THE ROAD AHEAD
More attention to research strategy will be needed if veterans are to benefit as they should from our blossoming technology and science

For those with physical impairments, and for those who seek to help them, whether in the area of mobility or of sensory aids, the present is a time of a strange mixture of confidence and frustration.

The confidence created by our world’s blooming science and technology is still there. We in rehabilitation research feel that we ought to be able to adopt, or adapt, any number of the new materials and devices for our purposes. The frustration is there because, while there have been some signs of success, we in rehabilitation research still haven’t perfected the knack of wrapping new gifts of technology into packages we can place on industry’s doorstep with any confidence that what’s in a package will become available, in the right form at the right price, where it is needed. At least, not very often.

Further, we can see signs that some of the old, tough prosthetics research problems are becoming permanently unsolved, Bypassed is probably the proper term. Is this happening because too many of those with the necessary research talent have absorbed (from business and industrial management theory and practice?) the strategy of seeking-out those challenges that seem most likely to yield reportable results? We think those who follow that rule too closely miss some bets and perhaps outsmart themselves as some of our industries have outsmarted themselves in the recent couple of decades.

And, on top of all these frustrations, there is the not-so-minor problem of fashions in lifestyle. The “strenuous pursuit of physical excellence” now powers a mass-marketing phenomenon. Running shoes displayed and sold in unbelievable variety, price, and promotional ingenuity are only one example. It has become so popular to run distances that thousands of us engage in running marathons somewhere each week. The standard marathon distance has been extended by a select few to races as long as 100 miles and farther. The once superhuman Triathalon is becoming a citizen event.

A popular national weekly news magazine recently devoted an issue to the subject of “The Most Amazing 60 Years in History,” referring to the past 60 years of its existence. It appeared that no area of human ingenuity and accomplishment has been more illustrative of change than that of mobility. We propel ourselves faster, farther, over longer periods of time, and with greater comfort, than our recent precedents dreamed possible.
This enhanced and various transportation crosses every aspect of our lives: work, play, inquisitiveness, challenge. Such transport includes not only the innumerable mechanical aids for our moving on earth, through the water and over it, in the atmosphere and beyond into space. Our culture’s obsession with mobility, it seems, has fused with the highly visible drive for self-mastery, self-development, and pursuit of physical fitness to create the phenomena we mentioned earlier.

We have been trying, here, to summon up for the reader some sense of the barrage of images that beats in upon the person whose mobility is limited by physical impairment, including limb loss. The sight of his neighbors ardently pursuing the satisfactions of running, like the reports of ever more exotic devices on the road, in the air, on the water and in space, can seem reproachful and ironic. Certainly mobility-enhancing and function-restoring aids for the mobility-impaired are improving, but do improvements come at a rate that reflects any of the dramatic breakthrough style we have become accustomed to in the reporting of events? Is the vigor, the rapidity, the dramatic excitement usually associated with technology altogether inappropriate to rehabilitation? Or does the perceived slowness simply reflect some structural inadequacy in the mechanism (or the lack of any purposeful mechanism) by which technology transfer is supposed to be accomplished?

The state-of-the-art excellence of the treatment and devices available for the relief of mobility and communication/sensory deficits is of particular concern to the Veterans Administration. The agency’s mission includes the need to play a leadership role whenever it may appear that its constituents, especially those with war-incurred deficits, are not participating as they should in the benefits one would naturally expect to flow from scientific, technical, and industrial progress.

A Perception of Priorities

Immediate and long-range priorities (which are not by any means identical at a given time) both change with the times as the characteristics of the unmet needs changes. For example, note that new technology and the heightened expectations it generates are enough to generate an urgent periodic need for adjustments in any system of priorities which may be in place.

A current perception of aspects of priorities would be as follows, in this author’s opinion.

1. The incorporation of modern materials technology.

Polymer chemists, design engineers, and other materials scientists, working with a wide assortment of plastics and composites, can design and fabricate structures with the ability to respond to repetitive forces in interesting new ways. Not only do these offer useful flexibility, strength, and endurance characteristics, but some of them can also be given the ability to store and release energy as well, especially gravitational energy.

What this contributes to prosthesis design is the potential for giving the materials some characteristics that simulate those of neuro-musculoskeletal function. This could be done, it seems clear, much more simply, cheaply, and effectively than with an assemblage of springs, elastic elements, and other individual segments and components. Such a monomorphic endoskeletal limb prosthesis sounds as if it might greatly improve prosthetics, especially for the lower limb.

The materials characteristics suggested here are being used by industry in the design and manufacture of products. Certainly some of this technology can be translated into prosthetic and orthotic terms.

The same degree of control over the characteristics of materials is available to improve cosmesis, in terms of form and surface texture, without loss of function.

2. The exact physical characteristics of the residual limb.

Studies are needed that will lead to better understanding of this in usable terms. With adequate numbers, and proper storage and retrieval of the information, greater standardization of socket design should be possible.

It is true that we are so uniquely individual physically (and this individuality is so true of the residual limb) that standard socket designs and sizes will never be more than a partial solution. However, “partial” solutions can be valuable. The current use of one or several transparent check-sockets indicates
what can be accomplished by meticulous, individualized fine-tuning related to a set of standards.

This most important quality, interface conformity, can certainly be approached even more closely by CAD/CAM and related techniques, once the data of the required range and density are available in the necessary format.

As to the materials for socket and interface, here also is a research area of potentially high research priority. It is noteworthy that the biological tolerance for organic materials (wood, animal and vegetable products) has been time-proven over the centuries. That is the generalization: actually the reaction of skin to its physical environment varies a great deal with individuals. As we move more completely into non-organic interfaces, we need to understand more about skin and scar tolerance for the many previously untried "inert" substances which promise so many advantages. Among those advantages are socket flexibility, the ability to conduct excess heat and moisture away from the interface, and qualities that are useful in the engineering of contour relationships and interface physics. More comfort, along with superior reliable force-transfer from the body to the device and vice-versa, are the goals.

3. The Various Uses of Electrical Energy.

External and body-generated electrical energy has many uses in the restoration of mobility. Outstanding progress has already been recorded and more is still to come.

A major drawback to the successful application of external power is the lack of effective sensory feedback techniques. Some work has been done in this area, but its clinical usefulness has been somewhat limited. Research in this direction should continue, because a solution seems to underly the ultimate successful application of much other work.

Meanwhile, most upper-limb amputees still use body-powered prostheses. We aren't putting much research effort into improving these appliances, with the result that a majority of the upper-limb prostheses in use today are little-changed from those fitted 15 to 20 years ago. A "re-visiting" of body powering, in the light of current technology, could yield great patient benefits.

4. Limb and Tissue Viability.

Continued studies into the nature of tissue ischemia are deserving of significant funding. The two main causes of the ischemia in question are pressure on insensitive skin, with its costly sequelae, and lack of perfusion of a limb secondary to arteriosclerosis and other types of peripheral vascular disease. Amputation levels, pressure-relieving devices, and many other practical spinoffs from limb viability studies relate to human mobility. This information is highly important to the veteran population as well as the citizenry in general: The interest is actually world-wide.

Most amputations today result from ischemia. Surgical and mechanical re-vascularization of ischemic limbs represent a great therapeutic advance. But with increased longevity, more people with limbs at risk will either have outlived their vascular reconstructions or be unreconstructable. We urgently need more information about the potential for wounds to heal in the presence of ischemia. This basic research should include not only the classical atherosclerotic, occlusive states but those associated with metabolic diseases, primarily diabetes.

5. Accurate Statistics.

Well-designed biostatistical information about the requirements, behavior patterns, and characteristics of the population served is absolutely essential for planning as well as for result analysis.

6. Sensory Deficit and Sensory Aids.

This field is certainly no less important than mobility impairment and loss. Technology transfer in this area is a high challenge because of the apparent high leverage gained when existing computer-associated devices can be adapted for use by those with impaired vision and hearing. In such work, the right interface can unlock very great potentialities of user and equipment alike. The opportunities call for creative research design and rigorously pursued science, with strong demands for a high degree of interdisciplinary spirit.

Impairment of vision, speech, or hearing (or combinations of these conditions) seriously erode the quality of life. There seems to be room for innovation and improvement in many aspects of the problems these individuals face, including patient education. Continued research should be fruitful.
7. Technology Transfer...and Recipient Acceptance.

There is a need for better handling of the results of research. When an idea or a device seems to be definitely useful and applicable, there is an urgent need for the existence of machinery in place to carry out the evaluation of the product. If it proves viable, the effort must divide into preparations for manufacturing and distributing, even while arrangements are made to train those who will be expected to prescribe and supervise its use and evaluate the long-term results. If the product is mechanical, a supporting structure of warehousing, maintenance, repair, and stocking must be worked out. And the entire network must somehow be provided with a sensing capacity so that information flows back from the points of use (and of repair) to the research unit where more advanced versions are under development.

Transfer of research results across this bridge is not an automatic procedure, nor is it often a well-established, structured procedure as was the research which produced the object in the first place. Some of the transfer requires techniques that have not been invented yet, in all probability. Work needs to be done in this area, which lacks administrative, legal, financial and personnel machinery.

"Recipient acceptance" could, and probably should, be the subject of extensive research itself. It is really ironic that the results of careful research can actually survive rigorous formal evaluation and even reach early stages of commercial production...only to sink into obscurity because the device fails to earn the respect or the enthusiasm of those who wear or use it.

Simply involving some potential wearers or users in the research and development does not seem to guarantee that a new product will earn a secure place in the hearts of consumers. Nor do features which delight scientists and engineers assure such a welcome. What is called for, it seems, is the right mixture of feedback from the clinical and consumer viewpoint into the ongoing development activity. Given that feedback, there is the requirement of receptivity among the scientific, medical, and engineering talent. Receptivity, in this case, implies interest in and curiosity about messages in the feedback stream that may seem to run counter to, or diverge from, fixed preconceptions that the investigators and developers may have cherished when they started working.

It is asking a lot of dogged investigators that they should, while pursuing results with determination and perseverance, also remain wide open to subtle, whispered hints of problems in the nebulous "recipient acceptance" area. However, the price for insensitivity can be a technically "perfect" product that gathers dust on hall-closet shelves or in hospital basements. It sometimes seems that sensory aids are the most vulnerable to this hazard, but the problem is not unique to that area. Perhaps the answer is not to be found in rationality and logical testing, but instead might be sought in the art of merchandising or the powerful irrational incantation of "fashion."

Clearly, fashion isn't enough, although a force that can assure volume sales of high heels and other discomforts deserves respect. What fashion teaches us, perhaps, is to look for the balance between things the recipient perceives as "benefits" and those perceived as nuisances, discomforts, and inadequacies.