Laser Therapy in Veterinary Medicine
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Photobiomodulation

Edited by

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To my family. Cynthia for her love, tireless support, and understanding; to my parents, children, and grandchildren, without whom my life would be empty and without inspiration.

To Dr. John C. Godbold Jr., my co-editor. Without his efforts, guidance, and wisdom, the completion and the comprehensive scope of this text would not have been possible.

To all of the contributing authors of this text. Their collaboration will benefit both our profession and our patients.

To Drs. Bryan Pryor and Sean Wang. The knowledge, insight, and opportunities they have provided have allowed me to pursue this paradigm in both the veterinary and the medical fields.

To all of my clients, who have given me the honor of allowing me to work on their animals, and to all of my patients, who have provided me a life of daily education.

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To all of the contributing authors of this text. Thank you. You made this happen.

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To George V. Kenmore, DVM and Louis Charles “Bud” Cardinal, Jr., DVM. For as long as I can remember, I wanted to be like you.

To all who have helped me learn about laser technologies. You transformed my career and led me on a new journey.

To all of my patients. Regardless of the direction, the journey has always been about you.

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About the Editors

Ronald J. Riegel, DVM

Ronald J. Riegel, DVM purchased his first therapy laser in 1979. It was a 1 mW HeNe laser. Throughout the 1980’s and 90’s, he observed the changes in technology, with power outputs reaching 500 mW. Laser therapy was always employed in his practice. In 2009, he co-founded the American Institute of Medical Laser Applications (AIMLA) to provide education on all types of medical laser in both the veterinary and the health care professions. His background in laser technology and applications encompasses not only companion, equine, and exotic animals, but also the human fields of non-pharmaceutical pain management, chiropractic, physical therapy, and sports medicine.

Since selling his multi-doctor private veterinary practice, he has authored more than 20 research papers, book chapters, professional articles, and books. His veterinary books include the subjects of anatomy (Illustrated Atlas of Clinical Equine Anatomy and Common Disorders of the Horse, Volumes I and II), utilizing physical therapy modalities (Helping Horses Heal), canine nutrition (From Bones to Biscuits), and laser therapy (Laser Therapy for the Equine Athlete and Laser Therapy in the Companion Animal Practice). The Illustrated Atlas of Clinical Equine Anatomy and Common Disorders of the Horse, Volume I won the Benjamin Franklin Award for Education/Teaching/Academic Textbooks in 1999. He co-authored the human laser therapy text Clinical Overview and Applications of Class IV Therapy Lasers.

Dr. Riegel has spent the last decade lecturing nationally and internationally to human and veterinary health care professions. In the last 3 years, he has spoken in over 78 national, regional, state, and local venues.

He has been a Fellow of the American Society for Laser Medicine & Surgery (ASLMS) since 2012, is a Board Member of the Optical Society, and is a member of the North American Association for Laser Therapy (NAALT), the World Association for Laser Therapy (WALT), and the American Academy of Thermology (AAT).

John C. Godbold, Jr., DVM
John C. Godbold, Jr., DVM graduated with honors from Auburn University School of Veterinary Medicine in 1978. In 1980, he established Stonehaven Park Veterinary Hospital in Jackson, Tennessee, where he practiced full time as a solo small-animal practitioner for 33 years. Dr. Godbold currently works full time with Stonehaven Veterinary Consulting teaching and assisting colleagues as a consultant for laser surgery and laser therapy.

Since 1999, Dr. Godbold has pursued a special interest in surgical lasers and the use of other laser modalities in small-animal practice. He has extensive experience with surgical and therapeutic lasers, has developed new surgical and therapeutic techniques, and assists equipment manufacturers with the development of new laser and laser-associated technologies.

Dr. Godbold has published numerous papers, articles, and chapters about the use of lasers in small-animal practice. His publications have appeared in the Journal of the American Veterinary Medical Association, Clinician's Brief, Laserpoints, The Feline Patient, The Integrative Veterinary Care Journal, and the Newsletter of the Veterinary Surgical Laser Society. He is a member of the Medical Advisory Board of the American Institute of Medical Laser Applications (AIMLA), the Companion Therapy Laser Veterinary Advisory Board, and the American Society for Laser Medicine & Surgery (ASLMS).


In high demand as a continuing-education speaker, Dr. Godbold has led over 500 laser workshops, wet-labs, and continuing-education meetings throughout North America and in over 21 countries around the world.
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Foreword

Meet Dixie! Dixie is not only a cat who thinks she is dog and enjoys sitting on her hind legs like a meerkat but also embodies how a good veterinarian can have a direct influence on the happiness and well-being of a whole family. I adopted Dixie from my veterinarian. She was rescued from the woods as a lone, tiny kitten, and was living at his practice.

Besides sharing a love for Dixie, my veterinarian and I also shared our interest in the use of light as a therapeutic tool. He had recently acquired a laser and was introducing it into his practice. However, as is typical for the majority of veterinarians who are now using photobiomodulation therapy (PBMT), he had questions on the appropriate device and treatment parameters to be used for different conditions. He attended a number of classes on the use of lasers and other light sources in veterinary practice, but these were often manufacture-sponsored and did not present a non-biased global view.

This book fulfills this need with guidelines for effective use of laser therapy in many clinical applications in various veterinary specialties. For that reason and many others, I am honored and delighted to write this foreword. For the last 25 years, I have been involved in the development of PBMT at the basic science and translational pre-clinical levels. My research has resulted in over 50 peer-reviewed publications on light interaction with cells and tissues, and in three patents.

As the field of photonic medicine matured, veterinarians were on the forefront of adopting laser therapy into their clinical practices. The acceptance of PBMT by veterinarians and their eagerness to learn about its clinical benefits and mechanistic basis afforded me the opportunity to meet and interact with this incredible group of clinicians. The first conference I attended devoted to the use of PBMT in veterinary care was held at Colorado State University College of Veterinary Medicine and Biomedical Sciences in 2010. The veterinarians I had the pleasure to meet at that conference and at other venues impressed me with their concern for their patients, love of animals, intelligence and thoughtful questioning, and their desire to adopt new promising therapies that could help their patients.

Two of the remarkable veterinarians that I had the pleasure to meet were John C. Godbold, Jr. and Ronald J. Riegel. John and Ron, co-editors and chapter contributors for this book, were early adopters of laser technology. They have years of experience with clinical applications of laser therapy and have successfully used this technology to treat companion, equine, and exotic animals. They are active members of a number of veterinary and laser societies. To educate their colleagues and dispel the prevalent myths about laser technology, John and Ron collectively have presented, nationally and internationally, over 700 laser workshops, wet-labs, and continuing-education meetings. They are experienced authors and editors and have amassed an impressive list of
national and international scientists and veterinarians from research, academia, industry, specialty practices, and general practice as chapter contributors.

This book represents a reputable source of information about laser therapy that is applicable to the diverse group of practitioners representing the veterinary community. The chapters on the history, theory, and science of laser therapy are clearly presented and serve to establish the credibility of this therapy. Furthermore, the chapters on clinical applications make this book a practical and usable clinical reference that will help practitioners use the technology effectively and therefore help their patients. It contains practical guidelines about treatment and safety and a thorough presentation of clinical applications in companion, equine, exotic, zoological, food-animal, rehabilitation, and regenerative-medicine specialties.

Another outstanding feature of the book is that it is non-commercial. Company names and logos were not allowed and the text describes treatment procedures and protocols in generic, non-commercially-specific ways. Hopefully, this book will counter some of the misinformation that has been presented in the veterinary market place.

Finally, the book supports trans-species application of research and clinical evidence and encourages veterinarians to use laser therapy in their practice by applying the basic concepts and knowledge to multiple species. I envision that this trans-species approach will provide important knowledge that will benefit a wide range of animals and inform pre-clinical research for translation of effective laser therapy to the human species. I sincerely believe that this book will prove to be an important, game-changing text for the veterinary community and will lead the way in establishing guidelines on the effective use of PBMT in many applications of veterinary care. I look forward not only to Dixie benefiting from the knowledge imparted in this book but also to the development of effective PBMT for the human members of her family.

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Parallel backgrounds led us to produce this much-needed resource on the use of lasers for therapeutic purposes in veterinary medicine. The initial focus of our independent careers was in private practice. While practicing, we developed interests in lasers and their use in practice, and became passionate about laser technology.

Our interests and passions gave us opportunities to work with those developing and supplying laser technology to veterinary medicine, and stimulated us to share knowledge and experience with colleagues through training and continuing education. We have both enjoyed working with colleagues all over the world, advancing knowledge about how to use laser technology to help patients.

Years of sharing information about therapeutic lasers and the clinical application of photobiomodulation (PBM) made us realize this textbook was needed. Our goal was to produce a reputable source of information to promote the application of photobiomodulation therapy (PBMT), help colleagues use the technology more effectively, and, in the end, help improve the quality of life of patients.

We recognized that we live in a world of rapid digital communication, filled with bullet-point information and often-confusing claims by therapeutic laser equipment vendors. The hundreds of questions colleagues ask about laser therapy require more than bullet points, and they should be answered in one place. The science and evidence should be gathered together, and should be more complete than glossy marketing claims. The shared clinical experience of thousands of practitioners, in a diversity of practice settings, should be available in one resource. This book is that place, that gathering together, and that resource.

The book was designed to be applicable to a diverse group. We understood that as the first complete publication about PBMT in veterinary medicine, it needed to be well grounded in science, yet practical and usable for clinical reference. Thus, the content covers a spectrum of background theory and science. It contains practical guidelines about treatment and safety. It contains a thorough presentation of clinical applications in companion, equine, exotic, zoological, food-animal, rehabilitation, and regenerative-medicine practice, and several chapters on integration and economics.

To give such a broad presentation required engaging a diverse, well-qualified group of contributing authors from research, academia, industry, specialty practice, and general practice. We have brought the depth of knowledge of colleagues from academia and research, and of those with specialty practice credentials, together with the practical experience of Main Street practitioners.

Contributing authors have been required to reference their chapters heavily. We recognize that in order to help the credibility of PBMT in veterinary medicine, the evidence for its use must be overwhelming. We recognize the importance of trans-species application of research and clinical evidence. The contributing authors were encouraged to facilitate what veterinarians do every day in practice: apply basic concepts and knowledge to multiple species.

As editors, we have ensured that this resource is broad-based and represents the different approaches that have historically been used to deliver PBMT. It is not specific to any therapy laser equipment, and does not have any commercial bias. The techniques described by the contributing authors reflect their experience and the success they have had with them, using a wide variety of therapeutic laser devices.

Throughout the chapters (and even in the book's title and subtitle), there is mixed use of terminology to label the technology. This reflects the current shift from the use of multiple descriptive terms for laser therapy to the use of the more accurate term “photobiomodulation therapy.” The contributing authors use the terms “laser therapy” and “photobiomodulation therapy” interchangeably. Older, less descriptive terms such as “low-level laser therapy” and “cold laser therapy” have been avoided except where used in a historical context.

We have tried, where possible, to standardize the format of dose recommendations. We understand that the historical variation in the way treatment parameters and doses have been reported has been a challenge in the clinical treatment of patients. To facilitate the application of recommendations in as many different therapeutic laser devices as possible, most doses are given as joules...
per square centimeter (J/cm²). In the very few instances where doses are reported using other parameters, the editors recommend consulting the general guidelines and recommendations in Part II.

We encourage those involved in research to use this book as a guide for future studies. We encourage those in industry to use it as a map for the development of veterinary-specific therapeutic laser devices. We encourage those in clinical practice to use it as a daily guide for how to treat more patients, with more conditions, more effectively. We will have succeeded with our goals if you turn to this book often. May your copy become well worn.

Ronald J. Riegel, DVM
John C. Godbold, Jr. DVM
August 1, 2016
Disclaimer

Please read the statements and therapy protocols within this text carefully before utilizing any of this information. The information and recommendations are based on previously published scientific information and years of practice, clinical, and research experience by the contributing authors.

Knowledge about laser therapy and photobiomodulation therapy (PBMT) is constantly changing through ongoing research, clinical trials, and day-to-day clinical experience. The information within this text is presented for educational purposes only and is designed to be a reference to complement formal training about laser therapy and PBMT.

This text contains neither complete nor comprehensive information about any of the conditions addressed, and each condition should be evaluated on an individual basis in each patient prior to therapy. This text is not a substitute for professional advice, care, diagnosis, or treatment. It is the sole responsibility of the veterinarian, veterinary surgeon, technician, nurse, assistant, and therapist to gain the knowledge and comply with all federal, national, provincial, state, and local laws regarding the use of therapeutic lasers for any condition. Dr. Ronald J. Riegel, Dr. John C. Godbold Jr., all of the contributing authors, and anyone involved with the publication of this text expressly disclaim any and all responsibility and legal liability for any kind of loss or risk, personal or otherwise, which is the result of the direct or indirect use or application of any of the material within this text.
Part I

The History of Laser Therapy
Introduction

Various forms of heliotherapy (light therapy) have been practiced around the world for centuries. Physicians and healers in Ancient Greece, Egypt, and Rome – including renowned Greek historian Herodotus in the 6th century B.C. – all realized the benefits of such therapy (Ellinger, 1957). Likewise, the Inca and Assyrian cultures worshiped the sun with the belief that it would bring them health. Around 1500 B.C., Indian medical literature described treatments combining herbal medicine with natural sunlight to treat non-pigmented skin. There are records in the Buddhist literature from around 200 A.D. and Chinese documentation from the 10th century recording similar therapeutic effects from light.

In the 17th century, Sir Isaac Newton discovered that prisms could disassemble or separate white light, a phenomenon he described in his book *Opticks*, originally printed in 1704 (Newton, 1704). He was also the first to use the word “spectrum” (Latin for “appearance” or “apparition”) in 1671.

Heliotherapy in the Modern World

Niels Ryberg Finsen, a Faroese physician and scientist of Icelandic descent, is widely regarded as the original proponent of phototherapy. In 1903, he was awarded the Nobel Prize in Medicine and Physiology for the successful treatment of diseases using phototherapy; specifically, lupus vulgaris, a skin infection caused by *Mycobacterium tuberculosis* (Nobel Prize, 2014b). He also famously utilized ultraviolet light to treat smallpox lesions (Nobel Lectures, 1967).

Shortly thereafter, in 1916, Albert Einstein postulated the theory of lasers to support his Theory of Relativity. First, Einstein proposed that an excited atom in isolation can return to a lower energy state by emitting photons, a process he termed “spontaneous emission.” Spontaneous emission sets the scale for all radiative interactions, such as absorption and stimulated emission. Atoms will only absorb photons of the correct wavelength; the photon disappears and the atom goes to a higher-energy state, setting the stage for spontaneous emission. Second, his theory predicted that as light passes through a substance, it stimulates the emission of more light (Hilborn, 1982).

Einstein hypothesized that photons prefer to travel together in the same state. If one has a large collection of atoms containing a great deal of excess energy, they will be ready to emit photons randomly. If a stray photon of the correct wavelength passes by (or, in the case of a laser, is fired at) an atom already in an excited state, its presence will stimulate the atom to release its photons early. The new photons will then travel in the same direction as the original stray photon, with identical frequency and phase. A cascading effect ensues: as the identical photons move through other atoms, ever more photons are emitted (Pais, 1982).

The Laser is Born

On May 16, 1960, Theodore Maiman produced the first ruby laser at the Hughes Aircraft Research Laboratory in Malibu, California, basing his new creation on Albert Einstein’s explanation of stimulated emission of radiation, coupled with Townes’ and Schawlow’s 1958 work with optical masers (Schawlow and Townes, 1958; Itzkan and Drake, 1997).

Several years after the invention of the laser, Dr. Endre Mester – considered the founding father of laser therapy – became the first to experimentally document the healing effects of lasers. Because he used mice as
his experimental model, this is also the first documented use of lasers to accelerate healing in veterinary medicine (Mester et al., 1967). His experiments would also later prove that the acceleration of healing was a systemic – not just localized – event (Perera, 1987). Mester’s work had a cascading effect, motivating other researchers in Western and Eastern Europe to recognize the value of laser therapy and initiate studies of their own.

Early in the 1970’s, the use of laser therapy was documented not only in Eastern Europe, but also in China and the Soviet Union; all of the early research emanates from these geographical regions. Over the next decade, the use of laser therapy spread to Western Europe and became accepted as an effective physical therapy modality (Goodson and Hunt, 1979). Unfortunately, the lasers used were only capable of 5–50 mW of power and didn’t generate the consistent clinical results that we have since witnessed with higher-powered lasers.

Yo Cheng Zhou, an oral surgeon in China, was the first to stimulate an acupuncture point with a laser. He used laser stimulation instead of standard local anesthetic protocols during routine dental extractions. A beam from a 2.8–6.0 mW helium-neon laser apparatus (Model CW-12, Chengdu Thermometer Factory) was applied for 5 minutes before the removal of a tooth (Zhou, 1984). Photonic stimulation was then applied to LI-4 Hegu. This acupuncture point has long been recognized to produce systemic analgesia.

From the mid 1970’s to the early 1980’s, laser therapy became an accepted physical therapy modality throughout Western Europe and several Asian countries. It finally appeared in the United States around 1977, but there were only a small number of therapists that understood its potential. All of the equipment in the United States during this time frame was in the 1–5 mW range, and acceptance by medical and veterinary professions was very limited due to the inconsistent clinical results.

The first Independent Institutional Review Board for Laser Acupuncture Research was established in 1993, based on research compiled by Margaret Naeser, Ph.D., Lic.Ac. through the Robert Wood Johnson Foundation of Princeton, New Jersey. This initiated the effort and motivation of several colleagues to compile enough current information and research to be in compliance with US Food and Drug Administration (FDA) regulations. Dr. Naeser is currently involved with a large number of research projects, including “Neural Networks and Language Recovery in Aphasia from Stroke victims” (Naeser, 2007). She has published papers on utilizing laser therapy in stroke cases (Naeser and Hamblin, 2011).

Three associations have formed over the years to encourage scientists and practitioners to exchange knowledge and information. The American Society for Laser Medicine and Surgery (ASLMS), formed in 1981, was the first (www.aslms.org). It was the dream of its founders that this organization be unique and include physicians, clinicians, and outstanding researchers in the areas of biophysics, biotechnology, biomedical engineering, laser biology, and laser safety. In 1994, the World Association for Laser Therapy (WALT) was formed by combining the International Laser Therapy Association (ILTA) and the International Society for Laser Applications (ISLAM) (www.waltza.co.za). The North American Association for Laser Therapy (NAALT) was established in 1998. It included the regions of Mexico, Canada and the United States of America. In 2015, NAALT changed its name to the North American Association for Photobiomodulation Therapy (www.naalt.org). All three of these organizations have the common goals of promoting research, improving the understanding of photobiological mechanisms, providing education, clinical applications, and new clinical techniques, and establishing treatment and regulatory guidelines.

The Evolution of Laser Therapy Equipment

The first laser diode, utilizing coherent light emission from a gallium arsenide (GaAs) semiconductor diode, was revealed in 1962 by two groups: Robert N. Hall at the General Electric research center (Hall et al., 1962) and Marshall Nathan at the IBM T.J. Watson Research Center (Nathan et al., 1962).

Later in 1962, other teams at the MIT Lincoln Laboratory, Texas Instruments, and RCA Laboratories also demonstrated the emission of light and lasing in semiconductor diodes. Early in 1963, a team led by Nikolay Basov in the Soviet Union utilized GaAs lasers to achieve emission of light (Nobel Prize, 2014a).

In 1970, the first laser diode to achieve continuous-wave (CW) emission was revealed simultaneously by Zhores Alferov and collaborators in the Soviet Union, and Morton Panish and Izuo Hayashi in the United States (Ghatak, 2009). However, it is widely accepted that Alferov and his team reached the milestone first, and they were consequently awarded the Nobel Prize in Physics in 2000.

While many types of therapeutic lasers were in use around the world, it was not until 2002 that Class IIIb lasers gained FDA approval for therapeutic purposes in the United States. These lasers are commonly referred to as “cold lasers” or “low-level laser therapy” (LLLT) devices. They are limited to 500 mW and are considered effective in the treatment of superficial conditions. The term “cold lasers” refers to the lack of a heating effect on tissue cultures in early experiments. The description
“LLLT” differentiates low-power therapeutic lasers from surgical or cutting lasers.

Class IV therapy lasers, operating above 500 mW, were approved by the FDA in 2006. This was the dawn of "high-power laser therapy" (HPLT). Delivery systems and precise dosage software have evolved through the years to allow the safe and effective delivery of 500 mW–60 W to target tissues.

Photobiomodulation: A New Name

The history of laser therapy and the evolution of laser therapy devices have produced confusing terminology. Multiple terms have been used to describe the technology. Many are more descriptive of the devices being used than of the therapy they deliver.

Recognizing that an accurate, clear, and unambiguous name was needed, 15 international participants joined in a nomenclature consensus meeting at the joint conference of NAALT and WALT in September 2014 (Anders et al., 2015). Respected authorities Dr. Jan Bjordal and Dr. Juanita Anders co-chaired the meeting. The term “photobiomodulation therapy” (PBMT) was recognized as being most descriptive of a science that involves complex mechanisms, some which are stimulatory, some inhibitory. Since that meeting, the National Library of Medicine (United States) has added the term “photobiomodulation therapy” to the MeSH database (MeSH, 2016).

The committee suggested a “definition for the term photobiomodulation therapy as ‘A form of light therapy that utilizes non-ionizing forms of light sources, including lasers, LEDs, and broadband light, in the visible and infrared spectrum. It is a nonthermal process involving endogenous chromophores eliciting photophysical (i.e., linear and nonlinear) and photochemical events at various biological scales. This process results in beneficial therapeutic outcomes including but not limited to the alleviation of pain or inflammation, immunomodulation, and promotion of wound healing and tissue regeneration’” (Anders et al., 2015).

Older terminology continues to be used even as the term “photobiomodulation therapy” becomes more commonplace in publications and practical applications. In this text, the terms “laser therapy” and “photobiomodulation therapy” will be used interchangeably.

Conclusion

The historic development of this new technology is in the past. There has now been a wealth of scientific and clinical evidence published. Thousands of veterinary practitioners around the world have adopted laser therapy into their practices. We, as veterinarians, should be at the forefront of this scientifically and clinically proven modality. Continued collaboration and sharing of information between us is essential to the future development of this 21st-century medical technology. The previous history has been written; be a part of the history other veterinarians quote 10 years from now.

References


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Part II

The Theory and Science of Laser Therapy