A Review of Texts for Biological Engineering Courses

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I. Introduction:

The field of Biological Engineering is relatively new and there exists a great need for textbooks in this area. This paper lists several of the currently available texts that Biological Engineering educators are using, in part or in whole, and also provides student reviews of these texts. This annotated bibliography can be a helpful place for instructors to find new materials and can serve as an indicator of textbook needs that have yet to be met. Biomedical engineering texts were not evaluated in this paper. Textbook reviews include educational material and features useful to the learning process.

II. List of Student Reviewed Textbooks:

Bailey, J.E. and D.F. Ollis. 1986. *Biochemical Engineering Fundamentals*, Second Edition. New York: McGraw-Hill, Inc.

Blanch, H.W. and D.S. Clark. 1997. *Biochemical Engineering*. New York: Marcel Dekker, Inc.

Doran, P.M. 1997. *Bioprocess Engineering Principles*. New York: Academic Press Limited.

Johnson, A.T. 1999. *Biological Process Engineering*. New York: John Wiley & Sons, Inc.

Shuler, M.L. and F. Kargi. 1992. *Bioprocess Engineering: Basic Concepts*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

III. Overview of Reviewed Textbooks:

1) Bailey and Ollis

Bailey is a biotechnologist, and Ollis is a chemical engineer. These authors have created a biochemical engineering text intended for use in a senior or graduate level class of chemical engineering students. Their objective is to provide information in the areas of governing biological properties, and chemical engineering methodology and strategy. Since the text is designed for chemical engineers, it has an extensive review of introductory biological concepts before progressing into more engineering-based concepts.

2) Blanch and Clark

Both authors are chemical engineers and have written this textbook of biochemical engineering intended for students in engineering and students in the applied sciences. It is assumed that students using this book have a background in biochemistry or cell biology, and does not include introductory sections covering biochemistry, microbiology, molecular or cell biology. This text was primarily designed for undergraduate and graduate courses in biochemical engineering.

3) Doran

Doran is a biotechnologist whose stated aim for this textbook is to provide an introduction to the principles of bioprocess engineering for biological scientists. Thus, the author assumes that readers have no engineering background and gives full explanations of mathematical equations and derivations. As such, it is a text that is suited to senior undergraduates or graduates in biological sciences and is useful in engineering courses introducing bioprocess engineering.

4) Johnson

Johnson is a Biological Engineer. The objective of the text is to "introduce biological engineering students to the concepts of transport processes" and to "prepare biological engineering students to design products and processes using, or to be used with, biological systems." This book provides introductory information in Biological Engineering, but also includes material suited for upper level engineering students.

5) Shuler and Kargi

Shuler is a chemical engineer and Kargi is an environmental engineer. These authors state that their aim is to introduce concepts of bioprocessing to chemical engineering students and practitioners. Consequently, this text assumes no background in any biological science and gives an introduction to cell biology, biochemistry and microbiology. This text is suited to senior and graduate students in chemical engineering and practicing engineers with limited background experience in the biological sciences.

Table 1: Comparison of broad subjects covered in each textbook (× indicates coverage of the topic in the textbook)

	Bailey and Ollis	Blanch and Clark	Doran	Johnson	Shuler and Kargi
Introduction to Engineering			×		
Mass Balances			×	×	
Energy Balances			×	×	
Fluid Flow and Mixing			×	×	
Heat Transfer	×	×	×	×	
Mass Transfer	×	×	×	×	
Downstream Processing Operations	×	×	×		×
Enzyme Kinetics	×	×	×	×	×
Cell Growth Kinetics	×	×	×	×	×
Bioreactor Design and Analysis	×	×	×		×
Introductory Biological Principles 1. Biochemistry 2. Microbiology 3. Molecular Genetics	 × × ×	 × 	 	 	 × × ×
Instrumentation and Control	×		×		×
Bioprocess Economics	×	×			
Psychrometrics				×	
Using Genetically Modified Organisms					×

Table 2 lists some features of textbooks that are perceived, by students, to be useful aids when referencing, reading, or using a text. Definitions of the terminology used in this table are defined in the pages following the table.

Table 2: A student survey of features of the textbooks (rated from 1 to 5, where 5 is high).

	Bailey and Ollis	Blanch and Clark	Doran	Johnson	Shuler and Kargi
General					
1. Organization	5	4	5	5	4
2. Emphasis of Definitions	3	3	3	5	2
3. Explanation of Key Equations	3	3	3	5	2
4. Structure	4	3	5	5	3
5. Chapter Reviews	NP	NP	3	NP	2
Readability					
1. Text	4	4	5	5	3
2. Tables	5	4	5	5	4
3. Figures	5	3	5	5	2
Accessibility					
1. Conversion Factors	1	1	5	3	1
2. Definition of Variables	2	4	5	2	2
3. Glossary	NP	NP	NP	NP	1
4. Reference Tables	2	3	5	3	1
Example Problems					
1. Organization	3	5	5	5	4
2. Explanation of Steps	3	4	4	4	3
3. Completeness of Problem Statement	1	4	4	4	4
4. Demonstration of Concepts	2	3	4	5	3
5. Presentation	1	3	5	5	3
6. Frequency	2	2	4	5	3
Real World Applications and their Use in the Text	3	4	4	5	3
Bioprocess Design	4	4	4	5	2
Synthesis of Biological and Engineering Principles	4	3	5	5	3

NP = not present

Definitions of terminology used in Table 2:

General

1. Organization –order of chapters and sub-divisions of chapters
2. Emphasis of Definitions – ease of locating important definitions within the text
3. Explanation of Key Equations – description and definitions of variables and application of equations
4. Presentation –general layout of textbook and readability of typeface
5. Chapter Reviews – availability and completeness of reviews at the end of each chapter

Readability

1. Text – ease of reading the text and style of writing
2. Tables – proximity to the appropriate text, clarity and how well the tables complemented the text
3. Figures – proximity to the appropriate text, clarity and how well the figures complemented the text

Accessibility

1. Conversion Factors – presence and accessibility of appropriate conversion factors
2. Definition of Variables – presence and accessibility of variable definitions
3. Glossary – presence and accessibility of a glossary of important terminology
4. Reference Tables – ease of locating and referencing reference tables (eg: steam tables, periodic table) required for example problems and homework problems

Example Problems

1. Organization – whether or not the problem was tackled in a logical, step-by-step manner
2. Explanation of Steps – how well each step in the solution was explained
3. Completeness of Problem Statement – clarity of problem statement and whether all the necessary information was supplied
4. Demonstration of Concepts – applicability of example problems to concepts described in the text
5. Presentation – ease with which example problems could be read and understood due to format in text
6. Frequency – frequency/number of example problems and their spacing throughout the text.

Real World Applications and their Use in the Text – frequency with which real world problems were used, in the text, to illustrate and bring important concepts to life

Bioprocess design – description and accessibility of important design equations and explanation of their use to engineer and design bioprocesses

Synthesis of Biological and Engineering Principles – how well biological and engineering principles were integrated in the text and synthesized into a holistic picture, rather than being presented individually

IV. Textbook areas of need. The Biological Engineering discipline is in need of textbooks for core courses. Courses common to Biological Engineering curricula nationwide include Introduction to the discipline, Biological Materials, Quantitative Biology in Engineering, Instrumentation applied to biological systems, and basic engineering sciences (fluid mechanics, thermodynamics, mechanics of materials) applied to biological systems. Educators often rely on course readers to provide this type of information in a cohesive fashion, but the copyright process is time consuming. Textbooks currently in press or in preparation are listed below.

In press:

Heldman, D., Editor. Encyclopedia of Agricultural and Food Engineering, Marcel Dekker, Inc.

This encyclopedia is due out in 2001 and contains three large parts in Agricultural Engineering, Food Engineering, and Biological Engineering respectively. The latter contains some thirteen chapters including subjects as follows: general Biological Engineering, physical and thermodynamic properties of biological materials, flow of biological fluids, kinetics of reactions, heat and mass transfer in biological systems, bioinstrumentation, and applications.

In preparation:

Cundiff J. S. and Mankin. K.R. Biological Systems Engineering. Simulation of biological systems, starting from simple systems and progressing to complex systems. Review of thermodynamics, psychrometrics, composting, photosynthesis, plant and growth modeling. Will be published by ASAE. Anticipated publication date: 2002.

Alocilja, E. Principles of Biosystems Engineering. Intended for sophomore level students, provides introduction to biological engineering.