Biology Should Not be Divided

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We recently had a faculty meeting where some of the specialists in ecological engineering were expressing discomfort about answering questions from advisees interested mainly in biomedical engineering. From their comments, it was clear that they would prefer to narrow the focus of their own academic lives to wetlands, restoration ecology, and emergy. I have heard the obverse from faculty particularly keen on biomedical engineering.

Whereas it is clear that in our own research we must focus on specific topics that usually, although not always, deal with narrow segments of the biological realm, we often forget that the burden of the Biological Engineer is to have some level of understanding of all of biology, just as we must be familiar with general engineering approaches to problem-solving. This generalized approach to understanding of biology sets Biological Engineers apart from others such as biomedical engineers and biochemical engineers.

Too many of us are more comfortable with talking about Biological Engineering than with biology, and that causes some of our hesitance to speak confidently about biological topics outside our areas of specialty. Yet, there are certain principles in biology that are not observed just at one level or another, but instead permeate all of biology.

It is at this general principle level that biology can be understood most easily. Once the general principles are known, it becomes more realistic to expect to be able to transfer knowledge of a familiar biological subject to one which is unfamiliar.

So what are these principles? Unfortunately, they have not yet been written down. They are waiting for Biological Engineers, such as you and me, to articulate them. I have tried to start this process in my Biology for Engineers book (www.bre.umd.edu/johnson.htm), but it will take many of us to get it right. One principle, however, is clear: the genetic foundation of a population does not change unless there is a reproductive advantage to doing so. "Desirable" genes are not selected for, and "undesirable" genes are not selected against unless there is a selective process going on to begin with. You can bet on it.

Brian Hayes, writing in the July-August 2004 issue of American Scientist, describes a time when all knowledge was classified together as *natural science*. Every kind of knowledge and understanding, from chemistry and physics, mathematics, and biology to philosophy, metaphysics, and religion were taught as one. As time went on, these fields gradually split, each developing appropriate methods and terminology, and this reductionistic trend continues today. In the subdiscipline of biomaterials, for instance, we have specialists in polymers, in ceramics, and in metals. Some day, it seems, we may even see one specialty per specialist, and no one will understand anything anyone else has to say.

Stepping back a bit, we explore our own selves and find that we have some understanding of science, engineering, philosophy, music, art, social graces, religion, and

countless other things. In other words, as biological beings, we integrate knowledge about many specialties all the time.

A Biological Engineering design to produce a product or process intended for you and me can only be successful if all these areas of knowledge are considered. A design that fails in one critical area will be unsuccessful even if all else is perfect. The same would be true no matter what biological system is involved.

I conclude from all this that a basic understanding of the entire field of biology is necessary for the Biological Engineer. We can not chop off pieces of biology and ignore the rest; we cannot fail to recognize biology as entirely integrative and unified.

So, while my fellow faculty members may not be able to give specific answers to job possibilities outside their own fields of specialization, they ought to at least have some understanding of the broad opportunities that exist. And, when it comes to answering questions about biology or engineering, they should be confident in the answers they dispense. After all, biology is biology is biology. Right?