Prosthetics and architecture are similar because both are combinations of art and engineering. Consequently, in prosthetics, as in architecture, there is usually much controversy concerning what constitutes good design. Conflict among designers and between designers and end-users abounds. There are those who insist that "form follows function." The typical hook prosthesis is a classic example of this. Others contend that form and function should be balanced or that anthropomorphoid form is paramount.

The motto "less is more," of the late Chicago architect Ludwig Mies van der Rohe, would seem appropriate for consideration and practice by many designers of prostheses. Frank Lloyd Wright's concept of "organic architecture" also seems applicable in prosthetic design.

In the recent history of prosthetics, design has followed device. That is, individual parts (artificial feet, knees, hands, elbows, and other components) were designed relatively apart from the complete system. Subsequent form and control of the system were largely determined by these parts. Today control design theories for complete prosthetic systems are emerging and design may follow theory. However, there is controversy as to which theory should be followed. Hence, the objective of this editorial is to attempt to raise the awareness of the prosthetic community to these new design concepts.

It is well known that, as the functions of a present-day prosthesis increase, the mental effort and time involved in control of the prosthesis sharply increase in a nonlinear way. Since the prosthesis must serve the man and not the man the prosthesis, a generalized design goal should be one seeking the subconscious control of multiple functions. At least four approaches to this generalized goal are recognizable today. These are:

1. extended physiological proprioception,
2. myoelectric pattern classification,
3. multi-mode approaches to coordinated control, and
4. learning systems.

Research scientists and engineers in Philadelphia and Gothenburg...
have demonstrated that the second concept, myoelectric pattern classification, is feasible in this application. A specific pattern of muscular activity is interpreted as a particular desired movement.

Various workers in many places have designed limbs whose joints are coupled so that a single input motion produces a complex coordinated output motion. If various coordinated motions, such as eating or toilet activities, may be selected, the third concept, the multi-mode approach, may be achieved.

It may be possible for a system to "learn" various patterned activities of an artificial limb. Therefore, repeated motions may be recognized so that control may be assisted through a learning system, the last of the four approaches. Experimental work is proceeding on this approach in Los Angeles.

The first concept mentioned, extended physiological proprioception (EPP), has been proposed and reduced to practice by Dr. David Simpson in Edinburgh. This approach will be emphasized here because it does not have an active protagonist in America, and because it is a promising concept.

Tennis, squash, and badminton are but a small number of sports played with a racket or other artificial extension of the body. Rackets, as is well known, become extremely effective tools in the hands of experienced players. However, even the neophyte can quickly learn to strike a ball with this artificial extension of himself. The human mind apparently soon learns where the racket is located and receives information concerning its position and velocity (acceleration may also be detected or determined) in space. Through the hand and body joints this information is naturally obtained. The external forces acting upon the racket are readily perceived and interpreted. Control quickly becomes subconscious in nature. This is a form of extended physiological proprioception.

The blind individual trained with a long cane for mobility is using the approach described; perhaps this perception may explain why the long cane is a highly successful mobility aid. Likewise, the below-knee amputee with a well-fitted PTB-type prosthesis also may benefit significantly from extended physiological proprioception. The intact human knee joint, coupled with a limb intimately fitting into the socket, provides position and velocity information about the shank and the relatively rigidly attached SACH foot. Forces acting on the prosthesis are transmitted to the individual through the socket; the better the fit and suspension, the more directly and immediately related the substitute sensory feedback.

Prosthesis design by this approach involves residual joint motion as a position input, with the system so intimately coupled that the input can "feel" the output position and cannot "get ahead" of it. In this way
velocity as well as position may be naturally detected through the residual joint. Forces acting on the output need to be discernible at the input through normal sensory pathways. This principle, properly applied, appears to permit subconscious control of prostheses and to diminish training time. It is the author's opinion that the principle should be more widely investigated and consciously incorporated into a variety of experimental limb designs. After all, it may be possible for prostheses attached to the limbs of amputees to be as effective as tennis rackets in the hands of skilled players. Tennis, anyone?