GUEST EDITORIAL

Working in Pasteur's Quadrant

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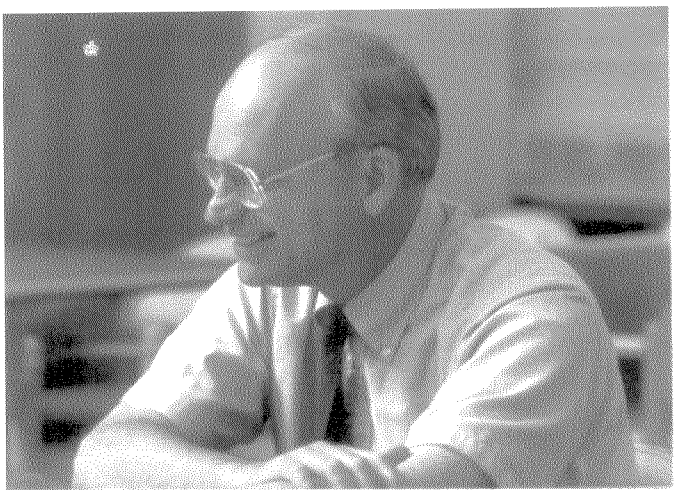
As we move away from the time of World War II, we notice that the post-war research agenda is gradually giving way to a new agenda. This is evident in DVA-supported research and in all of the nation's research enterprise. It is interesting that the coming of the new century and the arrivals of John Feussner, M.D., as Chief of DVA Research and of Mindy Aisen, M.D., as Director of the VARR&D Service coincide with this transition in viewpoint concerning research and development (R&D).

The American research agenda after W.W.II was greatly influenced by Vannevar Bush's report, *Science, the Endless Frontier,* which had been commissioned by President Franklin D. Roosevelt. Bush's vision of research has been characterized as a linear continuum from "basic to applied" and from applied development to technology transfer. Basic research was considered to be the fuel that drove the enterprise. This one-dimensional viewpoint, which has been so influential in America, is currently challenged as being too narrow. Donald E. Stokes, in his book, *Pasteur's Quadrant,* convincingly describes new and different ways to think about research efforts. Stokes suggests that a two-dimensional view is more descriptive of what really happens than is the one-dimensional "basic-to-applied" concept. His two-dimensional view is that "pure" research, such as the work of Niels Bohr on atomic structure, can be thought of as a vertical axis of research space, while the strictly "applied" research of Thomas Edison can be visualized as a horizontal axis. Stokes calls the area between the axes "Pasteur's quadrant," because the work of Pasteur exemplifies clearly the interwoven nature (not one-dimensional) of basic and applied research. The concept is that research, like Pasteur's, often is applied, practical *and* basic at the same time. It seems likely that research in the coming years will be considered "superior" if it produces practical results *and* promotes basic understanding! A wider scope of results than may have been expected in the past is likely to be desired of those participating in future R&D efforts. Work will be expected to occur well within the horizontal and vertical borders of Pasteur's quadrant.



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The changing expectations concerning R&D activities seem rather widely held. Robert Forsch, president of*Sigma Xi, The Scientific Research Society,* in an

editorial in *American Scientist,* (Vol. 85, Mar./Apr. 1997) wrote that "...the most successful application-oriented programs take a basic-research attitude and seek to understand, not just find an immediate solution." Rodney Nichols, president and CEO of the New York Academy of Sciences has written, "Revolutionary advances also come out of mission-oriented research. It is possible–indeed, often natural–to fulfill a social goal *and* create even richer scientific results than pure curiosity engenders." (from Working Hypotheses, *The Sciences,* Jan./Feb. 1997).

The way scientists, physicians, engineers, and administrators of research funding agencies (e.g., DVA) view expectations of the R&D enterprise strongly influences the approaches and results of R&D efforts. There is reason to believe that an expectation of both fundamental understanding and application-oriented results will have a salutary influence on research outcomes. It would seem that working in Pasteur's quadrant would be particularly valuable for rehabilitation investigators funded through DVA hospitals by way of the VARR&D Service. Rehabilitation research has previously made good strides, largely without seeking to understand so much as to find immediate solutions. Future advances in rehabilitation may require a stronger scientific base than they have had in the past.

Stokes visualizes a dynamic model of R&D advances as consisting of multiple paths. Although existing knowledge can be increased by pure basic research and existing technology can be advanced by purely applied R&D, he sees richer opportunities through use-inspired research. For example, he sees use-inspired research as being able to increase existing understanding *and* to create improved technology. Furthermore, he sees use-inspired research as being able to take existing technology to new levels, and to improve understanding of fundamental principles. Limb prosthetics forms a good example of this process. The study of the gait of ambulators on artificial limbs can advance our understanding of the mechanisms of human walking and at the same time lead us toward improved designs for artificial legs. Similarly, use-inspired study of the technology of leg prostheses can lead to new technologies for limbs and to new understanding of the walking process. This concept is similar to the ideas of translational research in medicine that seeks to interrelate bench research and bedside needs. In rehabilitation, it may bring persons with disability directly into the research process, which relates to participatory action research.

Van Phillips, the developer of the Flex-Foot®, has illustrated how a person with a transtibial amputation can contribute importantly to the advancement of prosthetics technology. Howard Eberhart, at the University of California (Berkeley) a generation earlier, demonstrated the same principle in a slightly different way. Margaret Pfrommer, who had tetraplegia from polio and who was associated with our laboratories at Northwestern University for 25 years, visualized that educated consumers can play important roles in the R&D process. In fact, her own life demonstrated the usefulness of this approach. Ms. Pfrommer died during October, but her legacy of use-inspired research and development lives on. The kinds of interaction and participation that she and others have achieved in the R&D process is difficult to bring about, but when properly managed it can result in zeniths of use-inspired research that richly exemplify work in Pasteur's quadrant.

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This guest editorial is an invited opinion.
The Editor