

## A New Form of Specialization

Though employment opportunities for biomedical engineers are projected to keep increasing at a rate much faster than most other occupations, there is no doubt that there are still concerns about our biomedical engineering (BME) or bioengineering (BIOE) profession, the way we educate our students, and the definition of our entire field. I do not intend to analyze such complex issues in this forum, but I would like to make some observations that, in my mind, suggest we are on the right path.

First, we need to realize where we stand temporally and historically in the continuum of engineering, medicine, and science. BME/BIOE represents a domain that is ever-expanding, re-shaping itself, and also modifying its directions. Many of our BME/BIOE departments worldwide are still rooted in the older disciplines that they locally sprang from, and their educational foci may be tinted accordingly. With our programs preparing for and receiving accreditation, there is increasingly more standardization in curricula and objectives. As a result, the large fluctuations in educational consistency among our BME/BIOE departments are getting smaller. Questions continue to arise from more classically trained engineers as to whether our students develop sufficient depth in particular areas. I believe firmly that the training our students receive is not only strong but quite appropriate for a field that straddles such a large continuum. All of us must be patient, as BME/BIOE is still in a time of rapid growth and also great flux.

There are also frequent, but diminishing, questions about the need of specialized education in BME/BIOE. Our field is integral with and central to healthcare and its various manifestations. Healthcare will always be here. BME/BIOE is the engine that provides ingenuity not only in terms of identifying new treatments and elucidating etiologies of diseases, but also toward reducing costs. For example, it is biomedical engineers who are designing processes and approaches to reduce the cost of drugs.

Despite my bias, there is no doubt in my mind that our students are the best trained in any field. I dare say that our graduates are bringing a new paradigm of

specialization that emphasizes global vision over narrow expertise. Our ancient ancestors approached knowledge holistically. Over the years as more and more knowledge was created, people could not study everything, so they specialized. Knowledge became so specialized that it was hard to be familiar with more than one field. Now maybe there is a slight swing back in the other direction. As biomedical engineers, we are asked to interact and work well with those in other areas. We now see that scientific boundaries are coming down. Our graduates need to know not just the engineering aspects of a problem, but also its physiological, biological, business, regulatory, and legal facets. Our students not only understand how to perform a numerical analysis of a stent, for example, but also the biological implications of their design, its ethical aspects, its regulatory difficulties, and its medical constraints. We are beginning to see a restructuring of the field toward blurred boundaries. I am convinced that as our graduates begin to populate industry, they will inevitably become the Presidents and CEOs, in addition to being in Research and Development, in many ways because of their ability to have a global view of any problem they approach. Our graduates will be the next generation of leaders in industry and business.

So, is the pendulum of super-specialization swinging back or do our BME/BIOE graduates represent a new form of specialization that is centered on holism? There is no doubt that our biomedical engineers and bioengineers are superbly trained, with deep roots in diverse, classical fields and disciplines while at the same time exhibiting facility in other fields and areas. It is with rational optimism that I say that our field has a bright future.

Respectfully submitted

K. A. ATHANASIOU  
University of California  
Davis, CA  
Electronic mail: [athanasiou@ucdavis.com](mailto:athanasiou@ucdavis.com)