Biological Engineering: What It Means to Me

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I have been involved with Biological Engineering for almost my entire professional life, and have been totally committed to its definition, promotion, and dissemination during that time. Here are some thoughts that come to mind when Biological Engineering (BE) is discussed. These are, of necessity, only very briefly presented.

1. History. Although the history of BE goes back farther than this (Johnson, 2006), Pat Hassler changed the name of the NC State program to Biological and Agricultural Agricultural Engineering in 1965. Bill Fox and Jim Anderson followed at Mississippi State in 1967, and, together with Rensselear Polytechnic Institute, were the first two accredited BE programs. There were many in ASABE who championed BE, among them Norm Scott, who, as IBE President in 2000 pushed for a common definition of BE, that, by consensus, became: "*BE is the biology-based engineering discipline that integrates life sciences with engineering in the advancement and application of fundamental concepts of biological systems from molecular to ecosystem levels*." My own BE efforts were more concentrated outside of ASABE, in The Alliance for Engineering in Medicine and Biology, The American Institute for Medical and Biological Engineering, and the American Society for Engineering Education.

2. Attributes of Biological Engineers.

- *They are generalists.* They have an appreciation for interrelationships and interconnections, approach BE problems from a systems perspective, and use analogical thinking.
- *They are enthusiastic.* They appreciate the wonders revealed about the ways of living things, see themselves as positive contributors to humankind and the state of the world, and are, consequently, highly motivated.
- *They are creative.* They work with biological tendencies rather than against them, do not need to subdue or dominate other living things, and use imagination to extend natural tendencies.
- *They are skilled.* Hands-on experiences enhance understanding and remembering. Personal involvement in making or doing begets inspiration and improvement for present or future BE solutions. They have confidence in their abilities. It is important for BE students to have meaningful laboratory experiences as part of their educations.
- *They are science-based.* This means that their interest and knowledge base encompasses all possible applications. Their interests are not tied to any particular industry, and advances in one specialty apply to all. This is one of the hardest attributes to embrace, and stands as an obstacle to full development of BE as a separate discipline. No matter what the foundational disciplines are for those moving in to BE, their concept of BE is colored by their former backgrounds.

- *They know biological principles.* These are important to know in order to be effective as a Biological Engineer. These include, but are not limited to (Johnson, 2010),
    - Competition for resources
    - Reproduction (amazing in itself; what other chemicals do you know that are compelled to reproduce at the expense of all other chemicals in the world?)
    - Selection of the most likely to reproduce
    - Information legacies
    - Influence of physical, chemical, and biological environments
    - Likelihood of unintended consequences
    - Redundancies
    - Exceptions to the rule is the rule

  They must be thoroughly familiar with the ways of biology. Web searching should be used to find details, not general information. Googling will not be effective if the Biological Engineer doesn't know where to start.
- *They are visionary.* They ask questions, such as:
    - What is possible?
    - How would this problem be solved biologically (bioinspiration)? Is there a biological solution to a similar problem (biomimetics)?
    - What are the limits?
    - How can I work with biological principles, not against them?
- *They have a common knowledge base.* Besides the principles outlined in Johnson (2010), they conform to the IBE definition of BE given earlier in the broadest possible sense.

3. Basic Textbooks. When inchoate Agricultural Engineering (AE) was just emerging as a discipline it was much more isolated than is BE at this stage. There was no explicit fundamental agreement about common educational objectives or foundational knowledge, but it did have the Ferguson series of textbooks that served the purpose of forming disciplinary cohesiveness. These became the basis for AE as a separate discipline. There is need in BE to do the same thing.

I have written three textbooks that could either serve a similar purpose or lead the way toward such an academic understructure. The last two are probably more relevant than the first:

- *Biomechanics and Exercise Physiology: Quantitative Modeling.* In this book are contained the means to predict physiological and ergonomic responses to work and exercise as would be needed in a BE design.
- *Biological Process Engineering: an Analogical Approach to Fluid Flow, Heat Transfer, and Mass Transfer Applied to Biological Systems.* This book uses analogs to demonstrate the concepts behind transport processes, and presents design equations and tabled values meant to assist with BE designs.

- *Biology for Engineers,* with significant Addenda at http://www.bioe. umd.edu/~artjohns/books/biology-for-engineers/1stEd-Addenda.pdf . This is the most fundamental of the three, but presents biology as engineers should know the science. It is broad and comprehensive, emphasizing how things work so that Biological Engineers know what to expect when working with living things.

4. The Future. BE can emerge as a separate and distinct discipline, but only if there is agreement about what it should contain and it is given time to develop (Johnson, 2002).

References:

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