

**Testimony of
Kenneth H. Keller, Ph.D
Chairman, Medical Technology Leadership Forum
Before the
Committee on Health, Education, Labor and Pensions
United States Senate
Hearing on
Biomedical Research: Opportunities and Innovations
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Mr. Chairman and members of the Committee:

Thank you for inviting me to speak to you today about the importance of our nation's commitment to medical research. My name is Ken Keller and I am the Charles M. Denny, Jr. Professor of Science, Technology, and Public Policy in the Hubert H. Humphrey Institute of Public Affairs at the University of Minnesota. Since 1999, I have been privileged to serve as the Chairman of the Medical Technology Leadership Forum, or MTLF. In this position, I work closely with your former colleague, David Durenberger, who serves as the President of MTLF.

MTLF is a national non-profit educational organization that was founded five years ago, when a group of leaders from the medical technology community—including physicians and bioengineers from clinical research institutions and academic health centers, medical device manufacturers, and patient and research advocacy groups—came together to discuss the challenges of developing good public policy for medical technology. We concluded that a small group of leaders could and should work to learn more about the relationship of public policy to innovation in this critically important part of the health care system. MTLF is neither an ivory tower think tank nor a lobbying organization. We identify issues, define problems, and develop policy options, first to inform ourselves and then to inform others.

Over the years, MTLF has held general forums, technically focused summit meetings, and informal task force sessions—each of which has been designed to foster an interactive dialogue between MTLF members, invited experts and policy makers. Following each meeting, we publish a report summarizing the major points raised during the dialogue. The reports that MTLF has produced so far have contributed greatly to an evolution in the way policy makers think about medical technology issues.

How we organize medical research is clearly one of those issues and, as a biomedical engineer and consultant to the NIH for almost 30 years, it is one that I have been interested in for a long time. I am honored that the Committee has invited me here today to share my thoughts about it. Let me note at the outset that these opinions are my own. They do not reflect a consensus position of MTLF members, since one of the greatest strengths of MTLF is its inclusion of members with varying perspectives and priorities. On the other hand, my comments certainly do reflect the insights I have gained from interaction with my colleagues at MTLF.

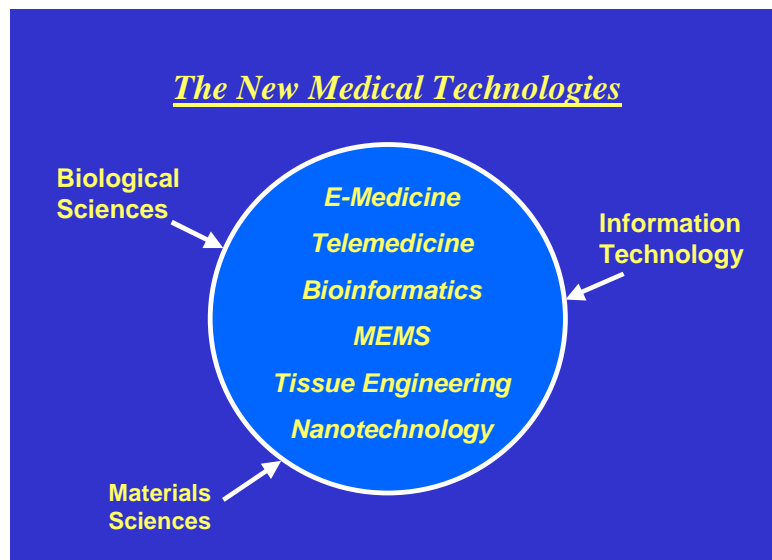
Dr. Keller is the Charles M. Denny, Jr. Professor of Science, Technology, and Public Policy in the Hubert H. Humphrey Institute of Public Affairs as well as Professor of Chemical Engineering and Materials Science at the University of Minnesota. From 1985 to 1988, he served as the President of the University of Minnesota. He also has served on a number of advisory committees of the National Institutes of Health.

I would like to emphasize three points this morning:

- First, exciting advances in medical technology in these next years will come about from the integration or combination of research in several scientific fields. In other words, it will involve and, in fact, require an essentially multi-disciplinary approach.
- Second, the development of new medical technologies, as is the case for most other modern technologies, is no longer a simple linear process from basic laboratory bench research to clinical application. It is an iterative or cyclical process in which we learn by doing, in which new technologies give us new tools that improve our basic understanding and, in turn, help us to do better fundamental research.
- Third, we need to structure the institutions that support medical technology research and development in a way that reflects the new characteristics of the research and development process.

Consider the first point. A strong argument can be made that, when measured by the rate of growth in our knowledge and understanding, the biological sciences, information technology, and materials science emerge today as the leading fields of advancing knowledge. And it is particularly in various combinations of those fields that we see the most exciting new developments in medical technology. I've listed some of them in Figure 1.

Figure 1.



- E-medicine and telemedicine— A range of information technology developments that can empower patients with new information about their health and health care, help physicians in treating patients, and even make specialist care available remotely to people in rural areas who often do not have access to much more than primary care.

- Bioinformatics— The fusion of molecular biology and information technology that has allowed us to characterize the human genome and to develop rapid genetic screening techniques, and holds forth the promise of an enormous range of applications including disease diagnosis, gene therapy, computerized pharmaceutical design, computer models of cells and organ systems, and highly individualized drug therapies that minimize patient side effects.
- Micro-electrical-mechanical systems (MEMS)— Miniaturized systems in which new materials fabrication approaches, miniature motors, sensors, and computer chips are all combined to make "intelligent" microsurgical tools, implantable sensors, and new kinds of drug delivery systems.
- Tissue engineering— A new field in which synthetic materials are used in combination with natural tissues, either to make the natural tissues grow appropriately— for example, in treating burn patients or promoting the regeneration of damaged nerves— or to create hybrid organs, where healthy cells from a donor can be protected from rejection in the recipient by using synthetic material to package them. This latter approach is opening up enormous new possibilities for providing artificial organs to replace the pancreas or the liver, where natural organs for transplantation are in very limited supply.
- Nanotechnology— The ultimate combination of molecular biology and materials science, where new systems can be designed and constructed molecule by molecule to have almost any desired properties and functions at any desired size. These new structures can be micro-computers, new systems for altering gene structure, drug delivery systems, new structural material for bones or tissue or glue, or micro-sensors to monitor physiological parameters in cells and tissues.

Because each of these exciting new areas involves some combination of fields, progress depends upon creating research support structures that promote interactions between and among those fields. Moreover, because each of the three major fields is, itself, highly dynamic and rapidly changing, medical technology researchers need to be deeply involved with those developments; they cannot apply the new knowledge deriving from research in those fields in a timely fashion unless they are integrally involved in producing that new knowledge.

This presents great challenges to our existing institutions. We who work in universities need to overcome the barriers to multi-disciplinary research that are created by our discipline-oriented departments, our arbitrary separation of science from technology, and the current, damaging pressures that health care reimbursement formulas have created to separate medical research and development from clinical practice.

The National Institutes of Health, the major source of medical technology research support, faces its own challenges. It is organized primarily around particular diseases and its review panels have generally expected research applications to be based on some hypothesis concerning a normal or pathological phenomenon. But the most exciting medical technology developments don't fit those constraints.

For example, the techniques we develop to create the polymer matrices that cause endothelial cells to be properly oriented as they grow may turn out to be closely related to the techniques for making epithelial cells grow rapidly in flat sheets or encouraging neurons to extend their growing axons and create functioning nerve fibers. However, work to perfect these techniques is not likely to be described in terms of a hypothesis about their ultimate application because it is more likely to be imbedded in an effort to develop a more basic understanding of the interaction between synthetic materials and natural tissues. Thus, it may not be cast as a hypothesis about generating new blood vessels in a damaged heart, even though it may ultimately be useful in that respect; it may not be premised solely on assumptions about how burn patients can best be treated—although we know that it is applicable to that problem; and it may not begin with ideas about nerve growth, although it may ultimately provide the solution to that very difficult challenge. As a result, such work would have difficulty in garnering support from the Heart, Lung, and Blood Institute, which might be interested in the first application, from the Arthritis and Musculoskeletal and Skin Diseases Institute, which might be interested in the second, or the Neurological Disorders and Stroke Institute, which would certainly be interested in the third.

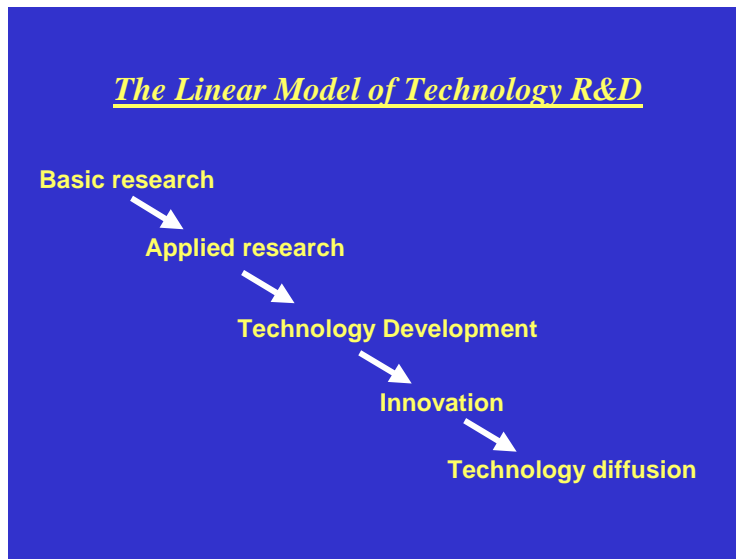
Although time does not permit me to do so this morning, one can easily cite other examples in MEMS research, in the development of applications in bioinformatics, and certainly in the field of nanotechnology. **This mismatch between the structure of our research support institutions and the actual needs of medical technology research has resulted in an underfunding of medical technology research in the past.** Recent reports have shown that only a small percentage of NIH funding has been directed to the bioengineering field in the recent past, despite its great potential for contributing to the diagnosis and treatment for such a wide range of diseases. Even this level of funding has required great effort by administrators in particular institutes who have seen the relevance of the field to their responsibilities and have pushed hard to make room for such research in the orthodoxy of their programs. However, the challenge has become more difficult as medical technology research has become more embedded in basic fields of science where we need to extend our knowledge in order to apply it to patient care.

The newly established National Institute of Biomedical Imaging and Bioengineering (NBIB) may help us to deal with this problem, although that will depend on two factors: what practical level of funding can be achieved for the new Institute and how connected its work will be to the work of the other Institutes. The administration is currently requesting an appropriation of \$40 million for NBIB's first full year of operation and a review is currently under way at NIH will determine which grants now administered by other Institutes should be transferred to NBIB. Many of us in the biomedical engineering community believe that it would be a mistake to move all bioengineering research to the new Institute because the ultimate value of new medical technologies is in the treatment of those diseases that remain the responsibility of the NIH's several institutes. If the effect of the creation of NBIB is to create one more silo in which specialized research is conducted, we may fail in the larger task of integrating medical technologies into the practice of medicine in ways that benefit patients.

Lastly, let me turn to a somewhat different challenge we face in developing new medical technologies: the increasingly blurred distinction between scientific research and technological development. For much of the post-World War II era, we have operated with what we call a

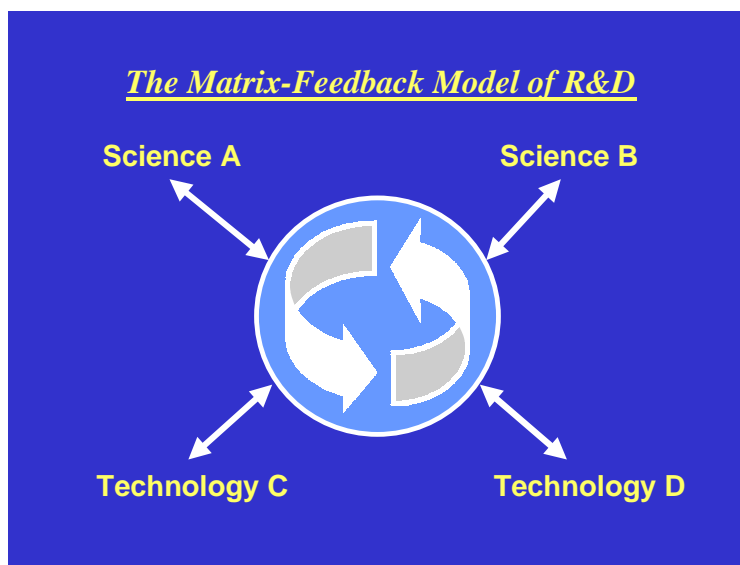
linear model of research and development. We start at point A with new basic research insights, we proceed to point B where we apply that research to a particular problem, then to point C where we develop a new technology using the research insights, and finally we develop a device or a therapy based on the technology (see Figure 2).

Figure 2.



Unfortunately, that system is no longer so elegantly simple. First, as I noted earlier, it is seldom a single line of basic research that leads to a new device or therapy. But second, there are many feedback loops in the process—technological developments that give us new information that adds to our basic understanding of the diseases we may be treating and causes us to rethink our technologies. Experience with our system that makes it possible to modify it so that it performs better or can be made at lower cost (see Figure 3).

Figure 3.



Most technology-based industries understand these changes quite well. They refer to the iterative nature of technology development, to the technology learning curve, and they organize themselves with that understanding in mind to upgrade technology, to stimulate new lines of research, and to connect their research laboratories with their operating and sales divisions.

Unfortunately, we have not reached that point in the development of medical technologies. By dividing responsibility between the NIH (for basic research and pre-competitive technologies), the FDA (for the safety and efficacy of experimental/investigational technologies) and HCFA and private payers (for determination of "reasonable and necessary" clinical use), we have created a series of one-way regulatory gates, a system that mistakenly assumes the continuous and iterative process of technology development can be effectively steered and controlled by a series of discrete regulatory judgments. It is a system in need of modification—not to reduce regulation, but to alter its mode; to recognize that medical technologies must be used to be improved and should not be used without attention to how they might be improved. This will require creating categories for technologies that are neither entirely experimental nor entirely clinical. It will require imposing on the users of medical technologies the responsibility for gathering data that can be used by the producers of technology to improve them. In short, it will require an institutional structure that recognizes the cyclical continuum of new technology research and development.

In conclusion, if we are to realize the potential medical benefits that scientific and technological advances hold out, we must find ways of breaking down institutional barriers— those that separate one scientific discipline from another; one approach to research from another; one stage of development from another. We do not need walls; we do not need gates; we need bridges.