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Bioluminescence and Fluorescence
for In Vivo Imaging

Lubov Brovko

Tutorial Texts in Optical Engineering
Volume TT91

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Introduction to the Series

Since its inception in 1989, the Tutorial Texts (TT) series has grown to more than 85 titles covering many diverse fields of science and engineering. The initial idea for the series was to make material presented in SPIE short courses available to those who could not attend and to provide a reference text for those who could. Thus, many of the texts in this series are generated by augmenting course notes with descriptive text that further illuminates the subject. In this way, the TT becomes an excellent stand-alone reference that finds a much wider audience than only short course attendees.

Tutorial Texts have grown in popularity and in the scope of material covered since 1989. They no longer necessarily stem from short courses; rather, they are often generated independently by experts in the field. They are popular because they provide a ready reference to those wishing to learn about emerging technologies or the latest information within their field. The topics within the series have grown from the initial areas of geometrical optics, optical detectors, and image processing to include the emerging fields of nanotechnology, biomedical optics, fiber optics, and laser technologies. Authors contributing to the TT series are instructed to provide introductory material so that those new to the field may use the book as a starting point to get a basic grasp of the material. It is hoped that some readers may develop sufficient interest to take a short course by the author or pursue further research in more advanced books to delve deeper into the subject.

The books in this series are distinguished from other technical monographs and textbooks in the way in which the material is presented. In keeping with the tutorial nature of the series, there is an emphasis on the use of graphical and illustrative material to better elucidate basic and advanced concepts. There is also heavy use of tabular reference data and numerous examples to further explain the concepts presented. The publishing time for the books is kept to a minimum so that the books will be as timely and up-to-date as possible. Furthermore, these introductory books are competitively priced compared to more traditional books on the same subject.

When a proposal for a text is received, each proposal is evaluated to determine the relevance of the proposed topic. This initial reviewing process has been very helpful to authors in identifying, early in the writing process, the need for additional material or other changes in approach that would serve to strengthen the text. Once a manuscript is completed, it is peer reviewed to ensure that chapters communicate accurately the essential ingredients of the science and technologies under discussion.

It is my goal to maintain the style and quality of books in the series and to further expand the topic areas to include new emerging fields as they become of interest to our reading audience.

James A. Harrington
Rutgers University
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Preface

Bioluminescence methods are gaining more and more attention among scientists due to their sensitivity, selectivity, and simplicity, along with the fact that bioluminescence can be monitored both in vitro and in vivo. Since the discovery of bioluminescence in the 18th century, enzymes involved in the bioluminescence process have been isolated and cloned. The bioluminescent reactions in several different organisms have also been fully characterized and used as reporters in a wide variety of biochemical assays. Discovery of green fluorescent protein (GFP) in 1961 initiated extensive research in the area of the naturally fluorescent proteins. As a result, Martin Chalfie, Osamu Shimomura and Roger Y. Tsien share the 2008 Nobel Prize in Chemistry for the work on the discovery of GFP and its application as a tagging tool in bioscience.

From the 1990s it became clear that luminescence can be detected and quantified directly from inside a living cell and, in some cases, from a whole living small animal. This gave rise to numerous possibilities for the in vivo monitoring of intracellular processes non-invasively using bioluminescent molecules and fluorescent proteins as reporters. The number of publications related to bioluminescence and GFP-based in vivo imaging has increased exponentially during recent years, indicating the huge interest and great potential of this technique.

Basics of bioluminescence and fluorescence systems are introduced and explained in the book, together with the principles of their application for in vivo imaging of intracellular processes. This book describes recent developments in optical (bioluminescence and fluorescence) imaging in the area of cell biology. Newly developed imaging methods allow transcriptional/translational regulation, signal transduction, protein–protein interaction, oncogenic transformation, cell and protein trafficking, as well as target drug action that can be monitored in vivo in real time with high temporal and spatial resolution, all providing researchers with priceless information on cellular functions in a timely and cost-effective fashion. Advantages and limitations of these novel luminescent methods are discussed, and possible future developments identified.

This book is intended for scientists and students involved in basic cell physiology research, for industry professionals, engineers, and managers involved in drug discovery and preclinical drug development. It will discuss the practical aspects of luminescence in vivo imaging for monitoring of intracellular processes. While some basic knowledge of biochemistry and biophysics is preferable, the book will include a brief review of fundamental principles that will allow people not familiar with these disciplines to grasp basic concepts.

Lubov Brovko
November 2010