

Mechanisms for Low-Light Therapy X

**Michael R. Hamblin
James D. Carroll
Praveen Arany**
Editors

**7–8 February 2015
San Francisco, California, United States**

Sponsored by
SPIE

Cosponsored by
THOR Photomedicine Ltd. (United States)

Published by
SPIE

Volume 9309

Proceedings of SPIE, 1605-7422, V. 9309

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

Mechanisms for Low-Light Therapy X, edited by Michael R. Hamblin, James D. Carroll, Praveen Arany,
Proc. of SPIE Vol. 9309, 930901 · © 2015 SPIE · CCC code: 1605-7422/15/\$18 · doi: 10.1117/12.2183938

The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:

Author(s), "Title of Paper," in *Mechanisms for Low-Light Therapy X*, edited by Michael R. Hamblin, James D. Carroll, Praveen Arany, Proceedings of SPIE Vol. 9309 (SPIE, Bellingham, WA, 2015) Article CID Number.

ISSN: 1605-7422

ISBN: 9781628413991

Published by

SPIE

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445

SPIE.org

Copyright © 2015, Society of Photo-Optical Instrumentation Engineers.

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 1605-7422/15/\$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.

SPIE 
Digital Library

SPIDigitalLibrary.org

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print. Papers are published as they are submitted and meet publication criteria. A unique citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc.

The CID Number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages.

Contents

- v *Authors*
- vii *Conference Committee*
- ix *Introduction*

SESSION 1 REVIEWS AND DOSIMETRY

- 9309 02 **Low level laser (light) therapy and photobiomodulation: the path forward (Invited Paper)**
[9309-1]
- 9309 05 **Beam profile measurements for dental phototherapy: the effect of distance, wavelength
and tissue thickness [9309-4]**

SESSION 2 IN VITRO STUDIES I

- 9309 06 **The effect of UV-Vis to near-infrared light on the biological response of human dental pulp
cells [9309-5]**
- 9309 07 **Controversial effects of low level laser irradiation on the proliferation of human osteoblasts
[9309-7]**
- 9309 08 **Biomodulatory effects of laser irradiation on dental pulp cells *in vitro* [9309-8]**
- 9309 09 **Impact of blue LED irradiation on proliferation and gene expression of cultured human
keratinocytes [9309-6]**

SESSION 3 ANIMAL STUDIES I

- 9309 0A **Low level light in combination with metabolic modulators for effective therapy
(Invited Paper) [9309-9]**
- 9309 0C **Transcranial low-level laser therapy increases memory, learning, neuroprogenitor cells,
BDNF and synaptogenesis in mice with traumatic brain injury (Invited Paper) [9309-11]**
- 9309 0D **Optical properties of mice skin for optical therapy relevant wavelengths: influence of
gender and pigmentation [9309-12]**
- 9309 0E **Effect of photon energy in collagen generation by interstitial low level laser stimulation
[9309-13]**

SESSION 4 CLINICAL STUDIES

- 9309 0F **To evaluate the safety and efficiency of low level laser therapy (LLLT) in treating decubitus ulcers: a review** [9309-14]
- 9309 0G **Tri-wave laser therapy for spinal cord injury, neuropathic pain management, and restoration of motor function** [9309-15]
- 9309 0J **Assessment of LED (λ 850 \pm 10 nm) phototherapy in the inflammatory process of rat's TMJ induced by carrageenan** [9309-18]
- 9309 0K **LED phototherapy on midpalatal suture after rapid maxilla expansion: a Raman spectroscopic study** [9309-19]

SESSION 5 IN VITRO STUDIES II

- 9309 0L **Brief review on the effect of low-power laser irradiation on neutrophils with emphasis on emerging fungal infections** [9309-28]
- 9309 0N **Evaluation of the efficacy of photodynamic antimicrobial therapy using a phenothiazine compound and Laser ($\lambda=660\text{nm}$) on the interface: macrophage vs *S. aureus*** [9309-21]

SESSION 6 ANIMAL STUDIES II

- 9309 0P **Far red/near infrared light-induced cardioprotection under normal and diabetic conditions** [9309-23]
- 9309 0Q **Low power laser irradiation stimulates cell proliferation via proliferating cell nuclear antigen and Ki-67 expression during tissue repair** [9309-24]
- 9309 0R **Biostimulative effects of 809 nm diode laser on cutaneous skin wounds** [9309-26]

POSTER SESSION

- 9309 0V **Low level light promotes the proliferation and differentiation of bone marrow derived mesenchymal stem cells** [9309-31]
- 9309 0X **Effectiveness of antimicrobial photodynamic therapy on *Staphylococcus aureus* using phenothiazinium dye with red laser** [9309-33]
- 9309 0Y **Prospective study of luminous radiation associated technology photosensitive compounds for treatment of diseases** [9309-34]
- 9309 0Z **Evaluation of the efficacy of photodynamic antimicrobial therapy using a phenothiazine compound and LED (red-orange) on the interface: macrophage vs *S. aureus*** [9309-35]
- 9309 10 **Evaluation of laser photobiomodulation on bone defect in the femur of osteoporotic rats: a Raman spectral study** [9309-36]

Authors

Numbers in the index correspond to the last two digits of the six-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first four digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Acirole, Joubert Mateus dos Santos, 10
Agrawal, Tanupriya, 0C
Ahmed, Ambereen, 0F
Ahn, Jin-Chul, 0V
Ak, Ayşe, 07
Almeida, Paulo, 0Y
Arany, Praveen R., 02
Bani, G. M. A. C., 0L
Barbosa, Artur Felipe S., 0K
Baumgardt, Shelley, 0P
Becker, Anja, 09
Bienengraeber, Martin, 0P
Bölükbaşı Ateş, Gamze, 07
Brigagão, M. R. P. L., 0L
Brugnera, Aldo, 0Y
Burger, E., 0L
Cangussu, Maria Cristina T., 0J, 0K
Carroll, James D., 02, 05, 08
Carvalho, Carolina Montagn, 0J
Chariff, Mark D., 0G
Chavasco, J. K., 0L
Choi, Sun-Hyang, 0V
Chung, Phil-Sang, 0V
Churm, James, 06
Cooper, Paul R., 05, 06, 08
de Araújo, Telma M., 0K
de Castro, Isabele Cardoso Vieira, 0J, 0K
de Oliveira, Susana C. P. S., 0N, 0X, 0Y, 0Z
Deana, A. M., 0D
Dong, Tingting, 0A
dos Santos, Jean N., 0J, 0K
Dweep, Harsh, 09
França, C. M., 0D
Garipcan, Bora, 07
Gesteira, Maria F. M., 0Z
Gorecki, Patricia, 06, 08
Gretz, Norbert, 09
Gülsoy, Murat, 07, 0R
Ha, Myungjin, 0E
Habib, Fernando Antonio L., 0K
Hadis, Mohammed A., 05, 06, 08
Hamblin, Michael R., 02, 0A, 0C
Huang, Liyi, 0C
Hwe, Christopher, 0P
Jun, Eunkwon, 0E
Jung, Byungjo, 0E
Keszler, Agnes, 0P
Kim, Dae Yu, 0V
Lee, Sangyeob, 0E
Mahato, Krishna Kishore, 0Q
Malaquias, L. C. C., 0L
Mendes, A. C. S. C., 0L
Milward, Michael R., 05, 06, 08
Monteiro, Juliana S. C., 0N, 0X, 0Y, 0Z
Neves, Bruno Luiz R. C., 10
Olszak, Peter, 0G
Oversluizen, Gerrit, 09
Palin, William M., 05, 06, 08
Park, Jihoon, 0E
Patthoff, Donald, 02
Pinheiro, Antônio L. B., 0J, 0K, 0N, 0X, 0Y, 0Z, 10
Pires de Sousa, Marcelo Victor, 02
Pires-Santos, Gustavo M., 0N, 0X, 0Y, 0Z
Prabhu, Vijendra, 0Q
Radfar, Edalat, 0E
Rao, Bola Sadashiva Satish, 0Q
Rhee, Yun-Hee, 0V
Ribeiro, M. S., 0D
Rosa, Cristiane Becher, 0J, 0K
Sabino, C. P., 0D
Sampaio, Fernando José Pires, 0N, 0X, 0Y, 0Z
Santos, G. B., 0L
Silva, D. F. T., 0D
Silveira, Landulfo, 10
Soares, Luiz Guilherme Pinheiro, 0J, 0K, 10
Solmaz, Hakan, 0R
Sperandio, F. F., 0L
Sticht, Carsten, 09
Tarte, Edward, 06
Ülgen, Yekta, 0R
van Abeelen, Frank A., 09
Vatansever, Fatma, 0C
Verinaud, L. M., 0L
Wu, Mei X., 0A
Xuan, Weijun, 0C
Yoshimura, T. M., 0D
Yüksel, Şahru, 07
Zanin, Fátima Antônia Aparecida, 0N, 0X, 0Y
Zhang, Qi, 0A

Conference Committee

Symposium Chairs

James G. Fujimoto, Massachusetts Institute of Technology
(United States)

R. Rox Anderson, Wellman Center for Photomedicine, Massachusetts
General Hospital (United States) and Harvard School of Medicine
(United States)

Program Track Chair

Brian Jet-Fei Wong, Beckman Laser Institute and Medical Clinic
(United States)

Conference Chairs

Michael R. Hamblin, Wellman Center for Photomedicine
(United States)

James D. Carroll, THOR Photomedicine Ltd. (United Kingdom)

Praveen Arany, National Institute of Dental and Craniofacial
Research (United States)

Conference Program Committee

Juanita Anders, Uniformed Services University of the Health Sciences
(United States)

Tomas Hode, Immunophotonics, Inc. (United States)

Daniel Barolet M.D., McGill University (Canada)

Session Chairs

- 1 Reviews and Dosimetry

Michael R. Hamblin, Wellman Center for Photomedicine
(United States)

- 2 In Vitro Studies I

Praveen Arany, National Institute of Dental and Craniofacial
Research (United States)

- 3 Animal Studies I

James D. Carroll, THOR Photomedicine Ltd. (United Kingdom)

- 4 Clinical Studies
Praveen Arany, National Institute of Dental and Craniofacial Research (United States)
- 5 In Vitro Studies II
Tomas Hode, Immunophotonics, Inc. (United States)
- 6 Animal Studies II
Caetano Padial Sabino, Instituto de Pesquisas Energéticas e Nucleares (Brazil)

Introduction

This issue of the Proceedings of the Optics & Photonics (SPIE 2015) from conference 9309 'Mechanisms of Low Light Therapy X' had 35 abstracts submitted, of which 27 were podium presentations and 8 were invited as poster presentations. Of these, 24 papers (some collated from multiple presenters) have been submitted as manuscripts broadly based in four categories that represent the meeting's 4 sessions: Reviews and Dosimetry, In Vitro, and Animal or Clinical Studies.

The highlight of this meeting was the wide range of interests and expertise in a rapidly evolving field of low light therapy that is best personified by the acceptance of a scientifically accurate term 'Photobiomodulation' by the National Library of Medicine. A comprehensive review by the organizers of this meeting outlines the current state of the field highlighting exciting new progress in the lab research and clinical applications. A massive problem in the field currently is the inaccuracy of the physical parameters of therapy and this is discussed in a concise review paper in this volume.

A majority of the ongoing investigations examine effects of light based interventions in simplified, in vitro models and this is well represented by the largest number of papers and presentations at this meeting. Among these, special emphasis is placed on lineage differences to light therapy such as distinct effects on dental stem cells, osteoblasts, keratinocytes as well as microorganisms such as bacteria and fungi. These differences are critical for our better understanding to applying light therapy for in vivo and human clinical applications. Demonstrating proof of principle in animal models provides the ability to test a large number of interventional variables as well as examining relevant, in vivo parameters robustly. Studies presented in these proceedings range from the basics of light-tissue interactions to effects in specific pathophysiological processes such as wound healing and diabetes. The final frontier for human clinical use is borne by translation research studies and these proceedings highlight the range of studies being attempted in pain, inflammation and wound healing.

The meeting also had a good number of posters being presented to promote interactions and active discussions in the forum. Overall, it was a very informative and engaging meeting showcasing the growing popularity and utility of light based interventions for human health. Next year promises to bring forth much more excitement and innovations. See you all there!

Michael R. Hamblin
James D. Carroll
Praveen Arany

