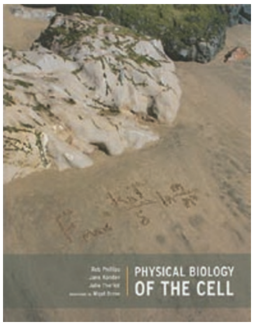
Physical Matryoshka of cell biology



Physical Biology of the Cell

Edited by Rob Phillips, Jane Kondev and Julie Theriot

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Reviewed by Patricia Bassereau and Pierre Nassoy

In contrast to the tremendous complexity that characterizes biology, physics attempts to describe nature with simple, yet universal laws. Despite the current popularity of interdisciplinary biophysical projects, the different approaches and language of the two disciplines still present many barriers. With backgrounds in physics, mathematics and biology, respectively, the authors of *Physical Biology of the Cell* have produced one of the first multi-purpose textbooks that is readily accessible to both physicists and biologists.

The structure of the book differs markedly from classical cell biology textbooks. Topics are organized like a collection of matryoshka, or Russian dolls, centered on ten physical concepts that the authors argue are sufficient to grasp the essence of many biological issues. Each physical concept, including continuum mechanics, statistical physics and electrostatics, is explained simply and concisely, before being applied to a range of biological examples that may seem entirely unrelated to each other at first glance. For instance, the structure of proteins, shape of membranes and conformations of DNA are all discussed within the space of four pages.

This 'matryoshka-type' organization also allows the book to be read at several levels. While the book should be readily accessible to graduate or undergraduate students in biology or physics, it also provides interesting material for experienced scientists starting a new topic of research. Biologists may be especially interested in the many quantitative descriptions and estimates of biological processes that have often just been described qualitatively as 'fast', 'long' or 'strong'. Meanwhile, physicists may find the book a good way to learn about current biological questions in a concise and accessible form. When read from cover to cover, the book is both very instructive and highly entertaining with the authors using humour to deliver strong take-home messages in each chapter. Furthermore, despite the unusual ordering of topics, the book should also serve as an effective reference.

R. Phillips, J. Kondev and J. Theriot have divided the book into twenty chapters grouped in four parts, starting with *The facts of life*, which introduces the different systems and problems explored in the book. The book starts with a presentation of the different tools used by biologists and physicists. On the side of the biologists, haemoglobin, bacteriophage, *E. coli*, yeast, the fly and the giant squid are presented as model systems. Interestingly, throughout the text the *lac* operon is used as a leitmotif to illustrate genetic networks, looping in DNA and electrostatic effects. Similarly, DNA is considered as a sequence of nucleic acid, a polymer with particular electrostatic, condensing and mechanical properties, and the foundation of biological networks.

The authors next consider *Life at rest* using basic concepts of statistical physics, thermodynamics and soft matter to describe the major elements of the cell, then dynamical aspects in *Life in motion* with a special focus on molecular motors and action potential, before finishing with a closer look at information, signalling and networks in biology. In each chapter, the presentation of a biological question is immediately followed by its physical modeling and possible quantitative estimates. As mentioned earlier, the physics toolbox consists of ten basic physics concepts. Using these, the authors are able to present equations in full detail without descending into mathematical abstraction. Whenever possible, experimental results are given to support these concepts. By the end of the book, both biological systems and statistical physics concepts should be familiar friends to the reader.

Physics is not only about models but also about numbers, and this is why the authors have carefully and systematically added an *Estimate* section after each proposed model. One of the most important points of the book is that models (physical or otherwise) must be quantitatively compared to observations. The authors argue strongly for the need for more quantitative biology, which in turn will require more biologists to receive a thorough training in physics and overcome any allergies to equations. The present book should contribute to this goal as it shows how a few simple, but nevertheless powerful, physical tools provide deep biological insights. Similarly, physicists and chemists have to learn more about life sciences. This reciprocal broadening of education should promote a common language and understanding in the scientific community. This book may help more physicists develop a taste for biology and interest more biologists in order of magnitude estimates and quantitative biology. On the basis of the long list of biological problems covered in this book, the connection between these two opposite approaches is now well established. *Physical Biology of the Cell* provides instructors with excellent material to create a graduate level course in biology or physics. The book is also very timely as it presents the most recent views in cell biology. The references, particularly those in the interesting *Further reading* section, are almost all for papers or books written within the last decade.

As physicists, we strongly agreed with the message of the authors, but will this be the case for our biologist colleagues? We will know for sure if blackboards in biology departments, like the sand on the book cover, are soon covered in equations!

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