
Preface for First Edition

Technology made large populations possible; large populations now make technology indispensable.

—Joseph Wood Krutch

Each of my books has been different from any other book on its topic, but more so with *Biology for Engineers* than the others. There just was not a book out there that looked at the engineering of biology. I had been involved in the earliest stages of the biological engineering movement in the American Society of Engineering Education and the American Society of Agricultural Engineers, and had written extensively about the field in general and about its philosophical foundations. Others had as well. But filling in the details and specifying exactly what should constitute education in the field was another matter. That was coming extremely slowly, and it almost seemed as if the great minds involved in the establishment of biological engineering as a distinct discipline could not divorce themselves from their own engineering education paradigms and define what should be the educational requirements for a discipline of engineering broadly based upon the science of biology.

One thing I knew for sure: I had received a very broad-based agricultural engineering education at Cornell University, augmented by elective courses that supported my own interest in the emerging field of biomedical engineering. I wanted to be sure that the breadth of my education was transposed into educational breadth for budding biological engineering students. So, when I realized that no one that I knew was going to write a biology book in a way that emphasized the engineering view of science and how science is utilized in a creative way, I began to write what I thought should be included in such a text.

The way that I have found to write a text that I can be satisfied with is to teach a course on the topic. I start with a framework for material to be included in the course, and let the students assist me by letting me know what is good about the approach and, most importantly, what is missing. They are usually not shy about giving feedback.

So, this text was pieced together like ornaments on a Christmas tree, one piece at a time and placed strategically on the proper branches. When the framework was not inclusive enough to accommodate new facts, then the framework was expanded. This process continued for nine years.

During this time, I have learned a huge amount by reading a lot of books and articles. Every time I came across something that I thought should be in a book on *Biology for Engineers*, I wrote it down and placed it appropriately in the next draft. Whenever I read about a new advance in biology or engineering related to biology, I gave myself a test, and this test took the form of a question: Is this topic covered in the book? At least the fundamentals of the topic had to be introduced so that students, when they came upon more details in later readings, would have seen the basic terms and introductory concepts. I knew that I could stop writing further drafts when I could continually say to myself, after reading newer articles, that all the new topics were already included in the text. I have reached that point.

One real challenge to writing a text of this kind, in a science that is progressing as rapidly as is biology, is to keep it current. It seemed as if new biological information was being discovered faster than I could include it in my class. How could I possibly presume to write a text that wouldn't be out of date in one or two years?

I now feel more confident about that. Although there will continue to be new biological information generated, many of the fundamentals are known. The science of biology is entering a phase of technological adaptation or utilization, and many of the fundamental processes, the real surprises, have been discovered and are covered in this text. At least I hope they are. We'll see in a couple of years.

Preface for Second Edition

In an atmosphere of liberty, artists and patrons are free to think the unthinkable and create the audacious; they are free to make both horrendous mistakes and glorious celebrations.

—Ronald Reagan

A few years ago, I realized that if I ever had a chance to update this book that I would have to get going, because advances in biology and technology related to biology were happening so fast that I would never be able to catch up if I didn't start soon. So, I read, and as I read, I wrote. This edition is how those notes came together.

In particular are the many new forms of shorthand for various biotechnological terms. I have tried to include many of them in this book, because their definitions may be hard to come by once they become generally used.

I have also filled in some voids that I realized, belatedly, were present in the first edition. I believe that to be a really good engineer dealing with biological subjects one must know more about the subjects than just the topics in one's specialty. One might never know how other advances can help solve a bio-based engineering problem if one is unaware of progress made elsewhere. One problem with a book as general as this one is the fact that keeping track of all the progress being made in fields as broad as genetic editing all the way to environmentally green roofs is not an easy task, and there are, undoubtedly, important facts that have been missed herein. I also realize that there are not as many generalists in the bioengineering field as I would hope, so reading or teaching from this book may be difficult for some. That's OK; this book is meant to be an introduction or a reference: it has a little of a lot of things in it. But, further details can be found elsewhere. If this book has provided enough background so that the reader or the student knows enough about a topic to know where to look and what for, then it will have served its purpose.

In some of my essays printed in other publications, I have commented on STEM, short for Science, Technology, Engineering, and Mathematics. STEM is a popular term lately when considering studying for careers. However, as an engineer, I have a problem with the term STEM. I prefer STEAM, STEM with the addition of Arts. Engineering is part STM with the addition of subjectivity and creativity. The practice of engineering combines elements of STM with creative talent that can be fostered by studying the softer subjects. You will see some of that philosophy in the contents of this book. One cannot know everything, but having a good knowledge of where bits of information fit into the overall scheme of things is not a bad trait to have when making engineering judgments, or any judgments, for that matter.

I stand by my prediction that the basics of biology had largely been discovered by the time of the first edition, but that applications of those basics to products and processes would continue to grow. And grow they have, more and more, faster and faster, it seems. This is an exciting time to be involved with biological technology. The fun has just begun...