Discussion Roundup Rapporteur Summaries

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Professor Richard Nelson
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Dr. Lewis Gilbert
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Science, Technology and Human Health

COLE: What about some of the conclusions, observations, comments, witty remarks, and other insightful ideas that emerged out of the breakout group sessions? We'll go through the agenda in the order that they're listed. We'll first hear from Professor Sam Silverstein, who was the rapporteur for the group on science, technology, and human health.

SILVERSTEIN: Thank you. Let me start out by an observation. I don't mean to be unfriendly because I have great respect for all the people in this room, but this conference is basically older, male, and white. And the people we're going to be talking about and who are basically concerned about what we're talking about are predominantly going to be younger, probably not exclusively male, and of course, of the broad demographic and racial makeup that's going to be this country in the next century. Having said that – and that we desperately need to engage them in the conversation – let me tell you what we talked about.

We decided to talk about the last three questions and basically ended up talking about structures a great deal. But no matter what structure we talked about, it basically came down to one discussion and that discussion was money. So, the structures got dissipated into "How do we fund this, and how do we fund that?"

As we focused on the National Institutes of Health and incorporated the CDC, we included the ideas that outcomes research was important, that population based research was important, that behavioral and psychosocial research was important, in addition to test tube-based bench biomedical research. Given all of that, there was still very substantial disagreement about the way money at the National Institutes of Health is divided among study sections by institutes – is there appropriate attention given to each area of research?

Certainly, there was a lot of head nodding up and down in agreement that there was inadequate attention to clinical research. And there are great tensions – that won't surprise you – great tensions between clinical and basic research scientists about what is inappropriate balance. How do you judge quality? Who should be in the room?

You have to have clinical and bench-based scientists sitting around the same table deciding what's good science, what ought to be funded, what are good questions. I think we haven't worked that out within our own communities effectively at all. There's disagreement about whether the councils at the NIH are effective mechanisms for setting priorities. I can tell you, I actually voiced that concern when Bernadine Healy (NIH Director, 1991-1993) had her meetings on the National Institutes of Health about how to go forward during her term. I asked, What's wrong with the councils as decision-making bodies? I think we need to look at that very carefully, and I think Harold Varmus is giving that some attention.

The group looked at past biases, specifically inattention to women's health issues in clinical trials. How is it that they got ignored and are there ways in which we can avoid such blind spots in the future? I don't think any solution emerged from the group, and I asked members of our group to make a comment when I finish, if they have a solution to suggest.

We moved on from this discussion of money and structures to a somewhat different discussion and that was the political approach. And I was quite surprised at least to see that there was even substantial disagreement there. Some believed we ought to continue aggressive advocacy for above-inflationary funding increases. And others say we'll be fortunate to be flat funded, and there was considerable waffling as to whether flat funded means an annual increase for inflation or just flat, no growth at all, with the budget losing buying power every year. There was disagreement about whether we'd be taken seriously by the politicians if we asked for more.

I didn't hear a lot of fervor in the room that said, "This is the right thing to do. We ought to be asking people to set priorities." It seemed to me that scientists in their advocacy position in this area, at least what I heard around the table, were essentially saying, "Well, we're not very comfortable with the data either." And I don't know how it goes in the bargaining around your kitchen table, but around my kitchen table, that's a sure loser.

There was no consideration given in our discussion to how much or whether we ought to have others help make our case, the pharmaceutical and bio-tech executives, et cetera. And I think there was total disagreement about whether a rising tide will lift all disciplines. There are those who say that even if we have more money, their area won't receive the attention it deserves, that I need to advocate specifically for my discipline, and we need to have structural changes in order to get effective change.

In the area of training, there was, I think, good agreement that clinical researchers are more of an endangered species than ever. There was considerable disagreement about whether physician scientists in training should be paid on an M.D. pay scale or on a Ph.D. pay scale.

It was unthinkable that we should charge graduate students in the health sciences tuition and that we shouldn't pay them a stipend. No other country does this. We'll send our students elsewhere, foreign students will stop coming here. It was also pointed out, of course, that these students, while they're our students, during the latter years of their thesis work, are actually contributing to the research and therefore payment to them is appropriate since they are actually performing work and research.

There was disagreement about whether we ought to limit the number of trainees we accept and discomfort about letting market forces work as to what happens to those trainees. But there was an unwillingness, I think, to confront alternatives to market forces. What other ways do we have of doing it? To illustrate the difficulty we have with our view of the pipeline, if I can call it that, I put up this diagram, which shows an B.A. coming in one end and a doctoral researcher coming out the other end.

This is the diagram Bruce Alberts has been using at the National Academy of Sciences. It shows the alternative careers, industry, teaching, et cetera. And what I've pointed out to the group is that in the eyes of the most articulate and thoughtful spokesman for alternative careers – who is, I think, Bruce Alberts – the alternatives don't appear sprinkling out the end of the pipeline, splaying out equally. They appear as alternatives that show you falling out of the pipeline.

We're in real trouble in our community – I believe, and I don't have group agreement here – in valuing other careers, other avenues. There certainly was agreement in our group that there ought to be better opportunities to pursue a wider spectrum of training during doctoral training in the biomedical and behavioral sciences.

The journalists among us pointed out that there aren't any heroes who are researchers, investigators in the biomedical sciences. The one chosen was Jonas Salk. That's a long time ago. Are there some new heroes that we could point to? And the journalists said, "If not, why not?" And we discussed not only the fact that there aren't popular heroes as seen by the press, but we as scientists had a hard time identifying them.

We also discussed the fact that some universities do a good job of creating heroes, that they try to expose their faculty to the press and to the knowledgeable members of the lay public as often as possible, whereas other universities, do that very infrequently. That failure to use the faculty and to make the faculty, if you like, visible figures, diminishes us in substantial ways.

I pointed out that a Nobel laureate at a major western university didn't even know the governmental affairs people at that major university. We talked a little bit, right towards the end, about cooperation and collaboration within the university and the way the tenure system discourages that until an individual has tenure. And so, rather than working as they do in the very best industries, where people are encouraged to cooperate and collaborate in many instances within the university, until you have tenure, the incentives for collaboration and cooperation are small.

While there were very good feeling and willingness to work together, it indicated to me that many of the divisions that I have seen in our science community are deep and strong and that we have a great difficulty in pulling ourselves together to advocate for very simple things – such as the NIH in total as opposed to the subdisciplines.

I hope I've not been negative in representing what the group says. What I focused on are the tensions and disagreements. And I've done that deliberately because, in fact, those tensions and disagreements, I believe, are as strong as ever. They are nevertheless important to recognize because if we don't recognize them and begin to work on them, I'm not sure that we can represent ourselves to the larger public as having a defined agenda. Let me stop. I'll take questions or comments. Those of you who were a part of this discussion may want to say that I've seriously misrepresented you, if not, I'll be surprised.

BROOKS: It wasn't clear to me from what you said whether you really addressed in your discussion the issue that came up somewhat briefly this morning – that is, how the whole change of emphasis in the priorities of the health care system is affecting the research agenda, and particularly whether the emphasis on high-tech medicine has been an important factor in the escalation of medical costs and to what degree the researcher is responsible for that phenomena.

SILVERSTEIN: We didn't address that topic. What we did address is that with managed care and decreases in Medicaid and Medicare funding, there would be substantially fewer resources for clinical studies and for research and education from the contributions of patient care dollars at medical schools. And that those dollars represent a very substantial input into the research and training activity. Conservative estimates are between a billion and $2 billion. And Don Frederickson's numbers, I think, are higher than that. We did not discuss at all whether technology is driving medical costs or is a solution to medical costs.

Let me just add some data that I have collected in that area. We now have documented $70 billion annually in medical care cost savings from advances in biomedical research supported by the National Institutes of Health. And in addition to that, there's another $90 billion annually in revenues generated in non-medical areas by advances supported by the National Institutes of Health. So, if one looks at the NIH as a contributor in some way to the U.S. economy, I think one ends up with a very positive number.

Science, Technology and Economic Change and Science Technology and National Security

COLE: Thanks very much, Sam, and also to members of your group. Next reporter we will hear from is Dick Nelson, who is going to talk about the discussions which took place on science, technology and economic change. Dick?

NELSON: Our group was joined by the group concerned with what was going on in the military R&D area. And I think that turned out mostly to be a fruitful combination of people and interests because it quickly became apparent that a lot of the trends in both areas are intertwined. As Nathan Rosenberg observed this morning, the history of accomplishments and then of troubles and difficulties is interesting and important to understand if you are to understand the nature of the current discussion.

While there is scarcely any mention of a specific civilian technology policy by Vannevar Bush, I think for understandable reasons, nonetheless, the performance of American industry in the early postwar years was really quite spectacular, economically and in terms of American industry forging to the forefront of technology across a very, very broad arena of activity.

As Bill Spencer observed, at a number of the areas where American industry became extremely strong, in civilian competition and products, the industry was drawing significantly on military R&D and procurement, which was clearing the way, as it were, for advances in very major civil applications. Also, the rise to preeminence of American industry in the health arena, particularly in pharmaceuticals, drew extensively and draws extensively on the National Institutes of Health programs.

By the middle 1970s, a number of different things are happening, and the context begins to change. One important thing that began to change is that American industry began to lose its dominance across a wide range of economic activities, and companies based in other countries began to achieve technological parody and, in some areas, even technological leadership over the U.S. At the same time, there was a significant slowdown in income and productivity growth in the United States – a slowdown close to virtual stagnation that's been with us for 20 years or more.

At the same time, by the middle 1970s, the military no longer was the dominant demander of high-tech products in a number of the important fields, nor was it the dominant R&D funder in the areas of electronics or civil aviation. There have been a number of studies showing that spillover to the civil economy from military procurement and systems R&D began to diminish significantly at about that time.

One can observe by the middle 1970s a number of interesting developments that shape the current context. And here we had quite a bit of discussion as to what was happening and why. For the first time in the postwar era, you began to get clamorings for an expressed civilian technology policy arising in various portions of American industry and in the polity – clamorings that in many cases have met quite hostile responses ideologically on the part of some folks and quite enthusiastic responses from other folk.

Closely related to that, there is the beginning of dual use. The military becomes increasingly aware that the preservation of strong military procurement and R&D capability is becoming dependent upon having American industry earning a considerable portion of its profits by selling commercial products, not simply military ones. And therefore it's in the military's interest to spur directly American industry. At the same time, American industry or portions of it are clamoring for some sort of an expressed industrial technology policy.

The group as a whole had a considerable amount of difficulty staying on one particular topic, I think in large part because people had different things on their minds and wanted to articulate them. But as I reflected on what was happening in the conversation, my impressions were forged that there is a real tension and perhaps a real contradiction between, on the one hand, the attempt to develop a coherent civilian technology policy that would involve funding of civil R&D aimed to help industry and, on the other hand, the political perceptions about what the real American economic problems are that color that particular discussion.

The problems that kept on bubbling up in the discussions of our group were general economic problems. They were associated with that very slow rate of growth of real income that has occurred over the last 20 years or so. They were associated with the perception of significant diminishing of the number of good, high income jobs that are available to the American work force, with strong perceptions that a lot of the problems were associated with sharp competition from companies abroad.

On the one hand, we're taking away American jobs and, on the other hand, there is the increasing internationalization of American business – with American business in any case setting up plants abroad rather than in the United States. Jobs were moving away, and when the discussion was focusing on those economic problems, there was a scrambling around initially for a set of research or technology policy ventures or steps that might deal with them.

And there was evident frustration that the solutions perhaps weren't to be found in the science and technology policy area. On the other hand, from time to time, the discussion went over to topics that were much more easily associated with issues of civil science and technology policy.

We had a quite interesting conversation – fragmented, but I think the fragments stayed together in a relatively coherent way, focused on the proposition that while government R&D was plateauing out, civil R&D in the more important industries is continuing to grow. And that the United States soon would find itself in a position similar to the other major industrial countries like Germany and Japan, with a very large share of the total R&D effort being privately financed.

And then the discussion was, what's going on in the private sector such that industry would come together and, cooperatively with government, reestablish long-run industrial research? Or would the situation continue to be a short-term rush?

So, there was a considerable amount of discussion of policies, potential developments that might occur there – and then that string would be broken by commentary to the effect that those kinds of policies really didn't seem to be all that interesting and that the real problem in the United States had to do with slow productivity growth and lack of growth of good jobs. The question then became, what can you do in the United States to essentially preserve jobs or expand good jobs? And again, there was this frustration that the policies that one grabbed for really didn't seem to be in the science and technology policy arena.

I came out of the discussion with a strong impression of non closure and indeed disjunction. It seems quite likely that we will have two discussions in this arena, and they won't be joined. One concerns civilian technology policy and a wide range of interesting and important issues that are connected. But that's not a discussion that will attract much in the way of political or popular enthusiasm. Rather, the discussion will turn to the question, what can we do about jobs? What can we do about productivity growth.

You're not going to get a coherent view for new civilian technology policy, because the more you look at what you can do with those policy instruments and the more you look at the kinds of economic problems that seem to be, maybe appropriately, grabbing high-level attention, the more the two topics don't seem to have that much to do with each other.

COLE: Thank you, Dick. Since we merged the two groups, I'm wondering whether Joel Yudken would like to add anything at this point.

YUDKIN: Dick has made my job very easy, so I just have a couple of things.

There was very little interest in the military group, myself included. I was really glad to be part of the economics discussion. I think it's interesting because despite their downsizing, the military is the largest single federal source of research and development funding. And it's going to continue to play a major role, including industrial R&D.

We did not talk about institutional issues relating to the Department of Defense. We did mention briefly that the military's emphasis in R&D is going to be increasingly away from strategic weaponry. It's going to be more on a whole different type of military systems, increasingly reliant on very advanced high-technology components which they want to buy at affordable prices from the commercial marketplace.

That's part of the civilian-military integration effort in the current administration, something the Pentagon really wants to promote as part of procurement reform. The perception that the military is falling behind rather than being the leader is another thing that's driving the military to push military/civilian integration.

Dual use will continue, although at a smaller scale, to be an important component of the military's R&D program because of its perceived utility to the defense system.

An important topic that we did not talk about was the federal laboratories: their fate, their relationship to industrial R&D, their role in cooperative research and development, and so on. One person did raise issues that had to do with the national security aspects of technology, but we really could not get into that. And so, that basically sums most of what it was that we talked about.

COLE: Thanks very much, Joel. Our next reporter is Dr. Lewis Gilbert, who is the coordinator for the Global Systems Initiative at Lamont-Doherty Earth Observatory. He was the rapporteur for science, technology, and the environment.

Science, Technology and the Environment

GILBERT: The environment group was a small one. To keep things moving along, I'm going to stick to what I have distilled as the two first-order points and some sort of positive considerations for how those points might be addressed.

The group was dominated by physical scientists, and in that respect we tended to have an implicit interpretation of the environment that had more to do with climate and larger regional issues than what considerations people might have regarding end-of-pipe pollution controls and that sort of thing.

It was noted early on that environmental issues span a very wide front – that to address the environment, we need to have strength in a wide variety of disciplines including physics, chemistry, biology, geology, and economics. In addition to a wide disciplinary front, environmental problems have a time scale that is long compared to political and economic structures in our society. These two considerations – that environmental issues are inherently interdisciplinary and they have time scales that are long compared to what we're used to – make environment problems different from a lot of other problems.

As a result, we came to the second first-order conclusion which was, the structures that exist currently are very badly broken.

Currently, environmental research is funded by a wide range of federal organizations including NSF, NOAA, EPA, NASA, and the USDA. Because this environmental research has grown up in a wide variety of institutions across a wide range of agency missions, there's very little coordination of environmental studies, and a large number of environment efforts are actually in conflict with each other. So, in addition to being highly fragmented, we often have conflict between existing missions and goals.

Another problem with the current wave of doing business has to do with litigation. Environmental problems are often synonymous with litigation.

In addition to this, the reward structure within the university is inappropriate to pursuing environmental work across the range of efforts that is necessary. University and industry cooperation is hampered by penalties to industry in particular. It was pointed out that it's often in an industry's disinterest to learn about environmental issues related to that industry. If they don't know something, it's better for them than if they do know it. It can cost them money if they know things.

In addition to that, the reward structure within academia makes it difficult to pursue interdisciplinary and long-term research projects, the two sorts of things that are necessary if we're going to address environmental research, science, and technology as it needs to be addressed.

Finally, in relation to things being fragmented and separated, there are cultural differences between science and engineering and between science and the policy community. This makes it difficult for what advances we make in science to be communicated or to be solved from the engineering point of view.

So, those are the two fundamental things about environment: that it takes a wide range and a broad view in order to address adequately, and we need to put in place structures that can do that sort of thing.

So, recommendations. We need to find mechanisms that can coordinate research across a wide range of disciplines and agencies. We need to be able to support efforts that range from single investigator-driven classic science to large-scale efforts such as the general circulation models which have been so successful at government labs. We need to be able support interdisciplinary work.

We need mechanisms that isolate basic science and scientific advances from politics. We need to find some way of addressing the penalty-to-know factor. And finally, we need to put in place education and training programs that can produce people who can work in interdisciplinary and multidisciplinary environments so that communication across disciplines and across sectors of our culture can be facilitated. Thank you.

Institutional Arrangements in the Organization of Science

COLE: Thank you very much. Our next reporter is of course Harvey Brooks, who's going to talk about matters that were addressed on the institutional arrangements in the organizations of science. Harvey?

BROOKS: Well, we had a very wide-ranging discussion, which included a rather unproductive discussion, in my opinion, on how you allocate resources among disciplines, so I won't say very much about that, although it occupied a disproportionate fraction of our time.

First of all, we began by making a list of the important institutional and organizational innovations post-World War II. And I would just list these quickly. First, the invention of the broad-based research contract based on level of effort, which has become the backbone for the support of university research and which is more or less really unique to the U.S. system. Incidentally, I might say that each of these innovations and advantages has a downside, which I'll come to later.

Second, the idea of indirect cost recovery, also a unique American invention which some of our members thought was an invention of the devil.

Third, the development of large multidisciplinary laboratories, particularly those that were started under the Atomic Energy Commission but have become very much of a feature of the U.S. scene.

Fourth, the evolution of the system that was very different from what was envisioned by Bush, of a multiplicity of agencies and sources of support. And we believe that this pluralism, while it has some appearance of wastefulness, has been a major factor in the health and vigor of U.S. science.

Just to give one example of why I think this is so, we have actually had both very good intramural government civil service laboratories – such as the intramural laboratories of NIH and the National Bureau of Standards – but also contract laboratories. I believe that the coexistence of contract laboratories and civil service laboratories has made both types of laboratories more healthy and more productive. Particularly, it has helped to keep the civil service laboratories from becoming too bogged down in bureaucracy and micromanagement. Unfortunately, it has also resulted in some growth of micromanagement of the major contract laboratories.

Fifth, again fairly uniquely American is peer review of research grants. Incidentally, that was something not at all envisioned by Bush in his famous report. It essentially stemmed from the biomedical research community but soon became applied to essentially all basic research in universities.

There was also some feeling, however, that the peer review system had gotten overly expensive and overly bureaucratic, with too much emphasis on promised results rather than track record. In fact, I quoted an estimate I had seen that if you allocated all the costs realistically, it cost $1.00 to spend $1.00 of a typical NSF grant – if you really compensated for the time spent by people in refereeing grants and in preparing grants.

Another invention which has gotten very little attention and yet has been a very important feature of the 1980s – studied by the group at Carnegie Mellon – is the university industry research centers. The study identified more than 1,000, with an aggregate budget of $4.2 billion, which receive about 31% of their support from industry as opposed to 7% industry support for academic research as a whole. This is a invention that has really gotten surprisingly little attention in the discussion of science and policy.

Somewhat of a downside is the increasing role of patents and proprietary research in university research, largely as a consequence of the change in policies that occurred, I think, with NIH in the late 1970s. This has had great benefits in better coupling university research to industrial research, but it has also, I think, produced undesirable restrictions on the dissemination of university research, which needs careful monitoring.

Also mentioned was the large number of consortia, networking arrangements particularly among universities. There was mention of a few other things that have become important to the system such as Internet and the bottom-up coordination that really results as an important by-product of the peer review system. Finally, there is the growth in public acceptance of science museums as a mechanism of informal science education.

Coming to the problems, I've already hinted at some of them. One that received a great deal of discussion was the future of the national laboratory system, particularly that part of it whose mission has declined as a result of a phasedown of the Cold War.

There was a great deal of disagreement as to the future of the system. Although everybody agreed it was a great national resource, just how it could be used and coupled to the rest of the system in a permanently sustainable and effective way was the subject of considerable debate.

There was considerable feeling in favor of a certain amount of privatization, probably in separate pieces, of the laboratory system, with much more of a downstream operational mission, particularly in those public laboratories that already have considerable downstream activity.

I've mentioned the micromanagement problems that beset both university research and the research of the national laboratories. Let me give my own impression of the state of the present system. The system of research in the U.S. grew up during the Cold War period, and the defense and the atomic energy parts of that research system were about five to seven times as research intensive as the average of economic activity in the U.S.

After phasing down of the Cold War, how do you divide the reduced research and couple it to the expansion of the downstream activity? That I think is the essence of the problem. Now, you could argue that the U.S. expenditure on industrially oriented research is only about half that of our competitors as a fraction of GNP. On the other hand, it exceeds that of our five largest competitors in absolute magnitude. And one of the questions one has to ask is, which is more important, the absolute magnitude or the percentage of the GNP?

Using the percentage of GNP as an index suggests there are no economies of scale in this activity, which seems to be absurd. At the same time, it's a little hard to know exactly how to look at this. Well, I think that's enough.

Science, Technology and Society

COLE: Thanks very much, Harvey. Our final rapporteur, reporting on the group that discussed science, technology, and society, is Susan Cozzens. Susan?

COZZENS: What a job, last speaker of the day.

Although the discussion questions for the groups were written in terms of field of science, we realized that that it wouldn't really do for our group to talk about science, technology, and society as a scholarly field and its accomplishments and problems. So, we altered the questions to some extent and to talk about the relationships among science, technology, and society to characterize the post-World War II period.

We ended up trying to focus our discussion in three areas. One, a sort of broadbrush evaluation of those relationships – what were the accomplishments? What were the problems that emerged? Second, through what organizational structures and processes had those relationships come to be mediated over the post-World War II period, over the last 50 years? And finally, how has the research community responded? How should it respond?

As to the questions that we were posed, is the system as it exists for mediating those relationships broken? If so, how should we fix it?

Like the last group, we ended up pointing out that much of what we're looking at in terms of the relationships among science, technology, and society over the last 50 years can't be attributed directly to Vannevar Bush or the framework that he laid out in *Science: The Endless Frontier*. Harvey mentioned internal aspects of the system that were never anticipated by Bush, like pluralism and the emergence of peer review.

We brought up some external forces that had also impinged and made things work out in ways that the original Dr. Bush would never have anticipated. The transformation following Sputnik, for instance, and the kind of scientific developments that Joshua Lederberg described for us, the sheer growth of the system itself, which surely was not envisioned by the founding father, and then the various ways that the world has changed around the research system, the current configuration of social problems, for instance, where they're located and how they fit into the rest of society, the economic competition, that sort of thing.

It means we can't lay either credit or blame really at the feet of Vannevar Bush – or not too much of it – in the picture that we drew. In terms of evaluation of this relationship, having talked about this for probably an hour and a quarter of our two-hour time, we really had to come to the conclusion that there was no simple way to evaluate this very complex set of relationships – that there were accomplishments in some places, problems in others. In some places, the accomplishments and problems are together, virtually inseparable.

One of the reasons this is difficult to do is because so much of what science has done over the last 50 years is now embodied in technology. So if we look at the public view of science, there's much about science that has changed everyday life that's not recognized and attributed back to science by the public.

The example that was used is that automobile manufacturing at this point has improved a great deal in terms of efficiency and the safety of vehicles by the use of supercomputers in the a process. Yet, there are very few of us who would attribute features of our automobiles specifically to the high-performance computing and communication initiative that the federal government has taken.

Again, the complexity of the relationship comes out as a kind of ambivalence of the public toward the whole science-technology complex. The public may be positive on things like improvements in their quality of life and at the same time fearful of the changes in values, with a sense perhaps of social disintegration that may be vaguely tied to what's going on here. And that ambivalence also then gets reflected in media images and popular images of science.

On the one hand, we have the mad scientist who stays up all night, neglecting his or her family to invent ways of blowing up the world. And on the other hand, we have the medical scientists rushing in and saving lives in various ways. And you can see both of those things out there.

One of the accomplishments that we did attribute directly to the Bush framework was really its long lastingness – it has stood the test of time and laid the groundwork for a kind of long-range view of investment in scientific knowledge and the scientific mode of inquiry for the country.

It's given the kind of innovations that we just described and has been flexible enough to allow a whole range of fields to emerge and rise. One example that we gave was actually the field of science, technology, and society itself and its manifestation in schools as well as in university programs. The framework has been flexible to allow a lot of improvement in media coverage, for instance, of science during the last 50 years, the media obviously being an important mediating institution between what scientists themselves do and how the public sees them.

Finally, it certainly laid a good basis for educating new scientists and engineers – although there are the "haves" of the system and the "have nots." There are people who have felt that they are incapable of competing, who have been left out and therefore don't get the full fruits of the society that we've created with science and technology.

It was pointed out that maybe this system has taken a long time to produce any benefits for the social sciences, in contrast with the situation for the physical and life sciences. Some members of our group pointed out that the original Bush framework tried to protect the autonomy of science, which is a good thing but can also lead to a lack of attention to what happens downstream from scientific activities.

And in some senses, things may have worked almost too well as scientists worked their way into the political system. They organized as lobbies, which contributed to the growth of science and government support for science, but the flip side is that it can also lead to the perception of science as just another special interest group within the political system.

What are the structure and processes that have led to these results? We've talked about funding structures, pointing out that there may be some inflexibility built into those structures in terms of disciplinary boxes, but that the system has responded in some ways as well. The media is obviously this kind of intermediate structure of the educational system.

In particular, we ended up coming back again and again to the fact that politics has come to permeate this relationship in ways that Vannevar Bush would not have anticipated. And there are a whole variety of forms in which politics appear, including the very strong influence that individuals can have in particular developments. We talked about George Bush and his administration’s stance in relation to AIDS education.

And politics of course has highlighted the problem of the disparity between the very long time scales in which we're talking about research playing out into society and the very short time scales in which most politicians operate. We pointed out that product cycles are very short as well. So, what's happened over this 50-year period is that a number of tensions have been set up in the long-term thinking around science.

The question was, "Is the system broken?" I think, by and large, our group felt that, no, it isn't broken. The fact that we're sitting here having this discussion is probably an indication that it isn't broken. We played with the “broken” analogy a little bit. We said, "Well, maybe it's bent. Maybe it needs a little bit of re-alignment in certain ways. Maybe we need to better convince Congress of the worth of science. Maybe there's a little too much bureaucratization in it, that we could clean out the engine so to speak. Maybe there's just a ping in the engine."

And of course that was the amount of the university overhead that goes to administration. That would of course be the ping.

To switch analogies rapidly here, we did end up talking about the fact that the contemporary system may be a bit like a gem that has a hidden flaw – if enough pressure is applied to the gem, it could actually split apart and then really be broken.

Of course, the pressure that would be applied is cutbacks in resources, and the hidden flaw is that, under those circumstances, this wonderful lobbying expertise that has been built up in the scientific community could be applied to setting disciplines against each other; to essentially in-fighting within the community over a shrinking pie.

We ended up optimistic on that. I think, by and large, this group said, "Well, there is another possibility out there, and we think that's at least as likely as that outcome." And that is, enough flexibility in this system that the various groups involved can recognize the inherent interdisciplinarity of the challenges that scientists are facing and hang together in the end. And we ended on that upbeat note. (applause)

COLE: Thank you, Susan. Well, in closing this second of the three-part conference series, I just want to thank each of you for joining us here for this day's session and some of you for joining us really for two sessions, the one in December and now. And we hope you all will return in the fall.

I certainly want to thank as well, the speakers who have presentations here today, and the discussion rapporteurs for not only shepherding the discussions but summarizing them very well this afternoon.

Where do we go from here? Well, I think that we have reasonably well set the stage for the critical third effort, which will be a two-day session. We will be talking about the future of the national system of innovation, possibilities of choices and structural modifications and weaknesses in the system, perhaps preparing ourselves for a report but also perhaps preparing the nation for a serious look at some of these issues sponsored by some national group.

One question that arose early this morning: "Suppose we were re-living the Vannevar Bush report and it's 50 years later. Who would write the letter, and who would it be written to?"

We weren't altogether clear what the response was, but I think that what we will want to consider is the ways in which there may indeed need to be modifications. What are the choices that we have? What are some of the political and social contexts for those choices? We would like very much to have your ideas about what might be included in the program in the fall.

Columbia has been very pleased to be able to provide the financial support necessary to bring this conference off and to develop it. We think it's an important subject, something that we think is of great value to not only the university but to the scientific community and the broader community concerned with science and technology and the nation's future. I thank you very, very much for joining us, and we look forward to seeing you again in the fall. Thank you for coming. (applause)