

Biological Engineering Elaboration

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The central message given by Mark Riley in the October issue of *Resource*, that a systems approach is necessary in order to appreciate fully the outcomes of engineering applied to biology, is something I agree with very much. As Mark has noted, the genome isn't the only determination of biological outcomes; each biological unit is a product of the interactions it has with its physical, chemical, and biological environments, something that has been taught in agricultural engineering since before I went to school. The problems are several:

1. Environmental conditions are chaotic in the mathematical sense of the word.
2. Individual genes in the genome may or may not be activated.
3. Cultural practices passed from older to younger generations are a parallel legacy of information and behavioral outcomes.
4. Biological units are adaptable and changeable.

That is why engineers need to learn about biology differently from the way biologists learn. Engineers need principles and basic concepts related to utilization, and they need the ability to avoid unintended consequences that are likely when dealing with living things.

As to the difference between civil engineering designs and biological engineering designs, one major difference is the time that civil engineers have had to develop empirical knowledge to help avoid disasters. Biological engineers have been in business for a much shorter span of time, and the range of applications is so much greater than it is for civil engineering, that it will take a long time to catch up.

Lastly, I think the real biological revolution is exhausted. By that I mean that most, if not all, of the basics are now known. What is left is to fill in the details, and there are certainly many to fill in. There are application opportunities galore, and these will continue to expand as long as anyone can imagine. Products and processes hardly considered possible until recently will become reality within the foreseeable future. Distinctions between the physical world and the biological world will blur, and we will have empirical models assisting in the designs of nearly all aspects of life. It's almost scary.