

# BIOMEDICAL & PHARMACEUTICAL SCIENCES

with Patient Care  
Correlations



EDITED BY

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I dedicate this book to my son, Kayhan, and his generation for keeping curiosity, motivation, and learning alive.

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# INTRODUCTION

As of November 2013, there were 130 colleges and schools of pharmacy with accreditation status in the United States. The Accreditation Council for Pharmacy Education (ACPE) is the only national accreditation agency that oversees pharmacy education in the United States. The curriculum of the doctor of pharmacy degree (PharmD) is offered in different paths, with two employed most frequently. The first path has a three-year curriculum with almost no summer break between two consecutive academic years. In this path the first two years' curricula are mostly didactic and the third year's curriculum is mostly experiential. The second path has a four-year curriculum where students have a break in summer between any two consecutive academic years. Regardless of the paths and curriculum, the ACPE requires that colleges and schools of pharmacy prepare graduates with a comprehensive foundation in four curricular subjects: biomedical; pharmaceutical; clinical; and social, behavioral, and administrative sciences. In addition, at least 5% of the curricular length must be assigned to deliver introductory pharmacy practice experiences (IPPE) and at least 25% of the curricular length must be assigned to deliver advanced pharmacy practice experiences (APPE). Furthermore, the ACPE requires colleges and schools of pharmacy to include in their prerequisite courses at least two years of academic study that include basic sciences, behavioral sciences, social sciences, and communication skills.

In my many years of teaching pharmacy students, I have experienced that students enter the study of pharmacy with a vast variety of prerequisite educations and competencies. There are two major reasons for such a variation. First, students have completed their prerequisite courses at different times since their graduation from their high schools/colleges and, second, students have completed their prerequisite courses at different universities/colleges with different standards of student learning. In addition, I have observed that many first year pharmacy students struggle in different areas of biomedical and pharmaceutical sciences and there is no consistent knowledge level among them. The lack of a consistent knowledge base among students often frustrates faculty, and sometimes student peers as well, as the pace of lecture delivery slows down to explain some of the material from prerequisite courses that students should have learned in the past. This process may lead to instructors being unable to deliver the intended lecture objectives in a timely manner and may produce gaps in the curriculum.

Student learning is the core mission of all colleges and schools of pharmacy in the United States. The landscape of student learning is evolving. Classroom teaching and learning is no longer the norm. Providing a conducive environment that supports active learning and critical-thinking are areas that many faculty strive to achieve. There is growing evidence that integration of didactic learning with experiential experiences assist students in becoming qualified contemporary pharmacists. In order to introduce pharmacy students to biomedical and pharmaceutical sciences and integrate their didactic learning with patient care, I decided to develop *Biomedical and Pharmaceutical Sciences with Patient Care Correlations* to introduce students to the majority of biomedical and pharmaceutical sciences. In addition, in order to provide clinical applications to enhance student learning, many clinical cases—called Learning Bridge assignments in the text—have been generated and are embedded within each chapter. The learning bridge concept was first described in the *American Journal of Pharmaceutical Education* in 2009 (volume 74, issue 3, 2010), which has subsequently proven to be a productive tool for integrating didactic learning with experiential experiences.

It is imperative to address the audience for this book and explain why it is useful for pharmacy students to study this book. First, the audience for this book is first year pharmacy students who

ideally have access to this book a few months prior to their matriculation at a PharmD program. This book is written in such a way that many figures, tables, and topics are explained in a simple way that pharmacy students can study on their own. This process will allow students to enter their PharmD programs with a high level of preparation and strong knowledge base in biomedical and pharmaceutical sciences. Second, this book can be offered to preceptors who precept pharmacy students at their experiential sites (pharmacies, clinics, hospitals, etc.). This book can help preceptors familiarize themselves with the pharmacy curriculum and may assist preceptors in invigorating their knowledge of biomedical and pharmaceutical sciences. Third, the goal for this book was not to replace the core pharmacy books. In other words, this book should be used shoulder-to-shoulder with other core books when students are in their first year of study at a PharmD program. For instance, while a faculty member is teaching a complicated topic, he/she can refer to this book in advance and ask students to study a specific topic so that the delivery of the complicated topic in classroom is facilitated.

This book delivers 16 biomedical and pharmaceutical sciences chapters and, as a result, it can be used by faculty in different disciplines. This will be of particular interest for many courses that occur during the first year (for a 3-year curriculum) and/or second year (for a 4-year curriculum) of study in PharmD programs.

This book begins with building blocks of molecules and biological chemistry that pharmacy students will encounter throughout their course of study. This chapter is followed by cell biology and important concepts in cell functions and structure, and the function of biomolecules. The third chapter discusses the basic elements of microbiology and understanding infectious diseases along with the most common existing bacterial, fungal, parasites, and viral microorganisms. The microbiology chapter is followed by a basic introduction to immunology by introducing students to innate and adaptive immunities and various types of hypersensitivities. The introduction to biochemistry chapter begins with basic thermodynamics and metabolism of carbohydrates, proteins, and fatty acids. The important physiological roles that enzymes play in biochemistry are also emphasized in the introduction to biochemistry chapter.

The introduction to pharmacodynamics chapter covers the dynamics and functions of the major signal transduction systems, and the important roles of dose–response relationships and the factors that affect pharmacologic responses. This chapter is followed by an introduction to medicinal chemistry, which describes major metabolic phases and the roles CYP450 isozymes play in drug–drug or drug–food interactions. In addition, the principles behind the structure and function of drugs are addressed in this chapter. The introduction to pharmaceuticals delivers basic physical pharmacy, reaction orders, and different dosage forms. This chapter is followed by an introduction to pharmacokinetics that introduces students to basic concepts in drug absorption, distribution, metabolism, and elimination. In addition, the importance and application of bioavailability, the volume of distribution, clearance, and half-life in pharmacokinetics are addressed in the introduction to pharmacokinetics chapter.

The introduction to pharmacology and pathophysiology chapter introduces students to the sympathetic and parasympathetic nervous systems and therapeutic agents that act through the autonomic nervous system. The pharmacology and pathophysiology associated with neurodegenerative diseases, pain, cardiovascular disease, and the respiratory and endocrine systems are addressed in this chapter as well. This chapter is followed by an introduction to toxicology, where various factors that influence drug toxicity are discussed and which provides a list of medications that are most frequently implicated in organ toxicity. The introduction to pharmacogenomics describes common types of genetic variation and how such variation influences pharmacokinetic and pharmacodynamics properties of medications.

The introduction to pharmacognosy brings to light the important roles plants play in the development and production of medications and discusses natural products that are available for common health conditions. In addition, information about safety concerns related to different natural products is discussed in this chapter. This chapter is followed by the introduction to nutrients that discusses the important roles carbohydrates, proteins, and fats play in generating daily calorie intake and the essential roles macronutrients and micronutrients play in maintaining homeostasis. The introduction to calculation introduces students to fundamental calculation skills and facilitates student learning in effectively performing calculations when preparing, dispensing, or recommending medications. The last chapter of this book discusses the important roles drug information, literature evaluation, and biostatistics play in effectively providing evidence-based pharmacotherapy to produce an optimal therapeutic outcome in a patient-care setting.

The following messages may be useful to students, faculty, and preceptors when considering using this book.

- **A message to students:** Study this book at home prior to beginning your first year and then continuously study this book to support and strengthen what you learn during the first and second years of your PharmD program.
- **A message to faculty:** Ask your students to study a pertinent chapter/topic prior to your course in order to prepare students for more complex topics within your course. In addition, direct students to relevant topics in the book during your course to support and strengthen student learning. This entire process will promote student learning and assist you in focusing your limited teaching time on the delivery of more complicated topics. A Test Bank has been provided for instructor support.
- **A message to preceptors:** Read each chapter to invigorate your knowledge base of biomedical and pharmaceutical sciences. Utilize the learning bridge assignments and ask your students to answer the corresponding questions. There is evidence-based data (please see *American Journal of Pharmaceutical Education*, volume 74, issue 3, 2010 and volume 75, issue 3, 2011) indicating that the learning bridge assignments can promote student learning and generate a productive environment for curricular discussions during IPPEs.

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