Healthcare and Biomedical Technology in the 21st Century

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An Introduction for Non-Science Majors

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Welcome

Dear Student,

Congratulations on having enrolled in this class! We don't know how you feel about engineering and science, or healthcare biotechnology in particular, but our promise to you is that everything you learn here will be useful to you for the rest of your life. It may take you more than one semester to realize that, but the moment will come.

We all know that at some point you or someone you care about will be in need of medical attention and treatment. That will be a difficult and stressful time, made so in part because you probably won't understand everything that's going on. Developments in healthcare technology are also an important contributing factor to the rising cost of healthcare in the United States, which in all likelihood will be a major economic challenge for your generation. We think that what you learn in this course will demystify some of that medical-speak for you and help you to make decisions about your own healthcare options.

We also suspect that from time to time you get involved in discussions about contemporary topics that are somewhat provocative, e.g., should the sale of high-sugar-content drinks be regulated; are genetically modified foods safe to eat. How do you argue your point in an intelligent and educated manner? How do you decide which claims make sense and which are nonsense? We're going to provide you with a framework you can use to analyze science-based arguments and develop well-informed opinions of your own.

In this book, we will introduce you to the healthcare dilemmas facing voters and political leaders everywhere and discuss what makes the scientific method so useful in arriving at decisions based on data analysis. We will expose you to the ethical questions that scientists and policy makers consider when assessing the cost and value of scientific progress, the pros and cons and ethics of performance-enhancing drugs, and how new drugs and devices are developed and approved for sale in the United States, covering topics such as animal testing, human clinical trials, and the patent system.

We will then relive the experience of a visit to a doctor and discuss the various tests and methods used to arrive at a diagnosis, explaining some of the core technologies that enable the sophisticated analytical methods used today. If you or a member of your family has ever needed a tissue or organ replaced, the chapter on implants will provide plenty of background information about the materials used, the way the human body reacts to implants, and you will read case studies that will help you realize how medical treatment decisions are made.

It's likely that someone in your family has suffered from heart disease; in the chapter on cardiovascular devices, we will explore heart anatomy and physiology, and you will learn the how and why of pacemakers, defibrillators, and artificial hearts. We will examine the clever strategies behind the development of new cancer-fighting drugs and how they are to be administered, as well as the techniques used by drug manufacturers to ensure that pills and tablets are designed to get the drug safely to its destination. Our focus on molecules will continue as we discuss the new and emerging field of tissue engineering, when biochemical cues are used to grow human tissue in the lab for eventual use as repair materials, and expose you to the promises and dangers of genetic engineering of crops and animals, and of our own cells to arm them for battle with disease.

In closing, we will describe a visit to the dentist and obtain a better understanding of the tools and procedures used to keep mouths healthy and functional, and how dentists can repair oral tissues when they are lost to decay or require adjustment for other reasons. In the last chapter, we will present an overview of the technology available to aid the disabled live as "normal" a life as possible.

At the end of each chapter, we list what we think are the most important concepts we have presented. These should be helpful to you as you reread and review the chapter and also provide topics for discussion.

We hope very much that your instructor will encourage questions and debate in class. Throughout several chapters we have highlighted questions that we hope will stimulate you to think about these timely topics. Scientists argue all the time, why shouldn't you? It's good practice to question authority and the "accepted" explanation. It will quickly become obvious who can make the stronger case, and arguments will help to clarify your thoughts.

Finally, we realize that science or engineering may not necessarily be your future chosen profession. But, if after finishing this course you leave thinking that the scientific method of rational thinking, evidence-based judgment, and peer review make a lot of sense, then do us all a favor and run for political office!

Preface

Dear Instructor,

We are delighted that you have chosen our book for your course! Let us tell you how the book came to be, and what our guiding philosophy has been during its development.

“Healthcare and Biotechnology in the 21st Century” resulted from our experiences participating in Temple University’s General Education curriculum. Every Temple undergraduate student is required to take four courses in subjects outside their major. For example, all non-science and non-engineering majors are required to take two courses in science or technology and two courses in mathematics (numerical proficiency). We decided to institute a new course covering medical technology (our own field of expertise) that would draw on basic biologic, physics, chemistry, and engineering principles, discuss the scientific method, gently underline the value of a quantitative approach to life, and introduce and explain medical technologies that our students or their family members are likely to have encountered as patients.

Our search for an appropriate textbook made us realize that one did not exist. The available biomedical texts were all written for science or engineering majors. We decided to write our own course-pack, and have been using it for several years. The opportunity eventually came along for us to devote some additional time to revising the course pack, and to compile a book on these topics. Discussions with colleagues and publishers were encouraging, and this volume is the product of a recent surge in writing and editing activity.

We want to emphasize that the book is designed for use in an undergraduate-level course taught to non-science, non-engineering majors: students who are likely to have graduated high school convinced that they would never have to take another science course again, who probably did not take more than the minimum number of science courses in high school, and many who may consider their participation in this course to be a waste of time.

In planning this book, we were fully cognizant of research indicating that students not majoring in the sciences or engineering would not profit (learn) from a

traditional science or engineering textbook. Instead, we have presented overviews of the developments in biomedical technology, attempting to engage students in scientific and critical thinking. Our reasoning is that although the specific biomedical areas we cover will develop during the students' lifetimes, learning about evidence-based argumentation, peer review, and the inquiry-driven scientific method will stand the students in good stead for many more years.

That's why we have also tried to write the book in a language these students should understand. It's not the language used to communicate with scientists via a manuscript, but students who make an effort to broaden their vocabulary should have little difficulty following the text.

The first portion of the book introduces healthcare policy and its ramifications for the future, discusses how scientists and engineers think and work, shows how science impacts daily life, reveals how medical biotechnology is regulated in the United States, provides an introduction to a few of the technologies that enable modern health care biotechnology, and ends with a description of the events that can occur during a visit to a doctor. In some of the chapters we ask questions designed to encourage student involvement; the answers are not always obvious, and do not require prior scientific knowledge, but provide an opportunity for the instructor to guide discussion according to scientific principles. Feel free to use them or come up with new ones. And yes, we do have a point of view on certain hot-button issues, and that point of view may become obvious to the reader; if you don't agree with it, there's a great opportunity for a classroom debate! We do make an effort to present some alternative views, but emphasize prevailing scientific or data-driven opinions.

That foundation sets the stage for the second portion of the book, where we focus on specific healthcare biotechnologies, with some case histories mixed in to illustrate our points. This is where students will encounter the most "science" information. We realize that each instructor will tailor the amount of material that is taught to the level of the student body. With that in mind, we will advise that portions of Sects. 7.2 and 7.4–7.7 in Chap. 7 may prove difficult for students with poor backgrounds in science and mathematics. Chapters 10 and 12 contain vocabulary that may be unfamiliar to students who have not had prior courses in biology, and the instructor may wish to devote extra time to vocabulary development. Students will need to know the meanings of the words if they are to understand the concepts being presented.

The book is lengthy, and not all the topics can be covered in depth during a typical 14–15-week semester. Feel free to pick and choose according to your interests and your student body, and good luck with the course!

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