

Preface

Using *Biochemistry: Essential Concepts*

Learning biochemistry is difficult for many life science students because, in essence, they are asked to learn a very complicated language, filled with many new concepts, all within a sixteen-week time frame. This “field manual” is a concise guide to biochemistry concepts and is intended as an efficient, pared-down aid to help students assimilate the key ideas. It presents a self-contained sixteen-week course, at a level that will help students proceed successfully to professional and medical school course work.

Biochemistry: Essential Concepts (BEC) has evolved over many years of teaching introductory biochemistry. In one concise volume it contains (a) a textual summary of the essential information distilled from a standard encyclopedic biochemistry textbook, and (b) relevant review questions and sample tests with answers. *BEC* thus serves as a complete and self-contained handbook, notebook, and study guide. Because *BEC* presents material in the same sequential order as most biochemistry textbooks, it may easily be used alongside another text. The content in *BEC* is intended to provide a backbone. It is not intended to replace a full textbook but, rather, through concurrent use, is designed to assist students in the learning process by presenting to them a clear, pared-down presentation of the basics together with problem-solving and review tools.

We have taught graduate- and undergraduate-level biochemistry and biophysics courses at North Carolina State University for over twenty-five years. The main challenges we have experienced are: (1) students arriving to take a biochemistry course who have not retained basic concepts from freshman and organic chemistry; and (2) the vastness of the field of biochemistry itself. Many students have relied on memorization in their previous science courses without grasping fundamental concepts such as pH, pK_a , nucleophilic attack, equilibrium, and thermodynamics. Reliance on rote memorization in a biochemistry course is a very ineffective approach and does not result in a deep understanding of more subtle aspects of biochemical processes, such as assessing the poise of a reaction equilibrium, predicting enzyme reactivity and substrate-dependent regulation. Our goals in writing *BEC* were therefore twofold:

- (1) To carefully extract and present the essential core concepts imbedded in a typical biochemistry textbook,
- (2) to reiterate in a variety of contexts those most fundamental chemical concepts that are essential to *understand* the processes of biochemistry and related biological science, not simply memorize them.

The text contains several key features:

Textbook Flexibility. The approach used in *BEC* focuses on teaching the fundamental structure of the field within a single semester time frame. It is not based on a single textbook. As a result, it is compatible

for use as a study guide with any of a wide variety of much more definitive tomes, several of which are cited in context within the text.

Integration of Concepts Into The Big Picture. *BEC* is a clear, concise guide to biochemical concepts, which is readily accessible and provides a wealth of well-chosen examples. A key strength is that one is rapidly orientated regarding a given subject, with emphasis on the big picture, and then shown how fundamental concepts become integrated to produce more complex linked processes. These lessons are reinforced by an extensive set of practice exercises and tests designed to reinforce key concepts and relationships, highlighting techniques from medicine and other biotechnological fields.

Many Real-World Applications. These notes are a map so that students can continually look at the big picture and see how the subject of the moment fits. The same fundamental principles govern many aspects of biological processes, so once students have built a set of models into their memory, they can use this knowledge to dissect some new, yet related, biological setting, predict the pertinent chemistry and sort out the processes that matter. Students can then use this kind of circumspect viewpoint to realistically understand the complexity of new situations. In the long view, this knowledge can be used to understand a process, develop new procedures, troubleshoot methodological problems, design a new pharmaceutical, and otherwise be applied to use in medicine, agriculture, and biotechnology.

A Concise, Clear Format. How does a professor decide what to keep and what to leave out when faced with a twelve-hundred-page textbook and sixteen weeks to teach the course? Current textbooks tend to be encyclopedic, requiring careful choice of the material to emphasize if one is to effectively transmit both a working knowledge of the fundamental tools of the discipline as well as their breadth and importance in medicine, materials science, genetics, cell biology, and so forth.

In the streamlined presentation of *BEC*, the focus is on concepts that govern and regulate biological processes. Those concepts include equilibrium, pK_a , K_d , K_M , pH, nucleophilic attack, the relation between bond polarity and reactivity, the enthalpic and entropic contributions to ΔG , and so forth. This emphasizes the more difficult-to-learn physical and mechanistic concepts and leaves the more digestible, qualitative and familiar biological foci for class discussion.

Reiteration of Core Concepts. The best way to show students that *the same fundamental principles govern many aspects of biological processes* is to reiterate those principles, where applicable, throughout the course in various contexts. If students grasp these core concepts, they can understand at a fundamental level the biochemical processes that underlie much of biological science.

Reiteration is built into *BEC* at several levels. For example, the concept of pK_a is reiterated a total of fourteen times: nine times in various text sections, twice in review material, and three times in the sample tests. The concept is first discussed on in the context of acid-base ionization and the relation to protonation and deprotonation. It reappears again in the context of the bicarbonate blood buffering mechanism and again a discussion of the functional groups of amino acids. It occurs twice in a table of pK_a values and in a section that defines the isoelectric point and explains how it is calculated. It appears again during the explanation of pK_a shifts at the C-terminus of amino acids on incorporation into a polypeptide, in a

discussion of the allosteric control of oxygen binding to hemoglobin, in an explanation of enzyme activity at different pH values, and in a discussion of the charge of backbone phosphates in nucleic acids. The concept occurs in several contexts in the review sessions. Sample Exam 1 makes use of the pK_a concept in a question that requires students to draw a specified oligopeptide structure and the corresponding pH titration curve. Sample Exam 1 also contains a multiple-choice question that focuses on the comparison of pK_a with pH and the partial pressure of oxygen (pO_2). The final occurrence of the concept is in the sample Final Exam in a question regarding factors that control the catalytic capability of an enzyme. Similar reiteration strategies are employed for other fundamental principles.

The material in *BEC* produces an interwoven set of reiterated ideas that shows how analogous chemical principles govern a large number of biological reactions. The intent of this reiteration is to help students retain the basics, understand how they apply to a variety of biological processes, and develop the ability to dissect new analogous situations on their own.

Reinforcement Through Review. Several review tools have been incorporated into *BEC*, complete with answers, to foster integration of the textbook material with the questions. A single volume contains a concise summary of the lecture material, the students' own class notes, and directly linked review questions and sample tests, with answers. This integrated format encourages students to work problems and think about results in a well-organized and efficient way.

The first six sets of review questions do not have an answer key *per se*, but the answers are easily located in the text of *BEC*. The expectation is that students can read the relevant portions of the text and *BEC* and use the information to answer the assigned questions. However, the material covered in review sessions 7–13 is more challenging and requires a more concept-driven approach. We've also found that students begin to feel frustration and fatigue at this stage of the course. We've therefore provided answers for each of the questions in these sections. In addition, four sample tests and a final exam are supplied with complete answer keys.

These review tools provide a completely integrated curriculum that stresses the core concepts of biochemistry and greatly facilitates student comprehension. By writing and drawing out the answers to the practice questions in *BEC*, students exercise and refine their use of the tools and language of biochemistry.