection be welcomed or resisted?

I would also add to the paper's subtitle the word "integrative" or "synthetic," meaning that interdisciplinary (or multidisciplinary or transdisciplinary, and I'll spare you the distinctions) research programs are challenged to achieve a novel recombination of ideas, methods, and explanations that form a new sort of scientist, a new ensemble of research technologies for conducting inquiry, a new and perhaps useful insight or explanation that finds a place in the literature. Integrative also means forming groups (and perhaps larger and more enduring social arrangements) that work effectively, despite heterogeneity in the disciplinary backgrounds of members. And the effects of heterogeneity on research activities can be profound, lasting, and consequential: researchers from different fields have different ideas about what is important to explain, what concepts and processes should be used to explain it, when an explanation is adequate, complete, and publishable, how much framing is needed to motivate a paper, what qualifies as good data or a sound research design, who contributed enough to deserve coauthorship, and many other things. While pidgins and Creoles facilitate communication across disciplines, they do not entirely overcome substantive, methodological, and ethical differences. For these reasons interdisciplinarity poses problems that extend across the entire length of the research act. Drawing upon the STS literatures, in combination with ideas and methods from cognate disciplines, the RPAC program could support research into the social and intellectual dynamics of interdisciplinarity as one example of a policy initiative with potentially deep consequences for the organization, conduct, and substance of science and engineering.

Interdisciplinarity is impossible without disciplines, so any policy to promote the former must take account of the latter. How disciplines coexist with interdisciplinary work is a rich topic for research, extending from policy formation within agencies (asking, for example, how interdisciplinary initiatives are developed and launched) through the proposal preparation and peer review processes and into the workings of research groups, laboratories, departments, centers, professional societies and journals. Some see consilience in the future of research: ideas jumping together to form durable explanations and, in the process, eclipsing their disciplines of origin.

More likely, I think, disciplines will live in dynamic tension with interdisciplines, competing for people and resources (money, journal pages, memberships in professional societies), contesting the completeness and soundness of one another's explanations, and enriching each other through reciprocal borrowing, immigration, and criticism. Rather than a teleological transformation of disciplines into interdisciplines (or, perhaps, one *uber*-discipline to rule them all), there may instead be enduring and fruitful exchange, competition, and even conflict that generates of ideas, explanations, research technologies, training programs, new scientists, and such. From time to time one side will have the upper hand, but viewed over time one would observe episodic recombination in interdisciplinary spaces and regrouping in disciplinary fortresses.

RPAC would not treat research policy as given or exogenous, of course, but would recognize that policies form with significant involvement of the communities that they will shape. The process through which policies are formulated and implemented would become an important object of study for RPAC. Specific studies might examine the negotiations underlying the development of program announcements, their understanding by the research community and the response they elicit (including perhaps cooptation), their interpretation and application by reviewers, and the quality and impact of the portfolio of research that results. Viewed from the perspective of the research community, the questions may be Which researchers are influenced by interdisciplinary research initiatives? and What in aspects of their research are augmented or replaced by the new opportunity?

The Government Performance and Results Act of 1993 (GPRA) is a quite different example of a change in research policy that is still reverberating through the system. Unlike substantive research initiatives that would stimulate research on a topic, theme, discipline, or interdisciplinary area, GPRA instead demands that researchers and the agencies that support them document the societal benefits that flow from research investments and, further upstream, support and conduct the sorts of research that would have societal benefits, and develop the benefits available from work already supported.

GPRA has had various consequences for researchers and research agencies, and I am not sure if these have been studied systematically. One consequence has been a reworking of merit review criteria to give more weight to societal benefits. This reworking, which took place in the late 1990s, replaced NSF's four review criteria with two (intellectual merit and societal impact), symbolically making societal impacts approximately equivalent to intellectual merit in determining overall merit. When an independent audit of review procedures (conducted by the National Academy of Public Administration) showed that the criterion of societal benefit was receiving relatively little attention, NSF made further changes (insisting that proposers and reviewers address both criteria explicitly, and that a section of the proposal summary be devoted to societal benefits). What needs to be studied systematically is whether and how the enactment of GPRA has influenced the kinds of research that are proposed, supported, and performed, and whether any of this redounds to the benefit of others (and, of course, which others and in what ways?)?

The rise of inter/multi/transdisciplinary research poses challenges for scientists, agency officials, the general public, and analysts of science. I couldn't possibly even sketch them all, but can suggest a line of thinking that outlines the nature of the issues. For forty years or so studies of science have recognized the importance of scientific disciplines, invisible colleges, scientific communities, and the like. We've somewhat lost sight of such things in the turn toward understanding the microsocial processes that produce credible research results, but while outside the analyst's gaze those larger forms of social organization have not disappeared (see, for example, Clarke's *Disciplining Reproduction*). Even those focused at the microsocial level appreciate how disciplines, networks, communities, and the like guide the conduct of research and shape research careers. Disciplines and specialties pose problems that are understood to be do-able and worthwhile, offer standard packages of research technologies, establish epistemic standards for recognizing sound research results, take solidary stances on the importance of the discipline and its research domain, and argue for more resources in Washington and on campuses. Interdisciplinary research suffers from the paradoxical problem of having none of these or too many of these: falling into a domain where clear guidance and support may be unavailable or where overlapping and inconsistent guidance may be present. In either case, it may be difficult for researchers to know quite how to pose, frame, and address a problem (and to recognize an answer when they have one); for reviewers to know a good idea when it is proposed to them, and for the public to know which results to rely upon in their daily lives. Those of us who study science may need to develop new ways of thinking about the structural influences on research.

Here are three specific research concerns of mine that arise from changes induced by research policy. They may be useful as examples of three sorts of structural outcomes of research policy that might have ramifications for the conduct of research, research careers, and research results. One study compares work life and research outputs from two academic tokamaks (machines for producing fusion energy). The second examines the origins, workings, and effects of the National Center for Ecological Analysis and Synthesis. The third, a collaboration with Diana Rhoten of SSRC that is just beginning, will compare educational experiences, research work and technologies, and early career characteristics for a sample of graduate students in disciplinary and interdisciplinary programs. I am certain no one would sit still for the details of three studies, so let me just mention a key point or idea from each. (I know I said "three," but I should also mention a symposium at the upcoming AAAS meetings on research collaborations induced by science policy, in the EU and US, organized by Caroline Haythornthwaite, Manfred Horvat , and me.)

The tokamaks study examines how changes in the policy environment, particularly whether and how a project was relevant to an international collaboration in fusion energy research, shaped the life courses of two academic tokamak projects and the work lives and research performance of their members. It traces how changes in the policy and resource environments guide the development of research technologies for fusion energy research at two universities, and how such forces together influence research performance and the work lives of scientists and engineers.

NCEAS is a research center in ecology, funded by NSF and the State of California. NCEAS's mission is to transform the field of ecology by encouraging combined or comparative analyses of existing data and development of synthetic theories that span wider areas or longer swaths of time. NCEAS also promotes interdisciplinary research and research that brings fundamental science into close contact with practical problems (e.g., resource management). Unlike centers with more or less permanent research staffs and generally stable research agendas, NCEAS supports and hosts working groups organized by members of the ecology community (broadly defined), which meet at the Center (in Santa Barbara) for several days at a time to collaborate on a research problem. Scientists propose groups to NCEAS, which uses a science advisory board to review proposals and advise the director on which proposals to support. Funding then allows groups to travel to Santa Barbara for extended meetings to work intensively on their research problems. My students and I observed several working groups, administered some questionnaires on group process, and developed some measures of overall research performance. Founded in 1995 and modeled on the Kavli Institute of Physics (which is also at UCSB), NCEAS has now become a model for collaboration that other fields wish to emulate. At this writing a competition for an NSF-funded center to study evolution is underway and a recent meeting of NSF-funded investigators in the biocomplexity program recommended that NSF found such a center to address biocomplexity research.

Diana Rhoten and I, with support from the EHR directorate of NSF, are about to begin a three-year study that will compare integrative interdisciplinary graduate programs (basically NSF-funded IGERTs, but there are others) with disciplinary graduate programs. There are many things to compare, but two that might be of interest here are (1) in what ways do students in interdisciplinary programs integrate diverse ideas and approaches into their dissertation research, and with what consequences? (2) how do students from the two sorts of programs compare in the early years of their careers? While interdisciplinary students may enjoy greater freedom and a wider intellectual base, they may in exchange concede some of the guidance and support that a discipline provides.

Infrastructure needs.

One desideratum is inside access to NSF and, through NSF to the Washington science policy environment. Related to this would be a mechanism for researchers to become NSF contractors or IPAs, permitted to work with confidential documents and attend confidential meetings with (nearly) the ease of NSF staff (and with all the essential guarantees of confidentiality and warnings about conflicts of interest). This sort of access is not essential for every imaginable RPAC project, but there are some (concerning peer review processes, for example) where access to proposals, reviews, ratings, panels, and so forth would be essential. Other projects might require insider access to NSF meetings and staff, with appropriate assurances. I'll defer to Deborah Johnson and Rachelle Hollander to discuss this as a matter of professional ethics and practice.

A second sort of infrastructure need is some way to work across agencies in Washington, to move from a study of a single policy or program at a single agency to a thematic examination of a family of related policies in use at several agencies. It is very hard for outsiders to identify and understand parallel developments at NSF, NIH, Energy, DoD, for example, that might form the core of a comparative study. It is harder still for us to do so in a way that yields a convincing proposal that agencies might support. Yet for RPAC to do more than provide policy guidance or critique—that is, for it to develop into an intellectually solid area of research—problems must be posed in more general terms. Specifically, for example, one would hope to compare changes in peer review practices across agencies, not simply the consequences of changes in NSF criteria. Similarly, the interdisciplinary impulse is probably in evidence across agencies, yet it is hard to frame a research project that spans agencies. For those with greater ambitions, cross-national comparisons are the obvious next challenge. The infrastructure request is for assistance in learning about related developments in different agency and national contexts, and for having a place to propose such comparative research that would see the merit in supporting research that extends beyond the agency's walls.

Integrating critical and instrumental approaches.

For this I can offer two contradictory ideas. First, any synthesis or integration of these perspectives might best be achieved in a focused and enduring collaborative research effort. That is, rather than aim for some reconciliation in principle, strive instead for limited, functional integration in specific inquiries. One sort of problem might ask what we have learned from the array of "ELSI" (ethical, legal, and social implications) studies that have been done of the Human Genome Initiative, information technology, and nanotechnology. The aim is for critical self-examination and frank appraisal of the knowledge gained and the outcomes affected (or, maybe, effected), with an eye toward improving problems, research practices, and utility. Both instrumental and critical analysts would make essential contributions to this effort. (And yes, I noticed that this is an RPACesque activity.) Second, and not entirely consistently, accept that instrumental and critical perspectives on science policy are incommensurable (or nearly so), and ask instead how they may be arranged to complement one another. Again, scholars affiliated with each approach would have the most to contribute. Try to frame the task as identifying which ideas and findings of the alternative approach have been most useful, and how they could become more so, rather than setting up a competition for resources or intellectual supremacy.

Problems and opportunities for NSF.

Where should RPAC reside within NSF? How near to STS and SDEST? How near to the 12th floor? One would want close connections with STS and SDEST, because RPAC should draw upon and contribute to the ideas and findings of those communities. But there are advantages to positioning RPAC near to the policy discussions that occur on the 12th floor, and which are intimately connected with science and technology policy discussions in the federal government. RPAC would work best if kept current with the latest policy discussions and statistics (meaning, also strongly connected to Statistics Resource Studies), but also kept somewhat distant so as not to be caught in the maelstrom. Less dramatically stated, RPAC should be informed and stimulated by the latest concerns, have available the best data in the most readily usable form, yet stand sufficiently apart from the policy community to allow independence and scholarship, not policy analysis and fact-finding. (On the last point I am thinking explicitly about the Utredningsinstitut in Oslo, Norway, which has done much commendable work but has a more limited agenda than I would imagine for RPAC).

A second significant problem is working out the principles of conduct and standards of evidence for RPAC studies. Precisely because research policy is a powerful agent of change it is crucial to study but essential to study carefully. Ill-structured research and ill-considered advice can do harm to the agency and to the researchers it studies. (For an example drawn from internal agency research, consider the studies of the mid-1980s that projected a significant shortfall of U.S. SMET talent.) A related concern has to do with the appropriate involvement of researchers from the communities studied and agency staff in RPAC studies. Both must certainly be involved in the research, because they are expert informants and intimately involved in the research and policy process. But for precisely those reasons RPAC researchers who work closely with scientists and agency staff may feel that their independence of judgment is compromised or, arguably worse, may be compromised or coopted without realizing it.

Let me close on a positive note: RPAC presents a valuable opportunity to NSF and other science agencies. First, there would be more and more solidly grounded research results that could inform policy. Second, the foundational literature—the ideas, relationships, methods, and approaches for such research would develop more richly and rapidly. Finally, a more visible and substantial RPAC program would attract young scholars to the field because they would see research opportunities, publication outlets, and a developing foundation of theory and results to build upon.

Research Policies, Emerging Technologies, and Significant Change

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One of the key challenges for a program on research policy as an agent of change is developing a better understanding of policymaking and politics in the area of emerging technology. The phrase "emerging technology" is as much a slogan as a descriptive term, but it generally refers to technological domains where important—even "revolutionary"—developments are expected to occur sooner rather than later. "Emerging technology" sometimes designates a relatively narrow area of research, such as injectable tissue engineering or nano solar cells, and sometimes a broad field, such as biotechnology, information sciences, or nanotechnology. In such areas, technological systems exist "in a state of flux as a mixture of blueprint and hardware, plan and practice, the nearly online and the almost obsolete" (Hilgartner 1995a), and change seems rapid and relentless.

Understanding the policies and politics surrounding emerging technologies is important in part because these technologies are expected to be implicated in deep and far-reaching change. These research domains are also important because they generate substantial investment by government, industry, and others. Not all of these investments are financial; many organizations and individuals also invest political capital, credibility, and hope in emerging technologies. Finally, emerging technologies often raise ethical issues and public concern, sometimes inspiring persistent opposition.

Expectations and claims about technological developments that have yet to materialize fully are inevitably uncertain. Moreover, not all of the uncertainties are technical; social, legal, and political uncertainties also loom large. To further complicate the picture, emerging technologies arise in a context where mobilizing capital, fundraising, and marketing are usually salient. Emerging technologies are thus the subject of extensive and often-self-interested speculation—in both the financial and epistemological senses of the term (Fortun 2001). The proponents of investing in what they predict will become the next big "breakthrough" are frequently engaged not only in prophesy but also in promotion. Opponents of particular developments also often traffic in overheated claims as they work to generate "counter-investments." Owing to these uncertainties and contested claims, the speculative world of emerging technology poses difficult challenges for analysts. Nevertheless, the area merits sustained attention.

To grasp the dynamics of the fast-moving world of emerging technology requires studies of research policies that do not neglect the role of non-governmental actors. Emerging technologies typically arise in multi-institutional networks of government agencies, corporations, universities, venture capitalists, think tanks, NGOs, and others. These diverse knowledge producers not only shape their own research programs and other activities, but also formulate institutional policies and make decisions that influence R&D far beyond their organizational boundaries. Thus, in genome research, corporate strategies interact in complex ways with government policies, and decisions about how to orchestrate multi-institutional collaborations may have far-reaching influences on who can access what scientific data and under what terms and conditions (Hilgartner 1998; NRC 2003).

Emerging technologies are also often sites of rapid institutional change in research systems. In biotechnology, one well-known example is the creation of startup companies founded by university faculty members who retain their academic posts (Kenney 1998). But the rise of new institutional forms is by no means limited to the commercialization of biology; many technological developments have provided occasions for institutional innovation: the rise of large, biological databases is a case in point, for they have built new regimes for managing communication and data with significant implications for science and for regulatory issues (Bowker 2000; Hilgartner 1995b). A major challenge for studies of research policy and politics is to shed light on the institutional changes that are reshaping contemporary research systems, especially in fast-moving areas, and to consider their political implications and other effects.

Emerging technologies often generate ethical dilemmas, public concern, and political controversies. Concern about the potential downsides of emerging technologies has created a new climate in which funding agencies are now expected to support research on the social implications of research in such fields as genomics and nanotechnology. The question of what programs on Ethical, Legal, and Social Implications (ELSI) should hope to achieve has frequently inspired debate, and both research and experimentation about the design of such programs is sorely needed. But the bigger message is that scientific institutions now must contain a reflexive dimension aimed at critically analyzing their own work, with the ultimate goal of improving the ability of contemporary societies to cope with new knowledge and rapid technological change.

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Shifts in the governance of science. From research policy to a network mode of governance of science.

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Characteristic for our times as a second major crisis of modernity is that many once settled boundaries between institutional domains are broken up (Wagner, 1994). The result is a blurring or hybridization of once sharply distinguished spheres. The blurring between science and society thus results in what is called Mode-2 science in a Mode-2 or risk society (Nowotny, Scott & Gibbons, 2001; Beck, 1992). The blurring between politics, markets and civil society results in a shift from hierarchical government into network types of governance (Van Kersbergen & Van Waarden, 2001). It may well be argued that there is a co-evolution[2] between concepts of rationality and governance: from formal-legal rationality in the classical-liberal state, to instrumental and substantive rationality in the welfare and administrative state, till dialogical and process rationality in our contemporary governance networks and risk societies. Whatever one makes of the controversies between modernism and postmodernism, one conclusion stands out. In the debate on what remains of the notion of scientific rationality after the 'march of folly' which brought humankind the 21st century, a fallibilist, pragmatic, and dialogical concept of learning appears the only tenable one. This implies that neither substantive, nor instrumental rationality, jointly or separately, defines science or government action. These types of rationality have become superseded, or at least supplemented, by the fallibilist, dialogical and pragmatic standards of a *procedural* rationality, characteristic for network modes of governance (Hoppe, 1999; 2002a).

Comparing national research priority setting in European countries like The Netherlands, the UK, Denmark, Germany, and Spain, Hackman (2003) finds that the network mode of governance is becoming quite popular. It means that governments, assisted by bureaucracy and scientific expertise, no longer draw up research policies. In that sense, we have come to the end of science policy. Instead, we should see science policymaking as meta-policymaking or system design (Rooney, Hearn, Mandeville and Joseph, 2003), i.e. science governance as "concerted action across institutional boundaries on behalf of public purpose" (O'Toole, 2000:278). Consider how Stefan Kuhlmann (1999) projects and designs a new regime of 'distributed intelligence' for research, technology, development and innovation (RTDI) governance in European countries and the EU.

He begins by carefully describing the participants in the governance network. First, there are the knowledge system organizations, like universities, research councils, contract research institutes, and national or regional research centers. Second, there are industry-related players, like multinational companies, SME associations, industrial associations, and specialized parts of trade

[2] The concept of co-evolution is used here in the sense of co-development and mutual shaping of interdependence and non-linear cause-effect relations, without specific reference to evolutionary theory.

unions. Third come the 'usual suspects' of government-related actors, like the national research ministry, other ministries involved in RTDI-related issues, regional and local governments, national parliament, the EU Commission and directorates. Finally, there are civil society actors like consumer and environmental groups. Traditionally, 'government' or 'administration' would take as primary unit of analysis the minister of research, say; and inquire about how this suspected 'prime mover' steers most other network actors towards ministerial, politically approved goals. Now one would look at the entire functional policy subsystem and its sub-politics; and one would assume that top-management of all the involved organizations were jointly engaged in 'governance'.

In a second step, Kuhlmann outlines how in such a heterogeneous network concerted action is nevertheless possible:

> " … RTDI policy is rather (and increasingly) a matter of networking between heterogeneous (organized) actors instead of top-down decision-making and implementation. Policy decisions are frequently negotiated in multi-level/multi-actor arenas and related actor networks. Negotiating actors pursue different – partly contradicting – interests, represent different stakeholders' perspectives, construct different perceptions of 'reality', and refer to diverging institutional frames. 'Successful' policymaking normally means compromising through alignment and 'reframing' of stakeholders' perspectives…"

In order to somehow manage the heterogeneity of a complex and non-transparant governance network, Kuhlmann proposes an 'architecture' for an infrastructure for the mobilization of strategic intelligence residing in the mutual contacts between the constituent actors as the 'glue' to keep the network from falling apart:

> "Approaches to evaluation have evolved away from a purist model of 'objective neutrality', …to more formative approaches in which evaluators act as process consultants in *learning exercises involving all relevant stakeholders* (italics by RH), providing advice and recommendations as well as independent analysis. This has led to more flexible and *experimental approaches* (italics by RH) to the construction of policy portfolios. And to even greater demands for well-specified systems of monitoring, evaluation and benchmarking to aid analyses and feedback into strategy development. … Since RTDI policymaking occurs in multiple policy arenas on regional, national and European levels there is a need for 'interfaces'… (We need) the creation of an architecture of 'infrastructures' for distributed intelligence (and) the establishment of brokering 'nodes' managing and maintaining the infrastructure, offering an 'enabling structure' that allows free access to all strategic intelligence exercises under public auspices, and that provides a 'directory', which facilitates direct connections between relevant actors…"

If the above analysis is approximately correct, what does it imply for research into the governance of science? No doubt, a first research task would be to investigate the new modes of coordination between the very heterogeneous actors and organizations making up science governance networks. This would mean to acquire a more complete and theoretically sophisticated understanding of the roles different actor types in such networks can play, judged by criteria like effectiveness/

efficiency and legitimacy/accountability. Especially intermediary roles – the brokering 'nodes' -- that straddle traditional boundaries between science and policy need thorough investigation and evaluation. Several possible research projects come to mind here:

- *The present and future of knowledge mobilization and innovation for vital policy issues*. In the Netherlands, recently, '*knowledge alliances*' are created to tackle serious, 'wicked' problems in society. Thus, poverty and other sustained problems of big metropolitan areas have been the occasion for creating a 'Knowledge Center for Metropolitan Areas' as a deliberate effort to create a forum or arena for all those organizations and individuals who claim expertise in the area – from the Dutch counterpart of the NSF to consultancy firms. A similar effort is going on in the field of achieving a more sustainable society through decoupling of environment and economy through technological innovation. Network construction/destruction and re-shaping appears to have become a strategy of knowledge production and creation that is very dissimilar to previous models of expert advice and an appeal to universities and other R&D organizations to do more research. Such efforts should be compared much more closely and systematically in order to reap any learning effects, if they exist.

- *The present and future of '**extended peer review**' and '**democratizing expertise**' (Woodhouse and Nieusma, 2001)*. We need to know much more about truly interactive, participatory and dialogical styles of involving both scientists and non-scientists in the (integrative) assessment of scientific and technological developments. We have lots of descriptions of such efforts, with tons of favorable comments and promises, but we have preciously few solid studies about the details of the methodologies used and the effects achieved for sober, but tenable conclusions (EUROPTA, 2001; Loeber, 2004).

- *The present and future of scientific policy advice through **boundary work** (Jasanoff, 1990) and/in **boundary organizations** (Guston, 2000)*. It is not an easy task to construct an accessible overview of the large variety of science/policy boundary configurations, but we can start by mapping accepted conceptions of different forms of boundary work. Concerning the *distinction* of science and policy, there are diverging views on whether science and policy should be strictly distinguished or whether the two should rather be seen in terms of a continuum. As concerns *coordination*, there are diverging views on who should dominate the division of labor. For example, should the experts bring in knowledge and signal problems or should policy makers initiate and define policy relevant research? Using these parameters, it is possible to construct a typology that gives a good overview of different possibilities in the division of labor between scientific experts and policy makers. (We will not treat this typology here in detail, as it has been discussed at length elsewhere, see (Hoppe 2002b).) For each of the models for the division of labor in this typology, strengths and weaknesses can be indicated. For example, in an engineering model of science/policy boundaries, instrumental knowledge is provided at the initiative of policy makers within problem definitions that are considered to be unproblematic. Such a model is well suited to quickly provide instrumental knowledge for well-defined problems, but runs the risk of ignoring new knowledge that could contradict dominant policy beliefs. This model also tends to overlook tensions in problem definitions, such as disagreement over what problem is at stake outside of established policy networks, leading to conflict later on in the policy process, and possibly even to the deconstruction of knowledge that at some point had been provided to policy so seemingly straight-forwardly. This conceptual approach is used in the project 'Rethinking Political Judgment and Science-Based Expertise' of the Dutch National Science Foundation (NWO). In this project, five large scientific advisory bodies of Dutch government policy are compared: the Scientific Council for Government Policy (WRR), Alters (a nature policy research institute at the Agricultural University of Wageningen), the Dutch National Institute for Public Health and Environment (RIVM), the Central Bureau of Statistics (CBS), and the Netherlands Bureau for Economic Policy Analysis (better known as the Central Planning Bureau, CPB).[3] The national focus of this project implies a considerable limitation on the possibilities to learn from international experiences of other boundary organizations. There may be a considerable collection of case study research on practices of expert advice to government policy in a large number of policy fields (e.g. (Jasanoff 1990; Cambrosio, Limoges et al. 1992; Barker and Peters 1993; Evans 1997; Abraham and Sheppard 1999; Van Asselt 2000; Bal and Bijker, 2002)) and even some limited international comparative research projects (e.g. (Brickman, Jasanoff et al. 1985; Abraham and Millstone 1989; Halffman 2003)), but there is hardly any research which tries to produce more systematic comparisons that could allow boundary organizations to learn from experiences elsewhere. In principle, it would be very possible to expand the structure of the Rethinking project to embrace an international comparison. This would imply that similar research projects are started in different countries, using the same parameters (the typology, the same kinds of advantages and disadvantages that should be considered), with comparable demarcation of cases and the same orientation to ultimately come up with models and stories oriented at policy learning in practices of policy advice.

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[3] For details, please consult the project's website: http://www.bsk.utwente.nl/rethinking/

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RESEARCH POLICY AS AN AGENT OF CHANGE (NSF Workshop, Tucson, AZ, October 10-11, 2003)

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Science and technology (S&T) policy—and its subset research policy—stands today at a transitional moment in history. I will begin by outlining some problems currently besetting this traditionally rather hidden domain of public policy and then consider some steps that could be considered in adapting S&T policy to the changing needs of global governance on behalf of a global civil society.

The Institutional Deficit in S&T Policy

Science and technology policy confronts massive and unexpected challenges at the outset of the 21st century. On the one hand, it is widely recognized that developments in S&T are essential for security, economic growth, and social harmony around the world. S&T issues have therefore begun to occupy increasingly prominent positions on domestic and international policy agendas. On the other hand, S&T are also seen by many as potentially destabilizing influences, giving rise to complex ethical dilemmas, social inequality, environmental degradation, risks to health and safety, and of course threats of war and terrorism, all on an unprecedented scale.

S&T policy, in short, has become both *global* and *political*. These two dimensions of S&T policy are the source of some extraordinary problems, but also some remarkable opportunities.

Today, S&T policy is a public, contentious, international, and increasingly fragmented field of governmental (and importantly corporate) endeavor. There is, to begin with, no single, unified field of S&T policy. We are faced with different ethical, political, and social—not to mention technical—problems in fields such as genetics, information technology, robotics, nanotechnology, and weapons development. S&T policy has also become difficult to contain within national borders. It is, after all, no longer just a domestic policy question whether the US builds a national missile shield or fails to curb greenhouse gas emissions, whether India tests an atomic weapon, whether Britain permits embryo cloning for research, whether Russia engages in biological weapons research, or whether Japan bans the import of genetically modified crops. Like it or not, S&T policy today is the world's business. And by this I mean the business of the world's most ordinary citizens, as well as of its scientists, engineers, social movements, corporations, and nation states.

The globalization and politicization of S&T policy have taken place almost in an institutional vacuum. The old institutions of the state are no longer adequate. Few would deny this. Gone are the days when decisions about science and technology were largely seen as a matter for technical experts—or "boffins" as our British friends used to call them—who left their quiet university perches to advise presidents and prime ministers for a time on matters of high national interest. Publics, as we see daily, demand much more accountability from science and much more transparency from decisionmakers than they did in the immediate aftermath of the Second World War. But in our conceptual structures of law and public policy, we continue to treat decisionmaking concerning S&T as if it were still the domain of technical experts lodged within systems of national governance.

There has been surprisingly little innovation—either in governmental institutions or in practices—since the structures of formal science advice were formed more than a half-century ago. Indeed, if anything, proposals like the Supreme Court's 1993 *Daubert* decision or OMB-OIRA's recent calls for the peer review of regulatory science seem like a throwback to an earlier technocratic era.

Curiously, the US, often regarded as the home of the most robust democracy in the world, has been among the most conservative nations when it comes to institutional innovation for S&T policy. To be sure, some of the legal experiments we initiated in the 1960s and 1970s still offer highly appealing models for the rest of the world. I would include here the requirements for public notification and participation in administrative proceedings that are written into most of our regulatory laws—beginning with our landmark 1969 National Environmental Policy Act. I would also mention the Freedom of Information Act and the Federal Advisory Committee Act, which together provide unparalleled public access to even the most technical work of the federal government. The 1998 Shelby Amendment, requiring disclosure of federally funded science, represented another, though more ambiguous, step in the same direction. Lawsuits remain for us a powerful instrument for challenging expert authority. It is a device that can be abused, but it does allow citizens to question arbitrary decisions, and it offers them an important remedy if they have been injured through negligent uses of science and technology.

The US, however, has been less creative with new forms of public participation than a number of European and Asian countries. We have few analogues for the wide variety of citizen juries, referenda, consensus conferences, and public inquiries that have proliferated in other industrial nations over the past two decades, especially in response to novel or hazardous technologies such as nuclear power and genetic engineering. One of our most innovative institutions from the 1970s, the Office of Technology Assessment (OTA) which advised the US Congress, was abolished by Congress itself in 1995. While OTA's impact on policy was perhaps not revolutionary, it did serve an important democratizing function by bringing a wide range of viewpoints to bear on crucial S&T policy questions facing the US government. On several fronts, such as the curtailment of juries and the insistence on "science-based risk assessment," one observes in the US a worrying return to a technocratic vision of governance that many thought had been abandoned a quarter century ago. In the wake of the terrorist attacks of September 11, 2001, there are added concerns that people's legitimate desire for security may be used to justify new, technologically assisted restrictions on civil liberty.

It is not only US institutions that have been slow to change, but the entire framing of S&T as a policy area. Old conceptual distinctions, such as that between "lay" and "expert" or "science and technology," have not been deeply reexamined in the light of ongoing research on the nature of S&T and on their relationship with society. Accordingly, reductionist models of the public and its scientific illiteracy and technical incompetence still dominate many policy debates. Far more money is spent on intellectually questionable research on the "public understanding of science" than on institutions to engage the public in more robust debate on the purposes of science and technology.

These problems are hardly limited to the US. The rhetoric of S&T policy worldwide scarcely reflects the extent of change that has come over the practices of science and technology in recent decades. Despite much talk about the "information age," one finds in high policy circles remarkably little attention to the changing character of information itself—or to the connections between citizenship, information, and communication. Since the phenomenon itself is imperfectly recognized, it is not surprising that efforts to generate knowledge about it have also not fully kept pace. I would like to make a few observations about this last set of issues before turning to a more positive program for S&T policy in the coming decades.

New Spaces, New Challenges

One of the most important developments of the past few decades is the state's loss of control over the forums—and even the forms—of public policy deliberation. In the now sketchily remembered US presidential election of 2000, for example, commentators noted that talk-show hosts controlled the fates of candidates more surely than did the formal debates organized by major political parties. Whatever we make of this argument, politics today clearly cannot be carried out without the active collaboration of the media. And while analysts like us still speak of "the media," it is no secret that the print media (newspapers, magazines, newsletters) are increasingly taking a back seat to the more visual forums of the television and the Internet. These phenomena will be profoundly significant for our futures; yet, today they remain largely incomprehensible and outside the reach of most research programs.

For global S&T policy, in particular, the rise of new forms of communication has produced many new challenges. Most widely discussed perhaps is the public understanding of science and technology, which was not an issue so long as experts and policymakers made decisions behind closed doors, but which becomes very much a topic of interest when television daily brings stories about science and technology into every middle-class living room around the world. The quality and credibility of information are other growing concerns, since the new media do not subscribe by and large to the old gatekeepers of scientific publication. Direct advertising and sale to the public of S&T products, such as pharmaceuticals, is a related problem that is giving considerable headaches to government regulators. Global political issues of great significance continue to evolve around the communication of science and technology: why has South Africa's leader rejected the viral explanation of AIDS; why do people destroy GM research plots; why do SUVs remain market successes and why is female smoking rising; why did people believe or not believe US evidence about WMDs in Iraq? Where do people get their S&T information anyway, and does it make any difference to their behavior? The issues are of extraordinary importance; our knowledge about them is ridiculously incomplete.

Other aspects of the dominance of television that are perhaps even more significant for global developments in S&T have barely surfaced in contemporary policy discussions—and still less in research programs. Most significant is the question of access. Who controls television and how easy is it for anyone today to challenge the reach of CNN or Fox? What are the implications of television for the *language* of global debate on S&T issues? If part of television's power comes from pictures rather than words, what does this mean, in a world saturated with TV, for people's ability to evaluate evidence and arguments which are central to discussions about S&T? Is television actually altering the accepted forms and styles of reasoning, as well as the accepted standards of proof and legitimacy, in the world's most prosperous democratic societies?

The Internet and the Worldwide Web bring their own questions. At the level of democratic theory, we have reason to celebrate their appearance. Here is one front on which institutional innovation seems alive and well, even in America. Competition is also having a salutary effect. It is instructive that the civic potential of cyberspace has not only been recognized by government agencies but by civil society; in fact, states were relatively slow compared with many NGOs and corporations to exploit the Internet's potential as a public discursive space. Entry barriers remain relatively low in the virtual forum of the Internet. It does not take impossible concentrations of money or skill to create a web site and distribute one's messages to the world at large—at least to that part of the world that has Internet access. The availability of this resource has increased the pressures for disclosure even on governments and agencies with little prior history of transparency.

While systematic studies are not yet available, one can cite important episodes in which the Internet has influenced the conduct of S&T policy. After the fiasco of BSE ("mad cow disease"), for example, the UK government created an extremely informative, award-winning web site devoted to the government's inquiry into the crisis. The Internet facilitated the formation of a successful citizen movement against the Monsanto Company's plan to market sterile seed technology in the developing world. Medical information available on the Web is increasingly serving as a resource for empowering patients, who can now ask their doctors about therapies available in other world markets. As an almost instantaneous and global communication medium, the Internet has enabled NGOs resisting oppressive technologies, from dams to genetic sampling, to form networks, identify donors, and build larger, multinational support bases.

Such examples could be multiplied. But as with television, the Internet has its darker side in relation to the politics of science and technology. It is, to begin with, not as accessible a forum as it seems to those of us who are fortunate enough to benefit from its presence. Governments, corporations, universities, and other large organizations still control much of the access, and the cost of using this resource varies greatly from country to country and from one user category to another. Then, too, the Internet raises many of the same issues about the quality and reliability of information as television does, only perhaps on an even bigger scale, simply because the medium supports so much more communication and dissemination. Moreover, it would be naïve to think that the Internet's potential is used only for responsible public debate. It also supports communication among terrorists, criminals, pornographers, political extremists, and all kinds of charlatans with a computer and a phone line at their disposal. How much do we know about these aspects of negative political and social communication? What investments are we making to increase our knowledge?

S&T Policy and the Global Constitutional Order

I have suggested thus far that S&T policy has become both global and political, but that our policymakers and decisionmaking bodies have not, as yet, responded very effectively to the magnitude of these changes. I firmly believe that the decisions we make about S&T in the foreseeable future will be critical to the ways in which we eventually live together as a global polity. In that sense, I believe that S&T policy has a constitutive role to play in the world that is unfolding before us.

Let me conclude with a few brief thoughts about the issues—some new and some old ones in new guises—that I think will be most important for S&T policy and associated research policy to engage with during the current period of globalization.

Reliable knowledge. The fact that scientific knowledge is contingent and both historically and culturally embedded does not undermine the importance of producing reliable knowledge as a basis for public policy. It only increases the difficulty of generating facts and interpretations that people can respect even if they are deeply opposed to each other in interests or ideology. One focus of future S&T policy has to be the methods of generating such globally reliable knowledge. Neither disciplinary nor regulatory peer review is any longer adequate for the tasks ahead. There is a grave need for institutional frameworks within which people can openly and democratically debate the assumptions underlying competing views of risk, technological costs and benefits, and the ethics of alternative technological choices. How to design the necessary institutions (including transnational ones) and harness the new information technologies for such purposes will be particular challenges.

Expertise. What defines an expert in S&T policy fields? How can policy systems locate the appropriate expertise? What can be done to improve people's critical capacities to evaluate expert claims in the relatively open forums of television and the Worldwide Web? Few issues of S&T policy today remain confined within single academic disciplines. Policymaking increasingly needs to draw on heterogeneous mixes of skills, knowledge, experience, and training. These may cut across the natural sciences, engineering, social sciences, and even the humanities. Training new generations of S&T policy experts, and creating contexts in which their advice will be effectively used, will pose enormous problems. The need for experts to operate across geographic, cultural, linguistic, and ethical boundaries only heightens the difficulties. However, we will have to find ways of meeting these challenges.

Technology assessment. This is another buzz word (or formulaic term) from the 1970s, but the need for it has steadily grown and become more pervasive with time. We have known at least since 1945 that the technological choices of the few (often the richest few) have the power to fundamentally reshape, and even destroy, the lives of many. For years we believed that these world-reshaping technologies were limited largely to the military sphere. This was disturbing enough, but today's advances in biotechnology, nanotechnology, microcircuitry, satellite technology, etc. make it clear that civilian technologies, too, have a transforming potential. On an even wider territory, the technological choices of the few are reshaping the lives of the many. The principle of democracy demands that these choices, and the purposes driving them, be debated as widely and as profoundly as possible. A major challenge for S&T policy is to find the means to foster this debate, overcoming claims of state sovereignty, corporate confidentiality, intellectual property rights, and narrow conceptions of technical expertise.

Constitutionalizing corporations. At the end of the 20th century, Microsoft and the Coca-Cola can were almost as widely recognized around the world as symbols of technological achievement as the mushroom cloud (a product of state-sponsored technology) and DNA's double helix (a product of university research). For better or for worse, we have developed far more elaborate systems of accountability for S&T done in both states and universities than we have for corporate R&D. With corporations exercising state-like power through their R&D choices, it has become necessary to rethink ways of making this power more accountable on global scales. Just as the constitutions of the late18th century set limits on the political power of states, so the S&T policies of our era should take on the challenge of placing constitutional limits on corporate power.

Principles of solidarity. Most of us would agree that it is better to live at peace than at war, that democracy is better than totalitarianism, that relatively free markets are better than totally controlled economies, and that sustainable development is better than untrammeled exploitation of natural resources. Yet, when we begin to work out these concepts in the context of S&T policy, it quickly becomes apparent that contemporary societies stand far apart on many of the fundamental principles that should guide decisionmaking. Countries as similar as the US and states in western Europe do not agree on whether or how much precaution is warranted as a basis for environmental standards, which uses of the human genome are morally permissible, what defines innovation, how to draw the boundaries between public and private sector research, or whether certain forms of knowledge should be regarded as the common property of humankind. Harmonizing these "principles of solidarity" remains among the most difficult issues to be confronted by S&T policy in this new millennium. Once again, appropriate research policies will be needed to make sure we are generating adequate and appropriate forms of supporting knowledge.

I realize that the vision of S&T policy and research policy I have presented here is ambitious, and some may call it idiosyncratic: it is clearly more vision than template. Many may prefer a picture that is much more low-key, issue-specific, and closely tied to economic and technical analysis. My strong sense is that the time for such modest approaches ended somewhere during the third quarter of the 20th century. S&T today have become forms of global governance, perhaps not yet recognized as such, but no less powerful for being unrecognized. To make this power explicit, and to steer it toward humanistic ends, must surely be among the most basic obligations of S&T policy. *Research* policy, designed to increase and deepen our basic knowledges of the world in action, should become more reflexively self-aware of its role as an agent of change in this process.

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Ethical and Value Issues in Research Policy
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This paper aims to: (1) explicate the ethical and value issues in research policy so that they are "on the table" for the workshop; (2) draw attention to some of those issues, in particular as they pertain to research policy framed as an agent of change; and (3) suggest innovative directions in which research on research policy and research policy itself might go to ensure that ethical and value issues are taken into account and addressed.

I. Understanding the Ethical and Values Issues in Research Policy

The territory we will be discussing – research policy – is not well-defined and while we need not spend time precisely defining it, the ethical and value issues cannot be understood unless we have at least a rough characterization of the kind of the activity on which we will be focused. Thus, I begin by proposing a broad definition to orient the conversation. I will take research policy to be something like the following: A research policy is a strategy for achieving developments of new knowledge, new forms of expertise, and new infrastructures. 'Infrastructure' includes educational programs and curricula as well as artifacts such as supercomputers and satellites. Research policies can be exclusively aimed at development or they can be a component of a broader policy aimed at other ends. Both the National Science Foundation and the patent system are examples of research policies though the former is primarily a research policy (or set of research policies) and the latter is secondarily a research policy in that the patent system also aims at economic and market outcomes along with innovation.

How, then, might we get a handle on the ethical and value issues in research policies? What are the normative issues? How can research policies be evaluated/ When do they go wrong? A good starting place is to consider the ends (the goods, the outcomes) at which research policies aim and then consider the means by which they try to achieve their ends. Here it is worth noting that contrary to mythology, research policies are rarely, if ever, aimed at knowledge, expertise, and infrastructure for their own sakes; rather knowledge, expertise, and infrastructure are sought to solve human problems and enhance human wellbeing or further other social goods. In this respect, research policy is at its core a normative endeavor. Research policies are aimed at doing some good – however 'good' might be understood.

Research policies are strategies for solving problems and facilitating human activities, and, as such, they involve decisions as to which problems are to be targeted for solution and which activities are to be enhanced or facilitated. Admittedly, research policies cannot guarantee what the results of research will be (that is, investment in the cure for disease X does not guarantee a cure for disease X), but research policy decisions increase the likelihood of certain problems being solved and certain kinds of activities being enhanced. In this way, they create and distribute benefits.

Insofar as research policies are about the creation and distribution of benefits, they are matters of justice, distributive justice. Buchanan (2001) defines distributive justice as follows: "Theories of distributive justice attempt to articulate, order, and justify principles that specify just distributions of benefits and burdens (other than punishments)." Research policies are systems for distributing the benefits that result from resources invested in research; decisions and the decision process determine which problems are targeted for solution, what knowledge and expertise is created, what infrastructures (facilitating what kinds of activity) are built. To be sure, decisions about what to fund and how much to invest in which project must take into account other factors as well, but whatever else they take into account, they result in a distribution of benefits, and, thus, the question of fairness is unavoidable.

Identifying the normative core of research of research policy is, unfortunately, the easy part; the hard part is figuring out what a just research policy would look like. Would resources be distributed somehow equally to all needs? Should there be a democratic process for distribution? Could a Rawlsian principle be implemented, that is, one that ensured that inequalities were arranged so that they were to the greatest benefit of the least advantaged? Notice that we can focus on outcomes or processes here. In other words, there are issues of goals to be achieved as well as fair processes in deciding what research gets funded. More on this later.

It may be helpful here to use medical research as a salient model of the normative issues implicit in research policy decisions, for in medical research we see limited resources being distributed and it is clear that the distribution means increased likelihood of a cure for one disease and neglect of many other diseases. Decisions such as these may result in some lives being enhanced while others are not saved. In the case of science and engineering research policies, the decisions are of the same character though the results are sometimes subtle; they don't quite hit us in the face.

If we think of distributive justice as the normative issue at the core of the end (goal/task) of a research policy, there are also important normative issues regarding the means, research practices. The ethical and value issues around research practices will be familiar territory to many at the workshop. Research practices are often constrained by moral principles and social values. Requiring researchers to obtain the informed consent of human subjects is perhaps the most obvious example here. In many cases, research results would easier to obtain and in some cases, better results would be obtained were it not for this requirement. The principle is also problematic when it comes to the use of children, the unconscious, or the terminally ill so that alternative means have to be sought to uphold the principle. Other issues arise with regard to the use of non-human animals; ownership of data; proper credit attribution; conflicts of interest; fraud and misconduct; and so on. Rather than delving into any of these issues, I put them on the table because they raise the broad question regarding the normative character of research practices. Ethicists often understand morality to be a constraint on the pursuit of self-interest and that is not an inappropriate way to understand it here. I should also add that there are two kinds of constraints at work here. Sometimes research practices are constrained so as to yield the best scientific results as in the case of prohibitions on fraud and misconduct; other times the constraint is aimed at a moral principle such as respecting the human beings involved in the research.

II. Ethical and Value Issues in Research Policy as an Agent of Change

For those of us who study the ways in which science, technology, and society co-create one another, thinking about research policy as an agent of change is the right way to think about it. New knowledge, expertise, and infrastructure go hand-in-hand with social, political, and cultural change. Here the ethical and value issues are intertwined with the social change that accompanies the new knowledge, expertise, and infrastructure. The big issue is, then, **who** is affected by the change and **how?**

From a distributive justice perspective, at least two important issues emerge from explicitly framing research policy as an agent of change. The first is, can research policy play a role in achieving social justice? In other words, can the social change brought by new knowledge, expertise, and infrastructure move in the direction of social justice? (More weakly, can it avoid outcomes that worsen existent inequities?) And, the second is, given that research policies have powerful effects on people's lives, shouldn't they (those affected by the policies) be involved in the policy decisions?

On the first issue, it is important to note that NSF has taken on a social justice agenda insofar as it requires grant proposals to address issues involving women and minorities. NSF has incorporated into its strategy for developing new knowledge, expertise, and infrastructure, a social agenda of addressing the small number of women and minorities in science and engineering. So, research policy can be an agent, not just, of change, but of change in the direction of a more just society. The hard question is not whether research policies can do this, but rather, when and how they should do it?

The second issue that emerges has to do with the involvement of those who are affected by research in decisions about the research. We could adopt a strategy like the one that Schinzinger and Martin (1999) use with engineering. They argue that engineering should be seen on the model of human experimentation because it always involves risks and uncertainty. Hence, engineers should be doing a lot more to seek the consent of those upon whom they experiment, that is, those whom they put at risk. The case for research policy as human experimentation is compelling, and especially when we think about research as an agent of change. However much we can anticipate and predict, we don't know what the results of research will be and we don't know what the new knowledge, expertise, and infrastructure will do in the world.

This makes a strong case for the involvement of those who are likely to be affected in research policy decisions. Here again we have a positive example, the case of aids activists who contributed to the research practices for testing of aids treatments (Epstein, 1996). In this case, aids activists and researchers came up with a research protocol that both achieved good scientific results and improved the treatment situation of those who participated in the research. The case illustrates the possibility of improving the outcomes of research by involving the subjects in the research.

Thus, a consequence of framing research policy as an agent of change is that it makes more visible the importance of involving those likely to be affected by research in policy decisions. Much more research needs to be done on alternative models for doing this.

III. Innovative Directions

In the proposal for this workshop interest in addressing issues of globalization and interdisciplinarity are indicated. My analysis of the normative aspects of research policy doesn't directly point to either of these things; however, it does suggest ways to think about both of these, though especially globalization. If globalization is effectively inevitable, we might take as our end to develop research and research policies that increase the likelihood that certain forms of globalization will take place rather than others. In other words, if there is going to be an intensely global economy, we ought to be thinking about different models of globalization and then we ought to fund research that will allow the alternatives to be seen and increase the likelihood of better models taking hold. Globalization raises the question of distributive justice on the broadest scale; globalization can mean a new system of exploitation or an opportunity for more equitable distribution.

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RESEARCH POLICY AS AN AGENT OF CHANGE (AND VICE VERSA)

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My research is based on empirical projects that lie at the boundaries of law, economics, history and technology. A recent paper, "Innovations in Law and Technology, 1790-1920," examines the relationship between the legislature, the common law, regulation and technological change, in the context of such major innovations as steamboats, railroads, telegraphy, medical devices and public health, and the automobile. The article emphasizes the extent to which the common law system comprised a decentralized method of mediation that was continuously calibrated to accommodate advances in science and technology (S&T). In another project, a co-author and I have assembled a data set of biographical information on over 300 "great inventors" including some 16,000 patents that they filed between 1790 and 1960, to explore the role of science and education and the impact of age on productivity. Much of my work analyzes the economic history of patent and copyright systems in Europe, the United States, and developing countries. These results have some bearing on our understanding of how national and international policies and institutions shaped and were shaped by science and technology. They suggest that research policy is an agent of change but, if outcomes are to be effective, change should also be an agent of updates in research policy.

Institutional flexibility has been a defining feature of the American experience. Courts in the seventeenth and early eighteenth centuries performed a comprehensive regulatory function that encompassed both the private and public realms. Soon after the first decade of the eighteenth century, as the scale of market activity increased, a division of labour across institutions led to caseloads in civil courts that primarily involved economic transactions to enforce debt contracts. The legal system was therefore well-prepared to accommodate the new economic challenges of the nineteenth century. Although my research centers on legal institutions, it highlights the complex network of institutions that function as complements or as substitutes to the law. By the start of the twentieth century, legal institutions still formed an integral part of American life, but their orientation had altered because their activities were bolstered by an array of associative and administrative institutions. This process of bureaucratization, perhaps because more visible than the decentralized decision-making of the court system, led some observers to highlight regulation as a twentieth-century innovation. Instead, economic activity in the United States has always been subjected to regulation in the name of the public interest: the major feature that has changed is the type of institution that accomplished this task. However, *which* particular institution prevails – norms, legal system, bureaucratic regulation, government or market -- may be less important than the degree of flexibility exhibited, for institutions that do not respond to social evolution will necessarily become irrelevant.

The second point to underline is that neither institutions nor S&T are exogenous. American intellectual property laws had a significant impact on the rate and direction of inventive activity and cultural output. The Framers of the American Constitution had been certain that social welfare would be maximized through the "progress of science and useful arts." In his first address to Congress, George Washington urged that "there is nothing which can better deserve your patronage, than the promotion of science and literature." Congress responded by drafting patent and copyright statutes that reflected a democratic market-orientation. As the creators of the intellectual property system recognized, inventors would be motivated to address important needs of society if they were able to appropriate the returns from their efforts. They felt that this would be best achieved through a complementary relationship between law and the market. Patent laws ensured the security of private property rights in invention. The attitudes of the judiciary were also relevant, since if courts were viewed as "anti-patent" this would tend to reduce the expected value of patent protection. Legal rules and doctrines influenced the identities of inventors and the nature of their inventions. For instance, relatively low patent fees served to encourage ordinary citizens to invest in creating new discoveries, in contrast to the European system, where mainly the wealthy or privileged were able to benefit. The United States also stood out because patents were objectively granted through an examination system, which served as a filter that increased the average technical value of patents, promoted a market in inventions, and encouraged the diffusion of information. The wish to further technological innovation through private initiative created a paradox: in order to promote diffusion and enhance social welfare it would first be necessary to limit diffusion and to protect exclusive rights. Thus, a key element of the policy debate has always concerned the boundaries of the private domain relative to the public domain.

In contast to patent policies, the copyright regime was hedged about with caveats and even allowed unauthorized access if it qualified as "fair use." Copyright differed from patents precisely because the objective of both systems was to maximize social welfare. Copyrights provided weaker incentives for new expression and risked reducing public access to science (knowledge) and freedom of expression. New technologies presented further dilemmas because they increased the scope and duration of copyright protection and had potentially deleterious effects on the public domain, leading some to question whether the fair use doctrine and copyright itself could endure. However, it is vital to understand that fair use was not formulated simply as a function of technologies that influenced the ability to monitor use, nor was it limited because courts recognized the (moral or other) rights of "authors." Even if monitoring costs were zero, and all use could be traced by the author, fair use doctrines would still be relevant to fulfill the ultimate function of property rights in cultural products. Without fair use, copyright would be transmuted into an exclusive monopoly right that would violate the Constitution's mandate to promote the progress of science. In short, according to American legal doctrines, fair use was not regarded as an exception to the grant of copyright; instead, the grant of copyright was a limited exception to the primacy of the public domain.

Another significant difference arose in the realm of U.S. policy towards international patent and copyright laws. A nation of artificers and innovators, both as consumers and producers, American citizens were confident of their global competitiveness in technology, and accordingly took an active role in international patent conventions. Although they excelled at pragmatic contrivances, Americans were advisedly less sanguine about their efforts in the realm of music, art, literature and drama. As a developing country, the United States was initially a net debtor in flows of material culture from Europe. The first copyright statute implicitly recognized this when it authorized Americans to take free advantage of the cultural output of other countries and encouraged international copyright piracy that persisted for a century. The tendency to reprint foreign works was encouraged by the existence of tariffs on imported books that ranged as high as 25 percent. It was not until 1891 when American literature was gaining in the international market that the Chace Act granted copyright protection to foreign residents in order to gain reciprocal rights for American writers and artists, and the U.S. failed to qualify for admission to the Berne Convention in Copyrights until 1988.

What was the impact of this policy of international piracy on research in the United States? Overall, the effect depended on the degree of substitutability in cultural goods across countries, and on the extent to which publications varied in response to material incentives. For both of these reasons, it is not surprising that domestic research and nonfiction likely benefited on net from piracy. Many researchers are more motivated by returns through reputation rather than through the market, and reputation varies positively with diffusion. Moreover, American geology (say) was not substitutable with the geological findings for Europe, so there was little merit to piracy of output, which would have displaced or reduced domestic efforts. At the same time, the works of foreign authors were freely available for Americans to draw on, so piracy reduced the cost of learning and increased its supply. As a developing country, the United States seemed to have benefited from weak domestic copyright laws, and from international copyright piracy.

Legal statutes and their enforcement in state and federal courts had a significant impact on productivity and output, as well as on consumption and welfare. The direction of causation was reciprocal, however, since legal doctrines also quickly responded to new findings in science and technology. My research identifies five different mechanisms through which S&T had an impact on the law: S&T innovations affected existing analogies; altered transactions costs; increased the speed and scope of transactions; influenced norms and expectations at both the industry and societal levels; and changed judicial and legislative conceptions of the most effective means to promote the public interest. In the first instance, courts attempted to mediate between parties to disputes that related to the incursions of new technologies through a process we can regard as "adjudication by analogy." Early on, the law was stretched to accommodate discrete changes by attempting to detect some degree of equivalence across technologies, either by form or by function. However, inappropriate analogies tended to increase the frequency of legal conflicts or appeals, which served as a signal to indicate that revisions were insufficient. Second, inappropriate rulings increased the cost of transacting, and made it necessary for legal doctrines and legislation to change in order to encompass the new innovations. The third mechanism related to technologies, such as major advances in transportation and communications, that led to a more rapid pace of activity, and thereby produced pressures for rapid responses in the legal system. Fourth, judicial decisions attempted to enforce community standards and expectations, which were a function of the current state of technology. Finally, the judiciary recognized that, in order to increase overall social welfare, the law must evolve to allow citizens the most effective way of taking advantage of new opportunities. At least one way in which this recognition manifested itself was a shift in the relative importance of state and federal jurisdictions as markets expanded.

American policies in the nineteenth and early twentieth centuries were utilitarian and pragmatic, in accordance with the Constitutional mandate. Research that was linked to specific and tangible outcomes was given strong protection in the form of exclusive patent rights. Facts and ideas could not be protected, in order to encourage diffusion. Today, a welter of socially inefficient policies threaten to prevail because of a lack of attention to the original intent of the Constitution. For example, current proposals to import European legislation to protect databases are inconsistent with the longstanding policy that basic knowledge should not be exclusive. Courts a century ago rejected the idea of patents on business methods under the dictum "advice is not patentable." While valid patents could not be viewed as monopolies, copyright raised the danger of monopolies on knowledge and reductions in learning. In order to promote social welfare, it was therefore necessary to continuously adjust the copyright system to maintain a balance between access and incentives. Technological change (such as the means to trace users on the Internet beyond the first sale of the item) raises the potential for exclusion to a greater extent than before. Rather than allowing publishers to monitor and enforce these expanding rights, copyright doctrines indicate that such technologies call for public policy to redress the balance by allowing *greater* leeway for public access. Digital technologies do not require a new theory of copyright; they simply call for a better understanding of existing principles. In the international sphere, historical U.S. experience demonstrates that S&T policies which are beneficial to a now-developed country are not necessarily appropriate for countries that have not yet attained self-sustaining growth.

Did the United States have "a" research policy in the nineteenth and early twentieth centuries? Clearly, it did not; and this proved to be its greatest strength. The most blatant failures in American S&T policies (such as the manned space shuttle programme) occurred when the U.S. abandoned a flexible, market-based democratic and decentralized approach. Both history and political economy suggest that effective management of innovation does not require "a" research policy; it requires a plethora of such policies.

Workshop: Research Policy as an Agent of Change

Tucson, AZ October 10-11, 2003

Institutionalizing Democratic Values in Research Policy

Frank N. Laird

My comments will span themes 3 and 4 of this workshop, focusing on the need for democratic values in research policy and the ways that institutions embed values.

Democracy

Implicit in this workshop is the concern that research policies be not merely agents of change but good agents of change. I posit that one requirement for that result is that they be, at least in some senses, democratic agents of change. The normative case for democracy in these policy areas has been argued by Fiorino, Jasanoff, Sclove, and myself, among others. The literature on democracy and S&T policy (of which research policy is a subset) presents some mature findings and leaves some large gaps. So what do we know with considerable confidence about democracy and S&T policy?

1. Deliberation. Good democratic policy processes are deliberative democratic policy processes. The core requirement of various versions of liberal democratic theory is that individuals be able to act to realize their potential and their goals in life. Only deliberative democratic processes can deliver on that goal. As I and others have argued elsewhere, deliberative processes let participants question the framing of an issue, seek the technical knowledge they need to realize their goals, bring their particularistic knowledge to bear on the issue, and come to understand the interests and views of others. An assortment of normative analyses make the case for the linkage between deliberation and effective democracy. Numerous case studies from the 1970s to the present document all of these results, with obvious caveats: the processes have to be well-designed and run; and sometimes even the best processes go awry.

2. Early and Often. Effective democratic participation has to take place early in policy deliberations and extend throughout the policy making process. If citizens only get to participate after policy makers have made most of the decisions, they will likely express their frustration in a variety of ways, including seeking to block whatever policy is proposed. In addition, only early participation makes it possible for citizens to influence the way an issue is framed. Ongoing participation enables citizens as well as policy makers to take advantage of new knowledge and adapt their positions to changing circumstances.

Interestingly, the deliberative and early and often criteria tend to rule out many of the processes that some people think are democratic. One could make a good case, for example, that referenda on S&T issues are bad precisely because they are not democratic. Citizens are presented with a pre-digested, simple, usually dichotomous choice, one that forces them to choose between two alternatives, neither of which may suit their needs or their notions of how the problem ought to be approached. Such referenda come late in the process, with all the pathologies that entails. Citizens have no opportunity to question the framing of the issue or propose alternative policies. Also, the processes leading up to referenda are usually marked by an assortment of interest group-driven propaganda, nothing that could be called public deliberation worthy of the name. Thus, in important sense, referenda do not enable citizens to exert the control over their fate that democratic theory would like to see.

3. Open negotiation of the science/policy boundary. Genuinely open processes require honesty about the need to negotiate the boundary between science and policy. As Jasanoff, Guston, and later STS studies have shown, that boundary is contingent and contested, and a democratic process needs to be explicit about that point. Such explicitness about the boundary will lead to more intellectual honesty about both the science and the politics, since none of the sides to the dispute will have as great an opportunity to hide their political goals behind scientific claims. Acknowledging this contingent boundary opens the possibility for all sides to negotiate and deliberate upon the issues that are genuinely in dispute, which may include fundamental principles and assumptions.

Problems of Democracy

All of the above discussion implies that it is in fact possible for participating citizens actually to know how a particular R&D policy will affect them. Obviously, making such predictions—the social and political consequences of a particular R&D program—presents extraordinary difficulties. In short, such predictions will always be wrong to some important extent. Therefore, democratic policy institutions and social movements need to understand that fallibility, be capable of making decisions under great uncertainty, and be adaptable and able to learn over time. The literature on institutional learning, though disparate, is developing some core ideas that apply both to governmental and social institutions. R&D institutions, whether in the state, the economy, or civil society, will inevitably do things that they come to regret, and so their ability to make good policy, including the ability to respond to democratic pressures, will depend on their ability to learn and adapt.

One of the core features of institutional analysis during the last couple of decades is the recognition that institutions contain embedded ideas, both normative and positive. By some definitions, institutions are little more than such embedded ideas. That means that if there are particular ethical or political values that we would like to see R&D institutions champion, such as democratic responsiveness or concerns for social justice, then those values need to be a component of the ideas embedded in the institutions themselves. They need to be a core feature of the way an institution views its mission and evaluates the policies it adopts. As I have argued in a longitudinal case study, it is much harder to graft such values on to the back end of the process.

Environmental Science, Politics, and Policy Change

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Paper prepared for NSF Workshop on "Research Policy as an Agent of Change"
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Research policy in the U.S. comprises a web of disparate and disconnected research programs, each of which is motivated (or at least justified) not by scientific curiosity but by practical concerns. In one area of research—science aimed at understanding the working of earth's natural systems—those driving concerns have undergone a fundamental transformation in the last 50 years. Prior to the 1960s, the objective of environmental science (e.g., research on fisheries, rangelands, forests, wildlife) was to learn more about how natural systems work in order to enhance their productivity for human use. Since the 1960s, however, most environmental science has aimed primarily at understanding the harmful impacts of humans on the environment and the consequences of those impacts. This shift raises several important questions about the relationship between environmental science research and policy: Do our investments in environmental science result in better environmental policies? Can we redirect scientific research in ways that are likely to enhance its impact on politics? Do collaborative approaches to research improve the quality of decisions, given that environmental policy disputes often hinge on conflicting interpretations of the available science? Answering these questions can help us direct our research energies in the face of increasingly urgent environmental problems and stringent budgetary constraints.

Environmental concern, not scientific knowledge, was the impetus behind such early legislation as the National Environmental Policy Act, the Endangered Species Act, and the Clean Air and Water Acts. However, those policies created a demand for science on which to base decisions about implementation, legal interpretation, and statutory revisions. The obvious question, then, is: Has improved scientific understanding of our environmental problems enabled us to address those problems more effectively than we might have in the absence of such knowledge? One general argument that has emerged from investigations aimed at answering this question is that both the content and the form of scientific claims largely determine the extent of their impact on politics and policy (see, for example, the work of Karen Liftin, Edward Parson, Judy Layzer, and others). Others suggest that the process by which scientific claims are formulated determines their acceptability in the political arena (e.g., Sheila Jasanoff, Dorothy Nelkin, Lawrence Susskind, and others). According to a third group of scholars, the characteristics of the individuals or communities that transport scientific knowledge into the political realm determine its impact (e.g., Peter Haas, Reiner Grundmann). Gaining insight into the relative value of these arguments can help policymakers direct the mode of scientific inquiry as well as its presentation.

Research into the impact of environmental science on politics and policy, in turn, has spawned a handful of fruitful research policy questions, one of which is: Do some approaches to environmental science research tend to be associated with more effective policies than other approaches? For example, given that ecosystems are enormously complex and heterogeneous, does it make sense to direct scientific energy towards research aimed at formulating ecological generalizations or at conducting detailed investigations of individual ecosystems? Investigation of this question might entail examining the way science is used in a variety of efforts to address ecosystem-scale problems.

Another question that arises is: Does "joint fact finding"—that is, having stakeholders and scientists collaborate in framing research questions, selecting methods for answering those questions, and collecting and analyzing the data on which decisions ostensibly are based—actually improve the quality of the policy decisions that are made? Proponents argue that such collaboration facilitates learning among all participants and hence enable the formulation of policies that are both more effective and more likely to be implemented. By contrast, critics contend that joint fact finding is likely to result in watered-down science and, hence, ineffective policies. Again, addressing this question will entail pitting these hypotheses against one another in a systematic investigation of cases.

A third question is: How do our environmental policies shape researchers' efforts to understand environmental problems—and hence, over time, the solutions offered to address those problems? For instance, does legislation that places the burden of proof of harm on agencies lead to research of a different type or quality than laws that require manufacturers to demonstrate the safety of a substance or process? A related but more narrowly focused question is: How does the Endangered Species Act, with its focus on individual species and their habitat, constrain the ability of scientists to gain a broader understanding of the workings of ecosystems?

The vast majority of Americans believe that the environmental problems we face—in the U.S. and around the globe—are real and serious and merit governmental attention. Most Americans also believe that our environmental policies ought to be based on "sound science." One critical role for those of us who are interested in the nexus between research and policy, then, is to elucidate mechanisms for building bridges between the things we value and what we know about them. Such efforts, in turn, can enhance the likelihood that policy decisions reflect the best available knowledge.

What If Science Policy Makers are Anti-Science?

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The U.S. has no real science policy, nor research policy. Policy exists only piecemeal, in separate policies made and implemented by divergent groups that often arise reactively and in conjunction with funding decisions. Until recently, those seeking to guide or develop research policy have focused on funding, regulating, and implications for adjudicating. If Congress funds environmental, space, or polar science, that is taken as policy; special initiatives for IT or genomics indicate policy. Agencies' development of guidelines to regulate recombinant DNA or chemical or animal handling are regarded as part of research policy, as is establishing Federal Rules of Evidence to guide the courts.

Throughout U.S. history, science and research have been assumed to be good, and government has accepted responsibility to support generating science and technology knowledge and applications. Science and technology will lead to a better society, we have assumed, though that has meant different things and has been played out in different ways historically. The 19th century brought mandates to explore and expand physical frontiers, while the 20th century emphasized growth of scientific knowledge as the way to conquer scientific frontiers. Vannevar Bush articulated these assumptions in their most familiar form, urging that scientific research and technological applications will lead to social goods, and therefore that we have a social, moral, and political mandate to carry out scientific research and development.

Environmentalists, animal rights activists and others have challenged the assumptions, and have been joined by a cacophony of divergent voices demanding social change. Some have invoked scientific research as an agent for social change and have sought to shape policy in order to promote their goals. Others have attacked scientific research itself as a negative force, but they have not prevailed politically. The history of science provides many rich cases of efforts to invoke research as an agent of social change, and it will be important to carry out historical research on these examples. We need historical study of science and research policy that will illuminate the current situation, such as the History of Science's current *Osiris* project.

Adroitly co-opting the social reformers' rhetoric, George W. Bush and his policy makers attack science in another way. They are not centrists seeking to negotiate a balance of interests. They are themselves extremists and the harshest critics of some (but not all) science and technology research. This administration requires us to ask: what happens when science policy makers are anti-science? By seeking to impose absolutist moral and religious standards on policy guiding what research can be done, what regulations we will impose, and what counts as "sound science," this administration demands that research policy conform to its moral, social, and political agenda. This should be cause for alarm – and careful study, including historical study.

In September, 2003, President Bush announced his plan to appoint Dr. W. David Hager to head the Food and Drug Administration's (FDA) Reproductive Health Drugs Advisory Committee. This committee oversees women's reproduction, and sets guidelines and policies to serve American women's health interests. Dr. Hager is author of "As Jesus Cared for Women: Restoring Women

Then and Now," and has expressed certainty about his pro-life stance and his commitment to instilling that view in others – as the "sound science" approach to health issues. Apparently he feels that science and medical policy are properly guided by (his) religion and should serve as an agent of (his) goals for social change.

In August, 2001, President Bush announced his Executive Order regarding stem cell research. U.S. scientists could carry out research on only those lines of stem cells that had existed at the beginning of Bush's August 9 speech, and with only very limited use of federal funds. This replaced President Clinton's Executive Order that had allowed some stem cell research with NIH funding. Again, Bush appealed to his religious and moral convictions as guidance for this research policy. Subsequent examples by Bush and his administration have led to interpretations of what counts as an embryo or fetus and what legal protections and penalties should prevail for injury to either.

Politically-motivated critics impugn the scientific claims of selected expert witnesses to disallow their contributions in courts or policy-making arenas by claiming that they are not good or sound science. Evolution is said to be unsound by such critics, while others attack evidence of global warming or studies of how children learn. By dismissing such claims as not-good-science, opponents seek to undercut the authority of research without having to establish their own claims on anything but grounds of purported moral or religious truth. As Bruce Alberts explained patiently at one Congressional hearing: if of 10,000 scientists, 9999 agree that evolution has occurred based on existing evidence (or whatever scientific claim), it can be taken as well-established and good science, never mind that one person disagrees. Yet at least two Congressmen insisted that we should always listen to the one who disagrees "if he is morally right." They denied that the history of evidence-weighing or that preponderance of evidence matter. This is research policy by appeal to moral authority.

Leon Kass serves as Bush's appointed bioethicist-in-chief. Kass's "wisdom of repugnance" relies on an intuitionism that is highly unscientific, yet he invokes his own purported wisdom in favor of strong claims about what research policy should be. We must not carry out cloning or stem cell or other embryo research because it is "repugnant" and we supposedly all know that if only we are honest. The fact that I (or you or others) do not agree only shows that we are wrong. On this view, only (his) morality and politics make wisdom, and (his) morality should make research policy.

Scientists claim a core value of scientific freedom, yet society has accepted some reasoned restrictions on research. We do not allow human experimentation without restraint, and a system of guidelines regulates such areas as chemical, nuclear, and radiation science with penalties for non-compliance. We do, therefore, accept legal, moral, and social restraints on research and research policy – but only where community discussion yields reasoned and reasonable decisions to place restrictions. We hold that democracy allows freedom unless there are reasons to impose restrictions. The current push to impose research policy based on moral extremist reaction does not follow this model. Instead, research policy is being set by anti-science and anti-research interests.

We are in serious trouble when research policy is dominated by anti-science and anti-historical interests, that is when interests are guided by values not only separate from but antithetical to the methods and values of science and in ignorance of larger traditions of democratic negotiation and compromise. We are in serious trouble when society allows extreme political and moral forces to determine what will count as "sound science" and to dictate research policy. So-called postmodern criticisms of science have, unfortunately, confused the situation and inflamed the passions of those opposed to scientific values. This is dangerous, and we are dangerously close to seeing anti-science triumph in the name of science in many areas, including in embryo and environmental research. Research policy may, indeed, become a powerful agent of change. The risk is that the change will reinforce a political and moral absolutism and a failure of rationally-based enlightened scientific research values.

Global Science and Global Governance: The Making of "Global" Research Policy

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The United States should be investing efforts and funds to strengthen the health structures in countries around the world. If we were to help train experts in epidemiology and surveillance, strengthen laboratories in key regions and link them to the best labs in this country and around the world, and support WHO, we would help to create a true global health network. This investment would protect our country and every other against global epidemics, save millions of lives, and change the U.S. image from one of self-interest to one of human interest.[4] – Barry Bloom, Dean, Harvard School of Public Health

Bloom's response to the SARS epidemic is illustrative of a growing demand for global scientific collaborations that can help address a new class of policy problems framed explicitly in planetary terms (see, e.g., Haas, 1990, 1992; Zehr, 1994; Litfin, 1995; Takacs, 1996; Jasanoff and Wynne, 1998; Miller and Edwards, 2001a, Long Martello 2001). Over the past two decades, scientists, regulatory officials, and citizens alike have increasingly come to see and attach importance to interconnections that tie together large parts of the globe (see, e.g., Jasanoff, 2001; Miller, forthcoming, b). In turn, significant resources have been put into efforts to develop new international expert collaborations, committees, institutions, and networks that can build scientific knowledge of global phenomena and link that science to the formulation and implementation of global policies to protect public health, the environment, financial stability, investor returns, and other perceived public goods (see, e.g., Miller, forthcoming, a). These efforts build on and significantly expand two previous generations of international scientific collaborations, during the boom of international intellectual exchange between 1871 and the 1920s (Iriye, 1997), during which many of the international scientific unions were formed, and in the period immediately following World War II, when nations created the Specialized Agencies of the United Nations (Burley, 1993; Miller, 2001a). Both historical and contemporary experience indicates, however, that constructing these new social arrangements among scientists and between scientists, diplomats, and publics is neither as simple nor as straightforward as Bloom suggests.

In this brief essay, I want to suggest that these trends have important consequences for the study of "reseach policy as an agent of change." Emerging global scientific collaborations form an increasingly important and potentially powerful element of emerging constitutional frameworks for global governance (Reardon, 2001; Miller and Edwards, 2001b; Jasanoff, forthcoming; c.f. Winner, 1986; Latour, 1993 for discussions of the technical and technological constitution of modern society). Consequently, there is a need for:

[4] Barry R. Bloom, "Lessons from SARS," *Science* 300(2): 701.

- **New analytic research on global science and research policy**: It is important that scholars in STS, science policy, and related disciplines develop a much better understanding of how global scientific collaboration is happening, what form it is taking, who is involved (and who not), as well as what its implications are for policy and governance outcomes.

- **New normative research on global science and research policy**: Research in this area has important normative potential for informing the process of creating global scientific arrangements, both in terms of evaluating current programs and offering generalized, critical reflection on how future arrangements might improve upon current efforts (including asking such questions as what does improvement mean, to whom, according to what criteria, to what end, and so forth).

- **New infrastructural support from NSF for global research**: More pragmatically, in order to do justice to research on global-scale social and institutional processes, there is a need for researchers in this area to have access to a higher level and new modes of financial and infrastructural support for their work.

Background: In the late 19th century, scientific characterizations of human psychology, behavior, cognitive capacity, organization, and social practices were codified and became closely tied to the growth and institutionalization of state power. Those sciences profoundly influenced modern understandings of what it means to be human, and how social problems should be defined (Foucault, 1971, 1973, 1978, 1979). Concurrently, they laid the basis for programs through which nation-states could ameliorate social problems and publicly justify their effectiveness and legitimacy (Rueschemeyer and Skocpol, 1996; Porter, 1995; Wagner et al., 1991; Nowotny, 1990; Ezrahi, 1990; Hacking, 1990). Terms like poverty, unemployment, criminality, violence, mental illness, gross national product, and welfare came into being, backed by new techniques of measuring and classifying groups, their status, and their behaviors in relation to these concepts—as well as new programs for collecting statistical data on social demographics, economic welfare, crime rates, and labor statistics, often managed by new government agencies. As these conceptual systems and practices evolved, so too did the indicators for characterizing the state's performance in managing these novel social phenomena.[5]

Today, scientific characterizations in what might be termed "global sciences" are playing a comparable role with respect to the emergence and consolidation of new forms of global governance. One of the starkest examples is global change research. Since the 1940s, a steady stream of national and international scientific research programs have explored the dynamics of environmental systems and process—the atmosphere, the climate system, the ozone layer, biodiversity—as natural objects that could be understood, investigated, and managed on scales no smaller than the planet in its entirety (Miller and Edwards, 2001a). In the 1980s and 1990s, this research became the basis on which elaborate new international legal and institutional frameworks were constructed, that in turn promulgated global policies that promoted new areas of scientific research, established standards for scientific research protocols, and fostered new global observing networks.

[5] The text of this paragraph and the broader ideas that the section is based upon are drawn from a series of collaborative proposals by Sheila Jasanoff, Clark Miller, and Marybeth Long Martello.

Much as poverty and unemployment became classification systems for measuring social welfare and redistributing wealth from the rich to the poor in the policies of the welfare state, today, the sciences of greenhouse gas emissions, environmental vulnerability, and sustainability are becoming the systems for classifying humanity on a global basis and redistributing resources. The Kyoto Protocol, for example, assigns responsibility for actions to mitigate climate change on the basis of a scientific calculation of each country's greenhouse gas emissions. It likewise allocates proceeds from its Clean Development Fund to those populations around the world that are deemed "most vulnerable" to climate change. The Protocol's Subsidiary Body for Scientific and Technological Advice is currently developing standard methods for assessing vulnerability as a basis for allocating disbursements from the fund. More generally, World Bank data indicate that unrestricted government-to-government aid is increasingly being replaced by environmental aid, as richer countries insist that their poorer counterparts adopt more sustainable policies in exchange for resource transfers. Here, too, policymakers at agencies like the Global Environment Fund rely on science to legitimate particular claims to sustainability. The Global Environment Facility, for example, is considering requiring countries to carry out a standardized, scientific assessment of ecosystem goods and services before disbursing funds for ecological protection.

One important result from preliminary studies focusing on the development of global scientific collaborations, networks, and institutions is the problematic character of their formation and operation. Studies adopting a co-productionist idiom (see Jasanoff, forthcoming) have shown that to succeed, such collaborations must build stable scientific *and* political arrangements. Where they have, as in the UN Specialized Agencies or the Intergovernmental Panel on Climate Change, scientists have become essential elements of broader socio-political orders (Takacs, 1996; Miller, 2001a, forthcoming, a, b). Where they haven't, scientific projects have foundered, as in the case of the Human Genome Diversity Project (Reardon 2001). Another important aspect of international scientific advisory organizations are the diverse political cultures and traditions that such arrangements bring into dialogue. Comparative studies have long demonstrated the very different institutional arrangements, evidentiary standards, policy framings, notions of expertise, and so forth, found even across the advanced industrial democracies, all of which have important consequences for the credibility and legitimacy of science advice. To operate in global policy forums, international scientific advisory processes must find ways to overcome these differences in norms, rules, and practices else they risk being seen as biased or illegitimate (Jasanoff 1998; Miller 2001b, 2000). A third example, capacity building, inevitably raises the question: capacity building for what purpose? Should capacity building focus on strengthening local knowledge and expertise, building "international"-caliber research programs, creating new science-policy linkages, training government bureaucrats to follow the requirements of international law, or simply exposing local officials and scientists to the findings of global science institutions (Miller 1998)?

New Areas of Research: Drawing on this background, one can suggest a number of important questions about "research policy as an agent of change". Some of the most critical include:

- **Who are the agents of "global" research policy, how do they interact with one another to shape research policy, and to what effect?** Even in "global" fields, most research remains funded by national governments (through, e.g., the US Global Change Research Program or the Centers for Disease Control), but scientific communities have enormous influence of the course of such research, and international agencies are often involved in planning and coordination. Some international agencies, like the World Bank and International Monetary Fund, fund and operate their own research organizations, whose results play key roles in their decisionmaking activities. Still others, like the World Meteorological Organization and World Health Organization, coordinate data collection and transmission around the world, including sending special research teams to countries on occasion, and then collate and retransmit data to consumers around the world. Still others, like the International Accounting Standards Board and the Kyoto Protocol, set standards for the conduct of knowledge-production systems. Still others, such as the International Scientific Unions, operate on behalf of the professions, as transnational communities, including pressuring governments to provide visas and allow non-local scientists to collect and export specimens. Within these varied organizations, how is research policy made? Who participates and whose voices matter? With what implications?

- **What are the instruments and mechanisms of "global" research policy?** The list of such mechanisms listed in the proposal (legislation, industrial policy, tax credits, etc.) need to be supplemented in international settings with standards, international treaties, formal rulings and decisions of international institutions, informal coordination, etc. For many global change scientists, one of the most important outcomes of the periodic assessments conducted by the Intergovernmental Panel on Climate Change is the identification of major gaps in existing knowledge that can guide future research programs.

- **What are the implications of research policy for the content and organization of global decisionmaking?** Put simply, the creation of knowledge about the functioning of planetary-scale natural and human systems is an essential element in the changing constitutional infrastructure of global society. As in domestic societies, choices about what kind of knowledge to pursue (and what not to pursue), among multiple potential standards for research methods, protocols, and practices, and between various potential researchers and research institutions will have important implications for who benefits and who loses from global policies, who has voice in global policy forums, to whom researchers are accountable for the knowledge they produce and for its consequences, etc.

- **How can global science and research policy be improved?** On what criteria should global scientific collaborations, networks, and institutions be evaluated? Using what methods and approaches? To what extent can criteria and methods be adapted from comparable national-oriented research and to what extent are new criteria and methods necessary? What does it mean to improve global scientific collaborations? Improve to whom? For what purpose or to what end?

Infrastructure Needs: Unlike the proposal for this workshop, I am unconvinced that "international partnerships" will suffice to address the infrastructure requirements of global research policy. As I see it, several forms of infrastructure support would strongly benefit research in this area.

- **Attendance at international meetings**. These meetings are a natural research site for work in this area for two reasons: first, they tend to be a source of important negotiation and decisions—they are, in this case, like Congressional hearings and votes, or court proceedings and rulings, except that they are rarely reported verbatim, necessitating participant observation research for adequate data collection and documentation; second, they bring together key decisionmakers from across the world in a single location, greatly facilitating interview research. Support for systematic attendance at such meetings is scarce, however, and travel to them is generally beyond the means of individual researchers acting on their own. Such meetings are often held in a series of cities, scattered around the world. Potentially local observers might be found on an ad hoc basis for each meeting, but only at much greater expense of time and money, I suspect, and less effective research, than sending the primary researcher. Yet, standard NSF dissertation research grants that range from $8-12k, for example, are unlikely to be able to support travel to even one—let alone three or four—such meetings (which may run several thousand dollars). Further, because many graduate students in the social sciences rely on teaching assistant positions to support their education, they choose research topics that allow them to carry out research during semester breaks. Unfortunately, international meetings rarely follow that schedule. In addition, they are rarely short enough to fit into the school year, in between class periods. Climate change meetings, for example, are often one to three weeks in length, and even the shortest take up four to five days with travel time, making salary support for research time an essential infrastructure need for both students and faculty researchers doing international research policy research. Funding for travel associated with multi-sited ethnographic methods is likely to raise many of the same questions.

- **Research teams**. Global research is, by definition, considerably more extensive in scope and scale than policy research in a single or even a couple of countries. Arguably, therefore, it is not amenable to the individual investigator model that dominates social science funding. The irony of NSF funding is that the "small" grants for training and research SDEST and STS fund are the largest awards it is possible to obtain through these programs. Only a handful of the most elite social scientists are able to generate sustained research funding at a level of even $100k to $200k per year to support graduate students and postdocs. Yet, rare is the scientist at a major research institution who does not easily command twice or more this level of funding, operating a research program that funds a number of graduate students and postdocs on an ongoing and predictable basis. The Center for Sustainability and the Global Environment at UW-Madison is, for example, a $1.5 million/year operation overseen by a single faculty member, with several research scientists and postdocs and a dozen graduate students. While the social sciences are never going to match the sciences for funding, there is an argument that global research requires a higher level of infrastructure support. This may need to be done through a networked center-type approach, but ongoing support for two faculty, a postdoc, and four graduate students for five years (somewhere around $750k direct costs), to tackle a major problem, is essentially impossible at the moment in this area—let alone larger collaborations.

- **International collaborations**. I do believe international collaborations have some role to play in global research, but their limitations must be appreciated. First, the pool of potential collaborators is small, all of whom are busy with their own agendas, and hardly coextensive with the planet. Second, coordinating research funds for teams in multiple countries, from multiple national funding agencies, is a problem of high politics—definitely not for the lighthearted. Third, such collaborations come with their own costs, both in money and in time. International collaborations require substantial investments to bring collaborators together on a regular basis to define objectives, to develop protocols, to compare results, and to finalize publications. Such collaborations are expensive and difficult to set up and maintain over time, especially when funded projects typically have durations of only a few years. In cases where training is required to establish a local research presence, considerable expenses are required to bring the person in question to the United States for PhD-level education, if the right person can be found in the first place.

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New Roles(?) for Universities in the U.S. R&D System

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The role of universities in industrial innovation and economic growth has received considerable fanfare in recent years, as U.S. universities have expanded their patenting and licensing activities since the early 1980s. Many observers have attributed this expanded patenting and licensing to the Bayh-Dole Act of 1980, although little hard evidence has been provided in support of this conclusion. Nor has much evidence been produced to support the argument that patenting and licensing of university inventions are necessary to support the transfer to industry and commercial development of these inventions. Other, more critical accounts of the Bayh-Dole Act have suggested that the growth in academic patenting and licensing has changed the "research culture" of U.S. universities, leading to increased secrecy, less sharing of research results, and some shift in the focus of academic research away from fundamental to more applied topics.

Throughout the 20th century, the U.S. system of higher education has been distinguished from those of other industrial economies by its large scale, the high level of autonomy enjoyed by individual universities and colleges, the dependence by these institutions on local sources of financial and political support, and the strong competition among universities and colleges for funds, prestige, faculty, and students. These structural characteristics of U.S. higher education created powerful incentives for university researchers and administrators to establish close relationships with industry. They also motivated university researchers to seek commercial applications for university-developed inventions, regardless of the presence or absence of formal patent protection. Finally, the large scale and vocational orientation of many U.S. universities, combined with the conduct of research within these universities, created an effective channel for the rapid dissemination of new research findings into industrial practice–the movement of graduates into industrial employment.

The economically important "outputs" of university research have come in different forms, varying over time and across industries. They include, among others: scientific and technological information (which can increase the efficiency of applied R&D in industry by guiding research towards more fruitful departures), equipment and instrumentation (used by firms in their production processes or their research), skills or human capital (embodied in students and faculty members), networks of scientific and technological capabilities (which facilitate the diffusion of new knowledge), and prototypes for new products and processes.

The relative importance of the different channels through which these outputs diffuse to (or alternatively, "are transferred to") industry also has varied over industry and time. The channels include, *inter alia*, labor markets (hiring students and faculty), consulting relationships between university faculty and firms, publications, presentations at conferences, informal communications with industrial researchers, formation of firms by faculty members, and licensure of patents by universities. Though the recent growth of patenting and licensing by universities has received considerable attention, it is important to keep in mind that patents are one of many channels through which university research contributes to technical change in industry and economic growth.

Patenting and licensing of publicly funded research by American research universities has grown significantly since 1975. This growth has contributed to some of the highest-profile debates in science and technology policy today. Witness, for example, the recent controversies over the high prices of drugs developed based on taxpayer-funded academic patents, concerns about the appropriateness of publicly funded researchers "racing" a private firm to sequence (and patent) the human genome, and fears that patents held by a public research university could hinder the future of embryonic stem cell research in the United States.

Much of the increased patenting and licensing activity of the past three decades represents the latest phase in a century-old collaborative relationship between U.S. universities and industry that was motivated by the unusual structure of U.S. higher education. The independence of central government control, competition among campuses for resources and prestige, and dependence by both public and private institutions of higher education on local sources of financial and political support that have characterized U.S. higher education created powerful incentives for faculty and administrators to seek collaborative relationships with industry and agriculture, and these close relationships have been a hallmark of U.S. universities (and a feature that is absent in the higher education systems of most other industrial economies) throughout the 20th century.

Although the Bayh-Dole Act is not solely responsible for increased patenting and licensing by U.S. universities, growth in these activities, along with other changes in the overall structure of U.S. policy toward intellectual property rights, may have profound consequences for the structure and performance of scientific research in the United States.

The Staffing of Research Labs by Graduate Students and Post Doctorates: Acting Locally Has Global (and Unintended) Consequences

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Introduction

Approximately an eighth of all R&D performed in the United States occurs in the university sector. Within the university sector, the principal investigator (PI) model of research dominates. It is the PI's responsibility to procure funding and to staff the lab. The university itself takes little direct responsibility for these activities. Instead, it focuses on recruiting top scientists through attractive "start-up packages" (Ehrenberg, Rizzo and Jakubson, 2003) as well as establishing rules for the allocation of such things as indirect costs and lab space.

Organizationally, PI-labs are structured as pyramids. At the pinnacle is the faculty principal investigator. Below the PI are the post docs; below the post docs are graduate research assistants. Some labs also have several scientists who stay on after completing one or more post doc appointments. They are generally referred to as staff scientists and have a compensation level that is generally not that much higher than that of a post doc. (Gerbi and Garrison, 2003). The pyramid analogy does not stop here, however. The research enterprise itself resembles a pyramid scheme. In order to staff their labs, faculty recruit Ph.D. students into their graduate program with funding and the promise of interesting research careers (Stephan and Levin 2002). Upon receiving their degree (which can take more than seven years), it is mandatory for students who aspire to be a PI to take a position as a post doc. Post docs then seek to move on to tenure-track positions in academe. In recent years, however, the transition from post doc to tenure track has been slowed as the number of tenure-track positions has failed to keep up with the increase in supply. In certain specialties the number of tenure-track positions has actually declined.

Thus, this PI-initiated model has unintended consequences for the U.S. scientific labor market. Moreover, these unintended consequences, the result of acting locally, have global consequences as well. Larger research budgets, especially from NIH, and a dwindling supply of U.S. students interested in graduate school, has increasingly led to training positions being filled by international scientists, many of whom wish to stay in the U.S. after receiving their training. Black and Stephan (2003), for example, estimate a stay rate of over 98% for male Chinese students receiving doctoral training in the life sciences from a top U.S. institution. The stay rate for post doctorates who received their Ph.D. degree abroad is harder to estimate, but there is strong evidence that for certain countries and in certain fields the brain drain produced by the post doctorate system is substantial.

The Labor Market for Ph.D. Scientists

By today's count there are more than 50,000 post docs at U.S. universities, making up approximately one in three of all science and engineering Ph.D.s working at U.S. universities.[6] Richard Freeman estimates that the ratio of the number of post docs to the number of tenured faculty in the life sciences was .77 in 1999, 43% higher than it was in 1987.[7]

The demand for postdoctorates is fueled primarily by the U.S. federal research budget. In particular, as the NIH budget has grown, the university research enterprise has become increasingly large.[8] But this growth has come not through the hiring of tenure-track faculty, but rather by the staffing of the research enterprise with graduate research assistants, postdoctorates and permanent non-faculty as well as the increased use of GTAs to staff undergraduate courses and thus free up faculty time for research. By way of contrast, the demand for tenure-track positions is arguably less dependent on federal funding. Instead, in the case of the public universities, demand for tenure-track positions is more related to tax revenues and competing state budget needs such as prisons and health care. In the case of the private universities, a commitment to balanced programs and enhancement of student services play a large role in affecting demand.

The supply of postdoctorates is fueled by the availability of funding for post doc positions and the perceived necessity of holding a post doc position if the Ph.D. has an interest in pursing an academic career. The post doc position allows the recipients the opportunity to hone their skills and enhance their research record. Moreover, the stipend and the training opportunity associated with the post doc position attract large numbers of Ph.D.s trained abroad to come to the U.S. for a post doc position.

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[6] The 50,000 figure was reported by several speakers at the November 1-2 conference held by the Network on the Scientific Workforce, NBER, Cambridge, MA. The National Science Foundation estimated the number of post docs in the United States to be slightly over 38,000 in 1997 (Schmidt 1999). This represents a tripling from the estimated 14,000 in 1979. Approximately ninety percent of these post doc positions were in the fields of science and health. Most of the remaining positions were in engineering. The institution with the highest number of post docs in 1997 was Harvard University, with 2505, followed by Stanford, University of California San Francisco, University of Pennsylvania and University of California-Berkeley. Combined, these five institutions had approximately 20% of all post docs in the United States (Schmidt 1999).

[7] Presentation made at the meeting of the Network on the Scientific Workforce, held at the NBER, November 1-2, 2002.

[8] Post docs play an important role in staffing faculty labs and, with their relatively short tenure, provide more flexibility than would be present if a permanent workforce staffed the lab, as is often the case in Europe. Post docs are also widely perceived as contributing new ideas to the lab and helping the principal investigator keep the necessary edge in maintaining funding from granting authorities (Stephan and Levin 2002).

This system has created a labor market in which the research enterprise attracts large numbers of students into Ph.D. programs and postdoctoral positions, but the university system has few permanent slots for hiring the growing supply of the research-trained doctoral workforce.[9] Richard Freeman estimates that tenure track positions would have to grow at an annual rate of approximately 5% per year for the postdoctoral pool to be effectively absorbed into academe. And, while industrial employment has grown for the doctorally trained in recent years, growth has not been sufficient to provide research positions for all of those with research training, creating what a recent National Research Council report (1998) called a "crisis of expectations."

The upshot has been a growing pool of postdoctoral talent at U.S. research universities, created by increasing numbers of entrants and longer stays in postdoctoral positions. Thirty years ago, for example, no more than 20% of S&E Ph.D.s trained in the life sciences took a post doc position at the time of graduation. Today, the figure stands at about 50%. Moreover, in earlier years, the postdoctoral position typically lasted only two years. This is no longer the case. For example, 35% of life science Ph.D.s observed in 1999 were in postdoctoral positions three to four years after graduation, compared to 12% in 1977; 20% held postdoctoral positions five to six years later, compared to 5% in 1977.[10]

The policy question is how to correct a system fueled by the federal government but implemented by "local" entrepreneurs who have strong incentives to recruit graduate students and post docs to work in their labs but have neither the wherewithal nor the incentive to create permanent jobs.

Whatever the answer, it is unlikely to be found at the local university level. It is going to have to be "fixed" at the national level. Here we merely speculate, noting that the solution could involve such things as

- Changing the way the United States funds science; lowering, for example, the percent of funding that goes directly to PIs.
- Tying grant renewal to a review of the job outcomes of graduate students and post docs who have worked in the PI's lab.
- Initiating incentives to create a permanent workforce that is somewhere between a PI and a staff scientist (Gerbi and Garrison 2003).

Better data also play a role in the solution, not just at the local level but at the national level as well. The Ph.D. is no longer the terminal training program for most researchers. Instead, in many fields of science, the post doc is mandatory. Yet we know remarkably little about the transition from the post doc position to the subsequent position. This is in part because the census we take of new scientists and engineers (the Survey of Earned Doctorates) is collected at the time the Ph.D.

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[9] Many foreign-born, having relatively few alternatives in their home country, find the stipend support associated with a post doc position, as well as the promise of a first-rate education and the possibility of obtaining a permanent position in the United States, especially attractive.

[10] Two recent National Research Council (NRC) reports have examined the plight of post docs in the life sciences (NRC 1998 and NRC 2000).

is received, not at the time the post doctorate is completed. It is also in part because our sampling frame is based primarily on individuals receiving their Ph.D. in the United States. Yet increasingly Ph.D.s who are trained abroad come to the U.S. to take a post doc position. Furthermore, we know little concerning the impact the system has on the countries of origin. For example, what percent of U.S.-trained post doctorates eventually return to their country of origin? If and when they do return, do they maintain networks with scientists working in the U.S.?

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D. Summaries of the Small Group Sessions

The small group process included two sessions. In the first, participants divided into three sections and each considered the question, What should a program on research policy as an agent of change look like? The second included two sections, one on ethics and democratic perspectives and one on measurement and assessment.

Abbreviated Summary of First Session (Three Sections)

To understand research policy as an agent of change requires an understanding of the human values, behaviors, and relationships that shape, and are shaped by, new knowledge; the human resources, scientific workforce, educational programs, citizen skills and capacity, and institutional governing arrangements of scientifically and technologically advanced democracies; as well as the flows of people, ideas, norms, and rules, both within and among societies.

A research policy is a strategy for achieving developments of new knowledge, new forms of expertise, and new infrastructures. Research policy includes not only direct public actions but also the knowledge production, use, and uptake activities of courts, regulatory agencies, scientific advisory bodies, as well as related activities in the private sector, both explicit and implicit, including the corporate sector and civil society.

Research areas should include historical, comparative and international studies, and address such issues as priorities for and framing of research policy and the constitution of expertise; the development of specific arrangements, including relationships between private and public sector organizations; and measurement and assessments of benefits and costs and issues of distributive and procedural justice,

Research methods in this area must have a major component of humanistic and social sciences, including quantitative and qualitative approaches. Methods should be geared to the understanding of research policy as networked and dynamic, and will include work in political science, economics, sociology, anthropology, and STS, including, where appropriate, engagement with science and engineering communities. All methods used in these fields are appropriate: case studies: historical and contemporary; comparative research; legal, political, and institutional analysis; ethnography; modeling; statistical analysis; measurement issues; evaluation and assessment methods; theory development and evaluation.

Mechanisms should include cross-fertilization activities, possibly through fellowships, that would enable other kinds of groups, e.g., officials in industry, civil society, government, to come to university or for academics to spend time into these other settings. There is a strong need to build both research and societal capacity in this area, making the normal 2 year research grant insufficient. Strong consideration should be given to training programs, infrastructure awards, etc. There is a strong need for this program to partner with other research agencies, OMB, state governments, international institutions, etc., to fully capture the broad range of research policy, to provide additional funds for this important activity, and to ensure access for researchers to actors and data in these other settings.

There are a series of international changes in the funding and incentives for research that are not recognized and appreciated in the US that have implications for future international competitiveness. While European scholars are engaged in a series of international comparisons, there is little participation by American scholars due to a lack comparable data and limited funding opportunities. The lack of sophisticated metrics predicated on a nuanced understanding of S&T could shift attention to short term outcomes to the detriment of long term competitiveness. Part of the Research Policy as an Agent of Change research agenda should include projects to enhance understanding of the innovation process. This agenda should pay attention to the diversity of outcomes from support for research, examining explicit and implicit goals and the variety of involved actors and mechanisms and intended and unintended consequences of policies and behaviors – micro and macro effects on the systems and their components.

Research policy, construed broadly, is transformative. For example, research universities do not merely carry out research. In addition to providing funds, research policy sets forth a complex set of conditions under which the university must operate when it does that research. Those conditions may also affect how and in what ways the university gets research funding from the private sector. From research on human subjects to rules about research on proprietary topics to licensing patents that its researchers create, universities change their structures and practices in response to research policy, in addition to taking money and seeking to influence future policy.

Research policies transform the phenomena on which science operates. Recent patent policy provides a useful example. The changed notion of "non-obviousness" has transformed the research enterprise and indeed the very character of nature. In the other direction, research practice and its results required the US patent office to respond. In addition to creating knowledge, research policy leaves gaps in knowledge, providing resources to some areas and not others. For example, the government simply bans some research on human beings on the grounds that performing the work would be immoral.

The patterns of funding across broad fields of science or technology emerge implicitly from a welter of other policy decisions, and more detailed choices about funding within a field come from a host of influences that include members of the scientific community being funded. An older literature on R&D policy referred to this issue as the problem of priority setting, pointing out that the United States did not set its priorities in a coherent fashion. It would be productive to study the dogs that do not bark, and assess more systematically the gaps in knowledge that research policy leaves.

A major research program in RPAC requires and would greatly benefit from important infrastructure. Improvements to this infrastructure should emphasize creating a lively network or community of scholars. This network would provide research opportunities for scholars and couple them with training for graduate students. It might include a physical place with strong access to data resources and primary documents (do we need our own Hagley Library?). Particular networking activities could start with face-to-face meetings and then continue over email. In the early stages such groups could be trying to figure out the resources they need to solve particular problem. Other groups would initiate directly some new research. To provide the groups focus and enable them to produce tangible results, they would initially focus on a particular policy problem or theme. Later one could assemble groups across themes, seeking a larger synthesis.

Democratic Perspectives/Ethics and Values Discussion Group

One important feature of an RPAC research program is attention to unpacking the often-implicit assumptions and practices involved in research policy. These can take many different forms and appear in many different parts of the policy process. They need to be unpacked to make them more amenable to a democratic society and to making research policy a positive agent of change.

Numerous research topics and sites would provide fruitful material for research. In no particular order, they are:

- Who gets to participate in RPAC decisions and under what circumstances? How are conflicts about participants resolved?
- What forms of policy making and participation present alternatives to the linear models of both S&T innovation and participation in such innovation? Have any of those alternative models been institutionalized? In the process, have any of them been scientized and lost some of their ability to capture and deal with unexpected, non-linear changes, what one participant called the "ragged edges of experience"?
- Research sites would include research universities, corporations, and the intersection of states, firms, and civil societies.

Numerous methods could contribute to an RPAC research program. In particular this group emphasized:

- Case studies of non-traditional forms of knowledge generation.
- Comparative analyses.
- Demonstration projects.
- Ethnographic methods.
- Historical analyses.

The group offered, not surprisingly, a wide variety of possible specific research topics. The following illustrates, rather than bounds, the range of topics.

- A re-evaluation of the research university that is reflexive and sensitive to institutional issues. This could include quite specific institutional adaptations to RPAC issues, such as the creation of technology transfer offices, as well as the broader questions of the effects of corporate funding for research or classified government funding for research on the culture and practices of the university.
- A host of issues associated with the development and diffusion of genetically modified food crops, such as the farm-scale trials of such crops in the UK.

- Discourses of evaluation. What are those discourses, including but not limited to peer review, and how have they changed over time?

- The relationships between types of fact-finding, deliberative, or other processes and social consensus or acceptance about knowledge claims concerning controversial issues. Can such knowledge actually lead to a resolution of the dispute?

- How does the National Science Foundation count as topics that are properly within its purview? This question can have many subtleties when talking about programs in chemistry and physics and even more dispute when looking at cross-disciplinary topics like ITR and nanotechnology research.

- How do pharmaceutical firms decide which drugs to research and produce and which ones to ignore? How does policy affect those decisions?

- How are critical scientific analyses driven into oppositional status and what are the consequences of that? What are the paths and circumstances under which oppositional knowledge enters the mainstream?

Data and Measurement Group Summary

1. What are the research policy issues and corresponding data needs?

The community of scholars needs greater access to data. The EU and Canada have undertaken new surveys on innovative activity and no comparable data exists in the US.

There is new emphasis on government accountability. Much of this activity is conducted in-house or contracted to external evaluators, with virtually no peer review or referring process on these efforts. The community of scholars would like to be partners in this federal evaluation effort and other program evaluation efforts.

Finally, there is a need to develop new metrics and new methodologies – what would be considered basic research for this community. These efforts would have practical applications. In addition, there is a need to model the endogeneity of research policy and develop methods for envisioning alternative futures.

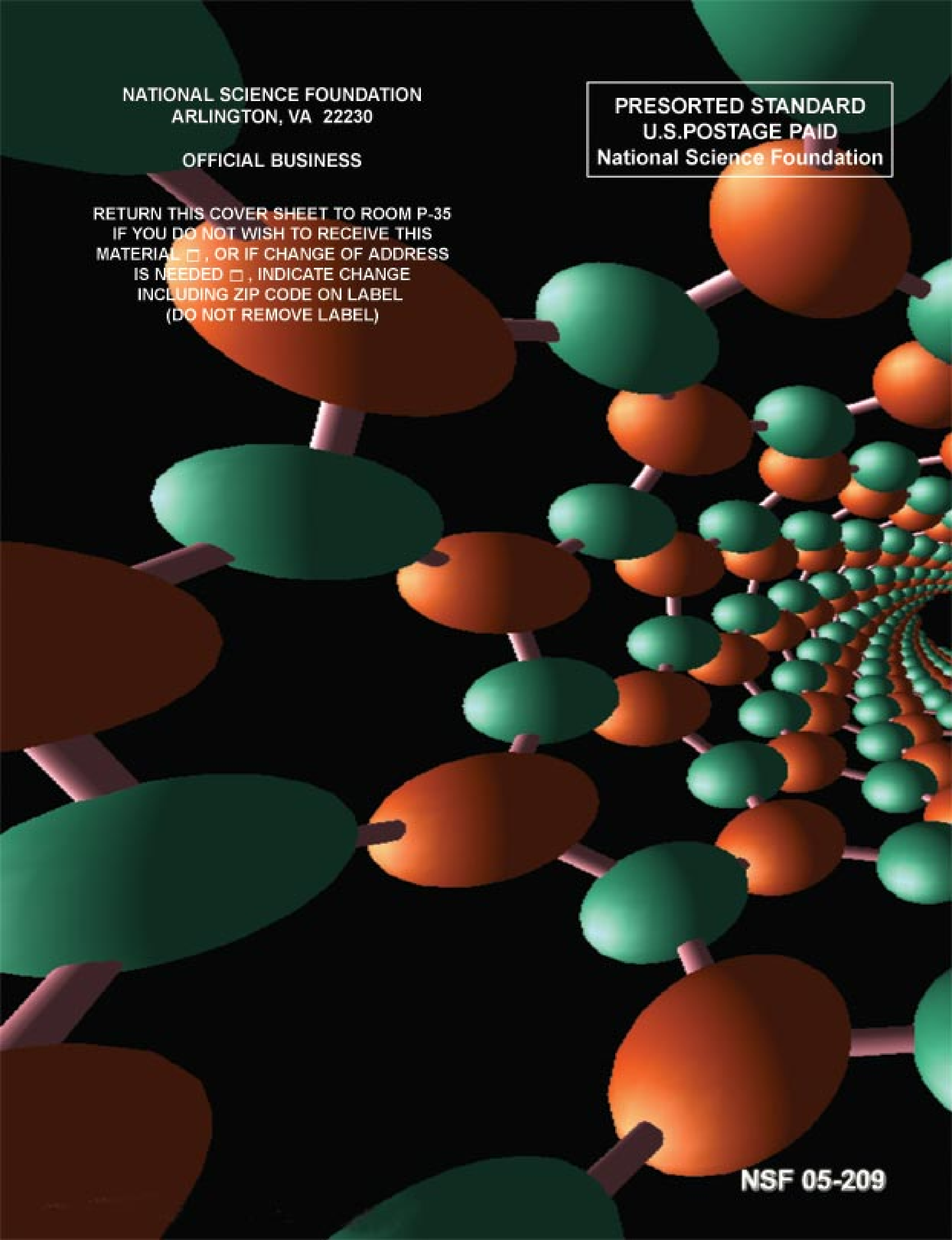
2. What infrastructure exists; how could it be better used?

There is limited dissemination of the types of data that are available and how the data may be accessed. The costs of research projects to analyze these data are significantly less than the costs associated with the original data collection efforts. A compendium cataloging S&T policy and research data could help catalyze the community of scholars. Existing surveys tend to focus on public data sources and ignore proprietary data. These surveys typically do not consider the quality of data.

The EU has instituted a new innovation survey that is providing useful data across Europe. There is no equivalent source in the US and a comparison of the data sources US and EU would be informative.

There are numerous access problems. A powerful tool is the Thomson ISI® (founded as the Institute for Scientific Information) which provides publication and citation information. Unfortunately it has become an expensive resource, and there is a perceived need to challenge ISI. The most interesting current work links different data sources. As a result of new information technologies there are privacy concerns that while intended to prohibit commercial firms from exploiting personal data may limit the ability of academics to link these data. In addition, there are many barriers to linking various data sources by federal agencies that collect data and could potentially benefit from the product of the analysis. Federal Government mission agencies collect data on a variety of indicators such as the number and characteristics of CRADAS. While this data is technically public data it is not currently available. Who negotiates rights to access data? Currently, access is negotiated on an individual basis which is inefficient and often frustrating for researchers. Certainly having standard procedures, policies and adjudication processes would facilitate access to data. In addition, across federal agencies there are no common criteria for reporting research results.

Given these concerns, several responses would be useful. NSF should consider ways to encourage international data coordination, perhaps via its International Office. Research on research evaluation, its pros and cons, should be given priority for support. Scholarship to identify gaps and opportunities for improvement in data series relevant to research on research policy should be encouraged. NSF should work with other research and development agencies to examine data resources and needs.



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