Book Review

Laser Manipulation of Cells and Tissues (Volume 82, Methods in Cell Biology)

Michael W. Berns and Karl Otto Greulich, 768 pages +xviii, ISBN: 978-0-12-370648–5, illus., index, Academic Press, San Diego (2007), $149.00, hardcover.

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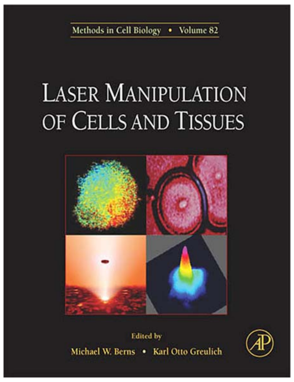


Laser Manipulation of Cells and Tissues (hereafter called *Laser Manipulation*) is a treasure for the reader. Michael Berns, who is one of the editors (Karl Otto Greulich is the other editor), became fascinated with the use of laser microbeams to manipulate cells and tissues during his doctoral research in 1964. His curiosity and interest in this field did not subside. Indeed, from his graduate work until today, he and his students and colleagues have continued to work in this area—predominately at the Beckman Laser Institute at the Department of Biomedical Engineering at the University of California, Irvine, and more recently at the Department of Biological Engineering at the University of California, San Diego. We are fortunate to have him present an introductory overview to the field that he augmented with his early seminal *Science* paper (1981).

The real beginning of the field of using light and mechanical micromanipulation in cytology is portrayed in a chapter that is at the end of the book. Greulich, Khodjakov, Vogt, and Berns authored a brilliant historical tribute to Sergej Stepanovich Tschachotin, the experimental cytologist and political critic who lived from 1883 to 1973. Tschachotin is credited with several seminal inventions for cell physiology: the 'micro-operator' for performing microsurgery on individual cells, microperfusion techniques with laminar flow around cells on the microscope stage, and a technique to fix an individual cell on the microscope stage. When he realized that perhaps light could be used for the micromanipulation and microsurgery of cells and cell organelles, Tschachotin in 1912 constructed the first instruments for microirradiation of cells and cell organelles with ultraviolet light. While he probably never used lasers in his cell irradiation experiments, it is likely that between 1934 and 1955 Tschachotin had a great influence on the use of microbeam irradiation by the French scientists with whom he worked and communicated.

From that time until 1958, when Tschachotin was 75 years old and he returned to Russia, he worked in many countries in Europe. This nomadic researcher was driven from country to country for his political activism. He first worked in Italy (Genoa) in 1927, then in Germany (Heidelberg) until 1933, when he was displaced from the Kaiser Wilhelm Institute (Berlin) due to his activities against the Nazis, then in Paris from 1934 to 1955. So you may ask, why was this scientist peripatetic? As was the case for many scientists, who were political critics and publicly expressed their political opinions, there were severe consequences: sometimes jail, sometimes forced exile, and sometimes death in a concentration camp. In 1940 in Paris, Tschachotin published a political work (*The Rape of the Masses: The Psychology of Totalitarian Political Propaganda*, George Routledge and Sons, London, translated from the French). It is appropriate to honor Tschachotin for his lifelong contributions to the topics of this book.

I now return to the beginning of *Laser Manipulation* and to Berns' chapter and his early reprint; they provide an insight to the history of laser scissors (microbeams). I recommend to the readers of the *Journal of Biomedical Optics* (JBO) a short book on microirradiation that Berns wrote 34 years ago (*Biological Microirradiation: Classical and Laser Sources*, Prentice Hall, New York, 1974); then, they can appreciate the progress made in this field. In his overview of the history of laser scissors or laser microbeams, Berns provides a concise historical review. Interestingly, in 1962, which is only two years after Theodorre Maiman invented the ruby laser, Marcel Bessi, G. Nomarski, and coworkers in Paris developed the first laser microbeam based on the ruby laser. With the development of each new type of laser, a wider range of wavelengths and pulse durations became available and these light sources were attached to microscopes to provide microbeam irradiation of cells and tissues. The author rightly points out that the technical advances in the 1970s are based on the development of various dichroic interference filters with optical coatings that resisted laser damage. There followed a proliferation of microbeam studies on cells that impacted all areas of cell and developmental biology, molecular biology, cell physiology, cancer biology, pathology, stem cell biology, and medicine. The reader is treated to an example of this new technique in cell biology with the reprinted paper from Berns group in 1981 (Berns et al., Laser Microsurgery in Cell and Developmental Biology, *Science*, **213**, 505−512, 1981). In 1987, Arthur Ashkin invented optical tweezers and provided another critical tool to biologists (Ashkin, *Optical Trapping and Manipulation of Neutral Particles Using Lasers: A Reprint Volume With Commentaries*, World Scientific, 2006).

The editors of *Laser Manipulation* begin their preface with the following quote: "Both of us are so excited about the combination of optical and molecular tools that are now available that we wish we were just starting our research careers.

We feel that this excitement must be conveyed to both young and 'seasoned' researchers...." Their excitement about the field of laser manipulation is certainly evident throughout the book. *Laser Manipulation* is Volume 82 in the Methods in Cell Biology series edited by Leslie Wilson and Paul Matsudaira. The word 'Methods' in the title of the series points to the intended audience. This book is a practical reference for "...both young and 'seasoned' researchers...." As a methods book it is replete with clearly written technical descriptions of both the instrumentation and the necessary technical details to permit the novice to succeed in the replication of these techniques. The technical descriptions are sufficiently detailed so that the methods can be replicated.

What is not clear is if the technical descriptions in the book are of sufficient detail to enable a researcher to build and calibrate an optical trap. I think that the inclusion of a more complete and comprehensive description would be extremely valuable to those readers who wish to construct their own optical traps. An extended chapter that describes the actual performance of a home-built optical trap, the calibration curves, and a critical discussion of the breath of the optical trapping technique would be a valuable addition to the present book.

In addition, the chapters provide many experimental results as well as microscopic images of laser manipulation of cells and tissues. Each chapter contains a judicious selection of references that serve to support and extend the text of each chapter.

I now address the scope of *Laser Manipulation*. In the first part of the book each editor presents their review of the history of laser scissors (microbeams) and a review of laser scissors and tweezers. The addition of a chapter that surveys the many laser-based techniques in cell biology points the reader to the many important optical techniques that are not included within the topics of laser scissors and tweezers. The second part of the book is related to the question: how does laser manipulation work? The reader will discover the physics behind the laser tissue interactions as well as the physics of optical tweezers.

The important topics of laser scissors and ablation are the subject of the third part. These subjects comprise the majority of the book and correspond to the research interests of the editors. Some of the topics included in this section are: cellular laserfection, techniques applied to *in vitro* fertilization, optical torques on microscopic objects, and the manipulation of plant sex chromosomes. Laser catapulting and capture describe many of these technologies that have provided commercially available tools for cell biologists.

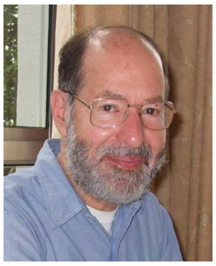
I now will describe some general features and specific chapters of *Laser Manipulation* that serve to illustrate the clear and comprehensive nature of the contributions. Since many of the chapters describe commercial instruments, it is appropriate to note in the acknowledgments the following statements: "The author has no financial or proprietary interest in any of the procedures or devices used in this chapter," or "The authors declare that they have no competing financial interests." I applaud the editors for their implementation of this policy of financial disclosure that should be standard for all publications (including those in JBO).

The early astronomers observed that the tails of comets are oriented away from the sun and they produced graphical accounts in their books that preserved their observations. In 1619, Kepler made similar observations and recorded them. These accounts may be the first to show the mechanical effects of light. More recently, the invention of the Crookes radiometer by Sir William Crookes in 1913 provided an interesting machine that seemed to demonstrate the conversion of sunlight into rotatory motion. Crookes explained the mechanism of the rotation of the vanes in his radiometer as a demonstration of the pressure of the incident light. Over the years, physicists attempted to provide alternative explanations, e.g., differential thermal effects on the vanes of the Crookes radiometer. Some physicists believe that the complete physical explanation of the Crookes radiometer is still a work in progress.

The physics of optical tweezers is not trivial and it is certainly not completely understood by the multitudes of researchers who use optical tweezers in their daily research. I strongly recommend that readers study the previously mentioned book that consists of commentaries and reprints written by Authur Askin, the inventor of optical trapping.

A group of researchers from the Centre for Biophotonics and Laser Science at the University of Queensland, Australia, contributed a chapter on the physics of optical tweezers. It is known that energy, linear and angular momentum, can be transferred from light to a particle. How can the transfer of optical torque be used to induce particle rotation? How do gradients of the electromagnetic field result in optical traps? What are the consequences of modeling the trapped particles as spherical, homogeneous, and optically isotropic? Finally, what occurs in highly focused light beams; i.e., in optical trapping microscopes with high-numerical-aperture objectives? How do these transfers occur and what are their consequences? First, the chapter authors provide a qualitative picture of the phenomenon. Second, they provide the electromagnetic theory with the simplifying assumption: they assume plane waves. Third, they provide a more correct theory and present their computational methods to model optical tweezers. Since this is such a widely used technique in so many areas of cell biology, it would be preferable to have a chapter in *Laser Manipulation* that provides the reader with a complete physical and mathematical description of optical tweezers. While such a chapter could be designated as an advanced chapter, it would provide a review of our state-of-the-art understanding of optical tweezers or traps.

What *Laser Manipulation* demonstrates is the imagination of the scientists and engineers who have taken the principles of microbeam irradiation and manipulation and developed tools that are extremely useful to a wide variety of biologists. The editors had to make difficult choices in the topics to be included in their book. Perusal of *Laser Manipulation* demonstrates a wide range of applications; all of the contributors are to be congratulated for the clarity of their presentations. Each chapter contains black-and-white figures; however, there is a color insert that contains many of the figures in full color. An index is provided for the reader to easily locate specific terms and applications. I highly recommend *Laser Manipulation* as a book that is practical, comprehensive, current, and of course very exciting.



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