Preface

This textbook has its origins in a course that I began developing at Union College in the mid-1980s to teach physics to life science students in a way that would interest them and show the connections of fundamental physics to modern biology and medicine. From my own research experiences and interests in biophysics, I know that almost all areas of modern life sciences integrally involve physics in both experimental techniques and in basic understanding of process or function. However, I and many colleagues with whom I have spoken have been unhappy over the years with published attempts to direct a textbook to this audience. Most such texts are watered down engineering physics books with occasional added sections on related biology topics that are easy to skip over or assign students to read on their own.

As I set out to write this textbook, I had certain definite goals in mind. I wanted to write a book that was truly directed at life science students, one that integrated modern biology, biophysics, and medical techniques into the presentation of the material. Believing in the *less is more* credo, I chose to omit certain standard topics that are usually included in texts for this audience, while expanding on topics that have more relevance to the life and biomedical sciences. From my experience teaching to these students, I also wanted a book that would be shorter and could be fully covered in a two-semester course. Although students at Union College and comparable institutions taking this introductory course have all had some calculus, only algebra and trigonometry are used in the main body of the text. At this level, I believe that calculus adds little to the understanding of the material and can detract from focusing on the basic physical ideas. However, I have sprinkled in optional boxed calculations that do use some calculus where I felt they truly added to the discussion (averaging less than one box per chapter). These "sidebars" can be omitted without any loss of continuity.

The order of topics for this text follows a more or less traditional sequence. An exception to this is the presentation of one-dimensional mechanics through forces and energy before introducing vectors and generalizing to motion in more than one dimension. This allows students to focus on the physics concepts of kinematics, forces, and energy without being distracted by the ideas of vector analysis.

Beyond the order of topics, the presentation of material is unique in that, wherever possible, themes from biology or medicine are used to present the physics material. The material speaks to life science students. Rather than optional sections at the end of occasional chapters, life science themes are plentiful and integral to the text. The role of these topics here is more fundamental, as can be gleaned from a list of some examples.

- The early introduction of diffusion as an example of motion (full section in Chapter 2).
- The early introduction of motion in a viscous fluid as an example of one-dimensional motion, development of Hooke's law and elasticity with applications to biomaterials and viscoelasticity, protein structure, and molecular dynamics calculations (all in Chapter 3).
- Discussion of centrifugation in Chapter 5.

- Examples of rotational motion kinematics of a bacteria and of a rotary motor protein, the atomic force microscope, rotational diffusion, and cell membrane dynamics (all in Chapter 7).
- A chapter (9) on viscous fluids with discussions of blood, other complex fluids, the human circulatory system, surface tension, and capillarity.
- A chapter (11) on sound with extensive discussions on the ear and on ultrasound.
- A chapter (13) with a molecular discussion of entropy, a section on Gibbs free energy, a section on biological applications of statistical thermodynamics, and a section on biological applications of nonlinear dynamics.
- Chapters (14–15) on electric forces, fields, and energy with sections on electrophoresis, macromolecular charges in solution, modern electrophoresis methods, electrostatic applications to native and synthetic macromolecules, an introduction to capacitors entirely through a discussion of cell membranes, and sections on membrane channels and electric potential mapping of the human body: heart, muscle, and brain.
- A chapter (16) on electric current and cell membranes covering circuits through membrane models: included are sections on membrane electrical currents, an overview of nerve structure and function including measurement techniques such as patch-clamping, the electrical properties of neurons, and a second section on membrane channels with a discussion of single-channel recording.
- Chapters on electromagnetic induction and waves (18–19) that include discussion of MEG (magnetoencephalography) using SQUIDs, an entire section on NMR, and sections on magnetic resonance imaging, laser tweezers, the quantum theory of radiation concepts (revisited later), and the interaction of radiation with matter, the last a primer on spectroscopy, including absorption spectroscopy, scattering, and fluorescence.
- Four chapters (20–23) on optics include a section on optical fibers and their applications in medicine, a section on the human eye, sections on the new light microscopies (dark field, fluorescence, phase contrast, DIC, confocal and multiphoton methods), discussion of polarization in biology, including birefringence and dichroism techniques, and sections on the transmission electron microscope, scanning EM and scanning transmission EM, and x-rays and computed tomography (CT) methods.
- Three chapters (24–26) on modern physics (many of these ideas have been introduced and used throughout the book) include discussions of the scanning tunneling microscope, a section on the laser and its applications in biology and medicine, including holography. The chapter on nuclear physics and medical applications (26) includes sections on dosimetry and biological effects of radiation, radioisotopes, and nuclear medicine, and the medical imaging methods SPECT (single photon emission computer tomography) and PET (positron emission tomography).

As mentioned above, we've chosen to omit some standard topics that are either not central to the life science themes or that students find very opaque. Omitted are such topics as Kepler's laws, heat engines, induction and LR/LRC circuits, AC circuits, special relativity kinematics, particle physics, and astrophysics; Gauss's law and Ampere's law are presented in optional sections at the end of appropriate chapters.

Each chapter contains three types of learning aides for the student: open-ended questions, multiple-choice questions, and quantitative problems. In about 60 of these per chapter, we have tried to include a wide selection related to the life sciences. Complete solutions to all of the multiple choice and other problems are available to instructors. There are also a number of worked examples in the chapters, averaging over six per chapter, and about 900 photos and line drawings to illustrate concepts in the text, with many in full color.

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