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Statement of

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Chairman Brooks, Ranking Member Lipinski and distinguished Members of the Subcommittee, it is an honor to be here this morning to speak with you about the important topic of the merit review process in federal funding for scientific research, and in particular at the National Science Foundation. My remarks today arise from my experience as a primary investigator funded for many years by the NSF, as a member of NSF review panels, and as an advisor for strategic planning at both the National Science Foundation and the National Institutes of Health. I also speak from my experience as Vice President for Research at two major research universities, for five years at the State University of New York at Buffalo, and since last August, at Indiana University. Both institutions are members of the American Association of Universities and the Association of Public and Land-Grant Universities. This morning I would like to speak with you about the importance of the merit review process, specifically, its integral place in establishing American preeminence in higher education, scientific investigation, and economic innovation.

My broad experience in different aspects of the process by which the federal government funds scientific research at universities leads me to conclude that while no system of review is perfect, nor guaranteed to fund only the best scientific research, **the merit review system is the most effective process we have for ensuring that federal funds are used most effectively** in support of scientific research, in particular at this time of limited resources when we need to prioritize how the tax payer dollars are best invested.

In some respects, the challenges facing federal funding agencies such as the NSF and the National Institutes of Health are very much like the challenges I face as Vice President for Research at Indiana University. As you may know, research universities often invest some of their limited resources to catalyze programs of research into issues that are of fundamental importance to our state, our nation, and the world. My goal is to help our researchers identify and address the most important scientific, social and economic problems of the 21st century, such as energy security, health care, national security and our global competitiveness. Addressing these problems is not only valuable but is also a necessity because the problems will not solve themselves. Seemingly intractable problems can be solved only when the best minds with the appropriate expertise are brought together, and America's current and future well-being depends in an essential way upon the results of research into these problems.

As important as this work is, research is just one among many important areas of the University's work and available resources ~ at IU as within the federal government ~ are limited. Given limited resources and given the importance of the problems, it is crucial that IU directs available resources to the projects with the strongest likelihood of being transformative and successful. I rely heavily on the ability of experts to assess each proposal, the work plan, and the potential of specific people to carry out a project successfully. This guidance helps to ensure that funding decisions are made on the basis of scientific merit rather than personal or political considerations. In short, merit review must be the foundation of funding decisions we make at IU because merit review enhances the likelihood that we will properly invest our limited available funds into research projects with the strongest potential for innovation, for transforming a field or addressing successfully an important problem.

We are, of course, following the path that was set up by Vannevar Bush in his *"Science- the endless frontier"* developed right after World War II, that led to the formation of the National Science Foundation. NSF introduced the merit review process as an essential component to assess and determine how tax dollars should be best allocated to scientific research. The merit review process has for the last 60 years led to many NSF notable successes. It is very important to recognize that a very large number of scientific problems are interesting in principle but a much smaller subset of those problems is important and deserve the investment necessary to search and find solutions.

Merit review is the best way to identify the *important* problems. It is the best way to ensure that federal funds are invested in a healthy array of important problems, covering a breadth of areas and approaches within a particular field. And merit review is the best way to ensure impartiality, so that the best science and the best scientists are funded.

In his planning for the NSF, Vannevar Bush drew on the experience of wartime scientific research, organized through the National Defense Research Council (NDRC). Wartime federal investment in scientific research resulted in the development of penicillin, the radar, and most famously, the atomic bomb. NDRC research brought together the very best scientific minds from Europe and the US to work on the most important problems of the time – and resulted in discoveries that helped America become the pre-eminent economic, military and scientific power of the 20th century. Since the end of the Second World War, federal investment in research at American universities has been central to the development of universities that are the envy of the world, and merit review has been central to funding research that enables the United States to remain the leader in scientific inquiry, the development of new technologies, and the translation of fundamental research into applications that shape our lives every day. While there are many ways to assess and demonstrate the value of the merit review system, allow me to focus on one. The strength of relying upon merit review to determine what small percentage of proposals will be funded is demonstrated by its adoption by other countries across the world. Funding agencies in Europe, South America and Asia, which are trying to emulate the research breakthroughs the US has had in the last 60 years, all rely on a merit review system in which experts assess proposed research much as we do in the United States.

I can give you a long list of items we use every day which were often developed as a result of the research that was funded by the federal investments in scientific research. One which the large majority of Americans use is the cell phone; another is the Global Positioning System, which was developed by the Department of Defense but which was based on a trail of research discoveries that started with the work by Einstein on his mathematical theory of gravity. GPS use is so common that it is hard to imagine how we found our way anywhere before it became commercially viable! We also hear the weather report, in particular during these hot days; the food we eat has been produced using scientific breeding techniques. We often don't think about where all these things came from, but we do know that Americans as a whole are very proud of the long tradition of

scientific research, inventiveness and innovation, a tradition which has made the US the advanced technological society that it is today.

It might be helpful to reflect for a moment on a couple of specific examples of the impact of federal funding for scientific research, because these examples point to the success of merit review. They also demonstrate that it is not always possible to anticipate what kind of impact research may have. For example, *Caenorhabditis elegans* (*C. elegans*) a transparent worm that most of us can go our whole lives without thinking too much about, but which has been the subject of significant research since the early 1960s. Only one millimeter in length, it was the *C. elegans* which first had its full genome sequenced, prior to the big achievement of decoding the human genome. For many reasons, *C. elegans* is a useful model organism, enabling researchers to learn about genetics, cell biology, and the pathogenesis that relate to many human diseases. Three times since 2002, Nobel Prizes have been awarded to researchers working with *C. elegans*. The 2002 Nobel Prize in Physiology or Medicine was shared by three researchers, Sidney Brenner (Berkeley), John Sulston (Cambridge), and Robert Horvitz (MIT) whose work was funded largely by the National Institutes of Health, through its processes of merit review. The 2002 Laureates identified key genes regulating organ development and programmed cell death and showed that corresponding genes exist in higher species, including man. The 2006 Nobel Prize in Physiology or Medicine was awarded to longtime NIH grantees Andrew Fire (Stanford) and Craig C. Mello (U. Massachusetts) for their discovery of RNA interference in *C. elegans* – work which has led to clinical trials in the treatment of macular degeneration, asthma, diabetes and brain diseases. Further the 2008 Nobel Prize in Chemistry was awarded to Martin Chalfie (Columbia) for his work on green fluorescent protein in *C. elegans* (along with Roger Tsien and Osamu Shimomura, who studied these proteins in other contexts). I still read many *C. elegans* papers in the current scientific literature that keeps unraveling important new discoveries with very likely applications including useful drugs to treat diseases.

You can imagine the response if you were to ask a regular person in the street if they felt that investing tax dollars would be justified to study a simple, almost insignificant worm. As the results show, this research has been a good investment – and it's an investment that relied on the experts who recognized that this organism was indeed an animal model system which had many properties in common with higher organisms like humans and that it was worth studying. It is important to

note that a significant percentage of the Nobel Prize winners for the last 50 years have been American or working in the US. This can be connected with the existence of our merit review system which tries to fund and identify only the best and more promising ideas for funding.

In the social and behavioral sciences, federal funding awarded through merit review has been at the foundation of substantial and important research. Elinor Ostrom (Indiana University)¹ and Oliver Williamson (Berkeley) won the Nobel Prize for their work on “Economic Governance.” Ostrom explored how communities often govern shared property and common resources more effectively than institutions do. Her research not only challenges the logical assumption about the inefficiency of informal groups, but also demonstrates that economic analysis can help understand myriad forms of social organization. Williamson provided a theory of why some economic transactions take place within firms and other similar transactions take place between firms in the marketplace. Their work inform us about how to handle one of the most basic choices in human organization: When should decision power be controlled inside an organization, and when should decisions be left to the market or governments themselves. Ostrom is the only woman who has won the Nobel Prize in Economics, and she benefited from long term funding from the Social and Behavioral Sciences section of the National Science Foundation. Those funds were awarded through merit review.

Why is the merit review process for awarding federal funds considered a strong or beneficial process? What is the impact of the merit review process on the breadth, type, and strength of research funded by the federal government?

At the center of the merit review process is peer review, in which experts review each proposal for its importance, soundness, and possible transformational and broader impacts when considering if it should be funded or not. The experts who serve on review panels not only have expertise in specific research; they also have an understanding of the broader context of the discipline. They are therefore uniquely qualified to assess whether an idea is important as well as interesting; the extent to which the research methods proposed and the qualification of the researchers are

¹ Distinguished Professor of Political Science, and Senior Research Director, Workshop in Political Theory and Policy Analysis, Indiana University; Research Professor and Founding Director, Center for the Study of Institutional Diversity, Arizona State University.

appropriate for the problem under consideration; the degree to which a proposed research project has transformative potential. The strength of the merit review process rests largely on the service of subject experts, their willingness to read proposals carefully, often for free, so as to identify those most deserving of funding. It is important to recognize that the expected results from the proposed projects for funding are not known in advance; otherwise they would not be called research. It is for this reason that expert reviewers are able to best assess the probability of success of a project based on the previous track record of the investigators submitting the proposal and the track record of the reviewers on the subject matter under consideration.

Of course, even the most well-intentioned group of subject experts are not immune from the biases, limitations and agendas that are part and parcel of being human. However, in my experience as a reviewer for many years and after having submitted many proposals to the funding agencies, it is clear that the agencies try to reduce as much as they can all possible types of bias. By and large, most of the reviews by the experts are more than likely to arrive at the correct overall decision about whether or not it is appropriate to fund a proposal. There can be outliers to the general process but reviewers for the most part are very strict about basing their decisions on scientific merit, which is why the percentage of proposals which are strongly recommended for funding is so low.

At its best, the merit review process is a system of checks and balances not unlike our system of government, in that program officers can also offer a counterbalance to the limitations of the peer reviewers. Program officers bring to the decision-making process an awareness of agency priorities and funding trends that individual reviewers or review panels will not have. In selecting reviewers, framing the review process, and interpreting the panel's recommendations, program officers place funding decisions in a broader context than just subject expertise. Together, program officers and reviewers have been remarkably successful at identifying the best proposals across a wide variety of fields, basing their funding decisions first and foremost on the intellectual merit as assessed by the experts, the transformative potential, and intrinsic importance of the research proposed.

With limited federal resources, what role does the merit review process play in ensuring that the best scientific and potentially transformative ideas receive funding? How do the broader impacts criteria requirements, in addition to intellectual merit, affect these funding decisions?

The merit review process is the best way to ensure that limited resources are directed to the best ideas. As I stated above, the collaboration of subject experts and program officers enhances the likelihood that funded projects will be the ones addressing important questions, in ways that are methodologically appropriate and that can lead to transformative changes in the subject matter at hand. The merit review process is, in my view, the best way to minimize the potential for politicizing scientific research, and to ensure that limited funds are allocated as well as possible, in particular when the federal financial situation is as precarious as it is at the moment.

The broader impacts considerations offer important additional criteria for funding. Allow me to stress that in my experience, the broader impacts criteria are used to decide between proposals of equal scientific merit ~ the contribution of a proposed project to achieving the extra-scientific goals included within these criteria does not outweigh scientific considerations. That is, assuming two proposals offer programs that are of equal importance and potential, *then* the broader impacts criteria should be used to distinguish them. In my view, funding decisions made in this way find the appropriate balance between intellectual merit and broader impacts of research.

As members of the Subcommittee are likely aware, in response to the America COMPETES Act of 2010, the National Science Board recently proposed an expanded list of broader impact criteria for NSF proposals, a list that does give some cause for concern. I do not believe that this expanded list might alter the appropriate balance between intellectual merit and broader impacts in funding decisions. Rather, my concern is that the expanded list will diminish the National Science Foundation's admirable and necessary leadership in promoting the participation of underrepresented groups (women, racial and ethnic minorities) in the sciences. Expanding the participation of underrepresented groups is an economic and intellectual necessity. Science and scientific innovation are increasingly important to a strong economy, and so American economic security as well as American pre-eminence in scientific inquiry and higher education depend upon expanding scientific education, at both the K-12 and higher education levels. To the extent that the

expanded list of broader impacts criteria diverts attention from this priority, it risks damaging our economic and national security.²

Expanding the participation of members of underrepresented groups in the sciences is not a matter of establishing quotas or prioritizing this participation over the scientific importance of a proposal. The NSF emphasis upon this is a demonstrated way of increasing the pool of talented and trained scientists. This in turn enhances overall American competitiveness, and over the long run, it will ensure that the United States continues to be the world leader in scientific research, discovery, and innovation.

How does the merit review process work to ensure review impartiality for all applicants while maintaining high standards of excellence?

Among the strengths of the merit review process is a degree of flexibility and breadth that other possible review systems would be unable to match. By this I refer to the ways in which our proposal review processes recognize that merit has many facets. For instance, an investigator at an early stage in her/his career cannot be expected to have the track record that a more senior investigator has ~ and yet, the early-career proposal may be as meritorious and promising as the ones submitted by the senior investigator earlier in their career. The NSF and other agencies have worked to develop programs that attend to differences in seniority, to allow the junior investigator to develop and flourish since they represent our future. CAREER Awards, available through the NSF, are targeted specifically at researchers early in their academic careers. But outside of these programs, the merit review system contributes to impartiality of reviews because it brings a group of scientific experts together to review proposals. Barring personalities or idiosyncratic agendas that subvert the process, merit review increases the likelihood of fair and open review of all proposals over any alternative review process I am aware of.

Please discuss any potentially novel ideas that should be considered in order to strengthen the process.

² See attachment A.

I am, as you have likely gathered, a strong proponent of the merit review system. I believe it is the process more likely to ensure that limited federal funds for research are awarded to the most significant scientific research, with the highest likelihood of long-term impact. Nonetheless, the process is not perfect. I have alluded to the possibility that review panels are not free from bias that can influence their funding recommendations. One weakness of the peer review process is that scientists can be somewhat conservative. By this, I mean that it is easier to identify and fund proposals with the likelihood of incremental scientific advances than it is to identify and fund proposals with the potential for transformative breakthroughs. To the extent that bias toward the incremental means that we fail to fund innovative, paradigm-shifting research, we may be missing opportunities for precisely the kind of scientific advances that characterized federally funded research in World War II.

This conservatism is recognized by funding agencies, which have occasionally responded by altering the charge given to review panels. “For example, when NIH concluded that it was not awarding enough high risk/high payoff grants, it changed its charge to panels accordingly.”³ Adapting guidelines given to review panels is one way to ensure flexibility and strength within merit review processes. ARPA-E, the Department of Energy program that focuses on funding breakthrough research, offers another model that might strengthen the merit review process. By using a multi-part proposal and review process, ARPA-E attempts to give reviewers a better understand of extraordinary proposals, and thus a better chance of recommending the best and most feasible proposals for funding.⁴ Similar multipart proposal and review processes might effectively be adopted by other funding agencies, in specific programs if not throughout all funding programs. This might strengthen the merit review process by making funding of extraordinary projects with transformative potential increasingly likely. Of course, scientific research advances slowly and having transformative discoveries is not as common as one would wish. Thus I am not advocating that funding be directed solely to risky research. Rather, I am suggesting that the

³ James Turner, “Best Practices in Merit Review: A Report to the U. S. Department of Energy,” APLU, December 2010, p. 7. www.aplu.org/document.doc?id=2948

⁴ Ibid., p. 10.

overall research funding apparatus could be improved by a measured emphasis on potentially disruptive discoveries and having mechanisms that allow them to be funded.

In these challenging economic times, it is more important than ever that federal funds are spent wisely. Continued federal funding for scientific research remains an important priority. Federal research funding ~ via the National Defense Research Council during the Second World War, and via the NSF and other government agencies since then ~ has for seventy years been a cornerstone of American economic security, scientific and educational preeminence. Maintaining our competitiveness globally, continuing American leadership in scientific research and innovation, and ensuring that our children and grandchildren enjoy a future in which American higher education and industry remain the envy of the world – all of these rely on continued, robust federal funding for scientific research and discovery. Yet each dollar we spend must be spent wisely – and a strong, flexible and rigorous merit review process is the best possible guarantee that American scientific research will continue to lead the way forward and that every tax payer dollar is spent with the highest possible return on investment.

I thank the Subcommittee on Research and Science Education for allowing me to express my opinions about the merit review systems used by the federal agencies in general but in particular by the National Science foundation, which funded a significant portion of my research for close to 25 years. I will gladly respond to any questions you might have.