Preface: Why Read This Book?

Physics and physicists can make important new discoveries in the biological sciences using quantitative approaches to systems that are often considered purely phenomenologically. Revolutions in quantitative biology promise to provide first-principles descriptions of phenomena such as protein folding and consciousness; advances in instrumentation hope to offer individual genomic sequencing in minutes. Because of these and myriad other new frontiers, more and more physics students are switching to the life sciences, or doing "real physics" using a biomolecule. Universities worldwide are creating interdisciplinary programs in biomedical engineering, biophysics, life sciences, and technology, and other crossover fields. Unlike in the well-established hard sciences, though, there is no agreement among any of these students or programs about what a "biophysicist" needs to know. A completely thorough undergraduate program in biology and physics would include all of the curriculum of each and take at least six years to complete—and that is without adding engineering, physiology, or medicine into the mix.

Getting started is often the greatest barrier. The biological literature is filled with acronyms, terminology, jargon, and references to kits and reagents with obscure or trade names. Many physical scientists entering the field are initially overwhelmed with vocabulary and are then left wondering which of the procedures described in an article are easy to master and which require highly specialized equipment or expertise. There is often little agreement among papers from different laboratories as to the best or easiest way to perform the same experiment. It is too easy to spend years trying technique after technique, and to waste thousands of dollars on unnecessary tests or reagents that may not even be the best choices for the experiment at hand.

This book arose after four years of teaching an introductory lab course designed to help physicists, chemists, and engineers work with biology, and in supervising a research lab where students come from every type of background from psychology to electrical engineering to physics to math. It is designed to help those who understand science, research, and a bit of basic physics get their hands wet (literally) in a biology lab, both conceptually and practically. The first chapter introduces and reviews the basic biology, chemistry, and physics needed in molecular biophysics, with references to books and articles for more in-depth treatment for those who need more. It then summarizes the types of experiments this book is designed to assist, with a guide to designing a molecular cloning experiment with different downstream goals.

The later chapters are designed to be highly practical. The concepts and vocabulary are introduced but not explained in detail; such knowledge can be obtained from basic introductory texts on the appropriate subject, which are referenced at the end of each chapter. Instead, I outline the key techniques and provide protocols for some straightforward yet potentially tricky experiments. Nearly all of the emphasized techniques are ones that I have performed for many years, or are contributed by other experts in related fields who can provide their insight into the perils and pitfalls of a given approach. When a technique is new or untested and I haven't tried it, I say so, especially when it is in an area where physicists may wish to contribute.

The first half of each chapter is designed to give the reader an idea of how to get started—where to go for reagents, what instrumentation is needed, and under which circumstances the basic techniques will work. An example is given of a straightforward experiment and how to proceed from start to finish. For many experiments, this will be sufficient to do everything that is needed. But for those who want to delve into truly complex biology or biochemistry, the later sections discuss some more difficult problems and approaches, with hints for when these techniques are necessary and when they are overkill.

Terms given in **boldface** are defined in the glossary, with the assumption that the reader is already familiar with technical terms from physics and mathematics. Each chapter is followed by recommended reading, resources, and sample problems.

The inspiration for this practical approach is that a lot of biology is easy to do and hard to do right. Gene cloning involves a good deal of manipulating small tubes of clear liquid with no way of knowing you have the right thing until the very end. Cell culture looks easy until the cells grow mold, die mysteriously, or turn out to express a gene that ruins the experiment. Part of becoming an expert in the techniques is learning to troubleshoot and figuring out at which step things usually go wrong. In the text and protocols, I give hints for making sure things are progressing correctly, based on experience, and often with pictures to show how things should and shouldn't look.

The field is vast and swiftly changing, and this book certainly can't pretend to cover it all. The idea is that after consulting it, any physical scientist should feel comfortable buying a biological reagent and using it, or consulting an expert for help when needed. Many of the reagents described here are only available from the private labs that created them, and part of learning biology is to communicate with biologists to obtain reagents, share results, and design experiments. The first step is to learn the language, the second is to get wet, and the third is to realize when new advances are needed and to adopt or implement them.

Happy cloning!

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The MathWorks, Inc.
3 Apple Hill Drive
Natick, MA, 01760-2098 USA
Tel: 508-647-7000
Fax: 508-647-7001
E-mail: info@mathworks.com
Web: www.mathworks.com