We Have a Good Start, But There's a Lot More to Do

Arthur T. Johnson
Biological Resources Engineering
University of Maryland
College Park, MD 20742

[Note: At this point all academic biological engineering programs have been derived from former agricultural engineering programs. As the field of biological engineering evolves, it is reasonable to expect that new programs will have different origins. This paper is directed to those who presently are associated with academic programs with agricultural engineering roots.]

It's probably fair to say that we have had some success at reforming ourselves from the agricultural engineering tied to one specific, but important, industry to the biological engineering that is based on a science instead of on an industry. In order to make the change thus far, we have had to contemplate what things we did previously that had prepared us for the reformation, and how biological engineering would be a natural extension of historical trends within agricultural engineering. Some people have embraced the change easily; others still don't see the relevance of biological engineering to their careers. The result is a lot of repetition of the definition of biological engineering at the expense of strategic perspective. It is time to assess our positions regarding what has been accomplished and where future efforts might need to be applied.

Here are some of our accomplishments:

1. **A significant minority of faculty have accepted biological engineering as their discipline.** My assessment is that this group may have reached majority in some places, but that the largest group of faculty are those who have accepted the change to biological engineering as an experiment without final results as yet. They remain somewhat skeptical, certainly unenthusiastic, and have yet to accept where they will fit into the new discipline. The committed biological engineers, however, are very vocal, energetic, and enthusiastic, and their numbers are growing.

2. **Many departments have changed names and curriculums.** A glance at the most recent ASAE Yearbook shows that 33 of 66 departments have some variant of biological engineering in their titles. Somewhat belatedly, a good number of these departments have begun to reform their curriculums to be more honest representations of their names.

3. **Enrollments have increased.** The increase in undergraduate student enrollments has been dramatic in some cases and less so in other cases (+100% to +1000% in several years),

but the increases have been treated as good news by all departments, especially those that saw themselves as vulnerable to discontinuance. Curiously, those departments that maintain agricultural engineering along with biological engineering undergraduate programs have seen increases in both

programs. Would the increases in agricultural engineering enrollments have happened if biological engineering programs had not been incorporated? The answer is not clear, but I'd like to think not.

4. **Program explanations have changed.** We used to spend a lot of time trying to convince every potential student that agriculture is much more than farming. We don't do that anymore; we now talk more about opportunities for engineers working with biological systems.

5. **We have embraced biomedical engineering, at least in undergraduate teaching.** Not long ago, the mention of biomedical engineering was enough to stop a conversation. Now, we have unrepentant biomedical engineers in several departments and several more are being sought. What is the difference? There is a new customer-oriented approach to undergraduate teaching that is telling us that if students are interested, we ought to try to give it to them. Incidentally, traditional biomedical engineering has always found it difficult to place biomedical engineers with no more than a bachelor's degree. I think that our programs that require students to take more biology and to develop an outlook broader than only medicine may be the model for successful student placement.

6. **We have increased diversity among our students.** The successful biological engineering programs are now bragging about this. There are more members of more minorities in our programs than ever before. We now see a larger pool of potential students because they are interested in what we have to offer. ASAE, a bastion for white male activity, could benefit from this group of students.

Now, among the things that have as yet to be accomplished:

1. **Many faculty and staff still think nearly exclusively of the agricultural applications.** Many faculty and staff, especially those not personally committed to biological engineering, are sending mixed messages to students. We all must learn something about non-agricultural aspects of biological engineering and convey those to students. Some would say that this is turning our backs on agriculture; it is not: it is committing ourselves to contributions to humankind that can be made by future generations.

2. **New constituencies must be identified and connections made.** If agriculture is not the only industry to be served under the new biological engineering paradigm, then new collaborations must be formed. The most difficult thing about this process will be to become unfettered from old ideas. The payoff will come when we find that the new constituencies have more resources than our old constituencies. What are these new constituencies? Use your imagination.

3. **Agricultural engineering has not been made into a specialty area of biological engineering.** Some departments have kept agricultural engineering coequal with biological engineering. Some departments have eliminated agricultural engineering altogether. If agriculture is a legitimate industry to be served by biological engineering, then we ought to be able to educate students from non-farm backgrounds to become agricultural engineers. For that to happen, specialty courses in agriculture may have to be taught by our departments, especially at the graduate level.

4. **We haven't assumed ownership of all areas of Biological Engineering.** Can you imagine a chemical engineering course taught in mechanical, civil, or electrical engineering? No? Then why is it that biological engineering students are sent to chemical, electrical, civil, or mechanical engineering to take courses in some areas of biological engineering (bioreactors,

neural processes, bioremediation, or biomechanics, for example). If we act as if this entire field is ours, others may begin to believe it.

5. **Biological engineering has not become established in non-land grant universities.** Agricultural engineering belongs historically in land grant universities. Opportunities in biological engineering are so vast that establishing programs at private institutions can help this emerging discipline. We need to have a pool of graduates large enough for industries to be interested in them. Thus far, we have not yet come close to saturation of the job market. Additional programs will help the job market and help build legitimacy for the discipline.

6. **We haven't combined with existing biomedical engineering or bioengineering programs on campus.** Fragmentation of the field of biology into multiple fiefdoms can only weaken claims that biological engineers represent engineering applied to all of biology. Medical and biotechnology subareas of biological engineering represent a great deal of the wealth and influence in the field. We need to work towards consolidation of all these subareas. Even if it cannot be accomplished in totality, it must be accomplished at the undergraduate level where the same depth of expertise does not have to be present in faculty interests.

7. **We haven't moved as close to the colleges of engineering as we should.** In some universities, biological engineering departments are already fully-recognized parts of, if not administered by, the colleges of engineering. In other places the association with engineering is much less formal. If biological engineering is to truly represent engineering applied to biological systems, it must be unequivocally identified with engineering, and not identified with one application area represented by the college of agriculture. There is also a survival issue here: the opportunities in biological engineering will continue to grow, and will be attractive to other programs on campus, especially in engineering. Colleges of agriculture do not represent a threat to biological engineering programs because their administrations are not usually interested in any more engineering than they already have. Colleges of engineering, on the other hand, can dilute the territorial claims of biological engineering by assigning small pieces of the field to other disciplines. It is better for biological engineering programs to thrive by establishing and maintaining close relationships to engineering than for biological engineering to retreat to the relative, but confining, safety of agriculture.

8. **We have yet to develop texts and other teaching materials in biological engineering.** We can say as many times as we want what we mean by biological engineering, but the field will actually be defined by the books that everyone uses. Biological engineering has been described as broad and fundamental; in truth, the engineering is fundamental, and the biology is broad. If biological engineering is to emerge as something different from chemical engineering, then it must develop approaches distinguished from chemical engineering approaches. Will biological engineering use the unit operations approach developed by chemical engineers? Perhaps, but, in addition, the analogical approach to biological systems, whereby similarities between different systems are used to provide overall unified concepts of various applications in biology, will be a distinguishing feature. It is through textbooks written specifically to serve the field of biological engineering that this will be made clear.

9. **We haven't completely expanded our environmental engineering into bioenvironmental engineering and ecological engineering.** The emphasis here is on the bio- part, and that will distinguish between the biological engineering approach to environment and the usual civil engineering approach. Our environmental engineering must embrace biological issues, including bioremediation and biomotivation. Ecological engineering is beginning to become popular with students, and we should also claim it as one of our own.

10. **We haven't become competitive enough.** One disadvantage to biological engineering is that it draws attention. While we were still agricultural engineers we could be comfortable in the feeling that there were not a lot of engineers who wished to compete with us for the limited resources available to us. The opportunities in biological engineering are so vast that

the situation has changed greatly. Other engineers would like part of this action, and we must be able to deal with them.

I'm sure that there are other things that could be added to both lists, depending on your viewpoint and your interest in detail. Real progress can only be made if we move beyond the question of "What is biological engineering?" to "How do we get there?". It should be somewhat reassuring to know that few, if any, have reached the land of biological engineering, and the challenge for all of us is to realize that to achieve the utmost goal, the changes required are profound.

ARTHUR T. JOHNSON is Professor of Biological Resources Engineering, Food Science and Nutrition, and Kinesiology (Affiliate) at the University of Maryland. He received his PhD from Cornell University in 1969. He is a Fellow of ASEE and AIMBE, Chairman-Elect of the Institute for Biological Engineering and of NABEC, and serves on the Board of Directors of AIMBE and ASAE.