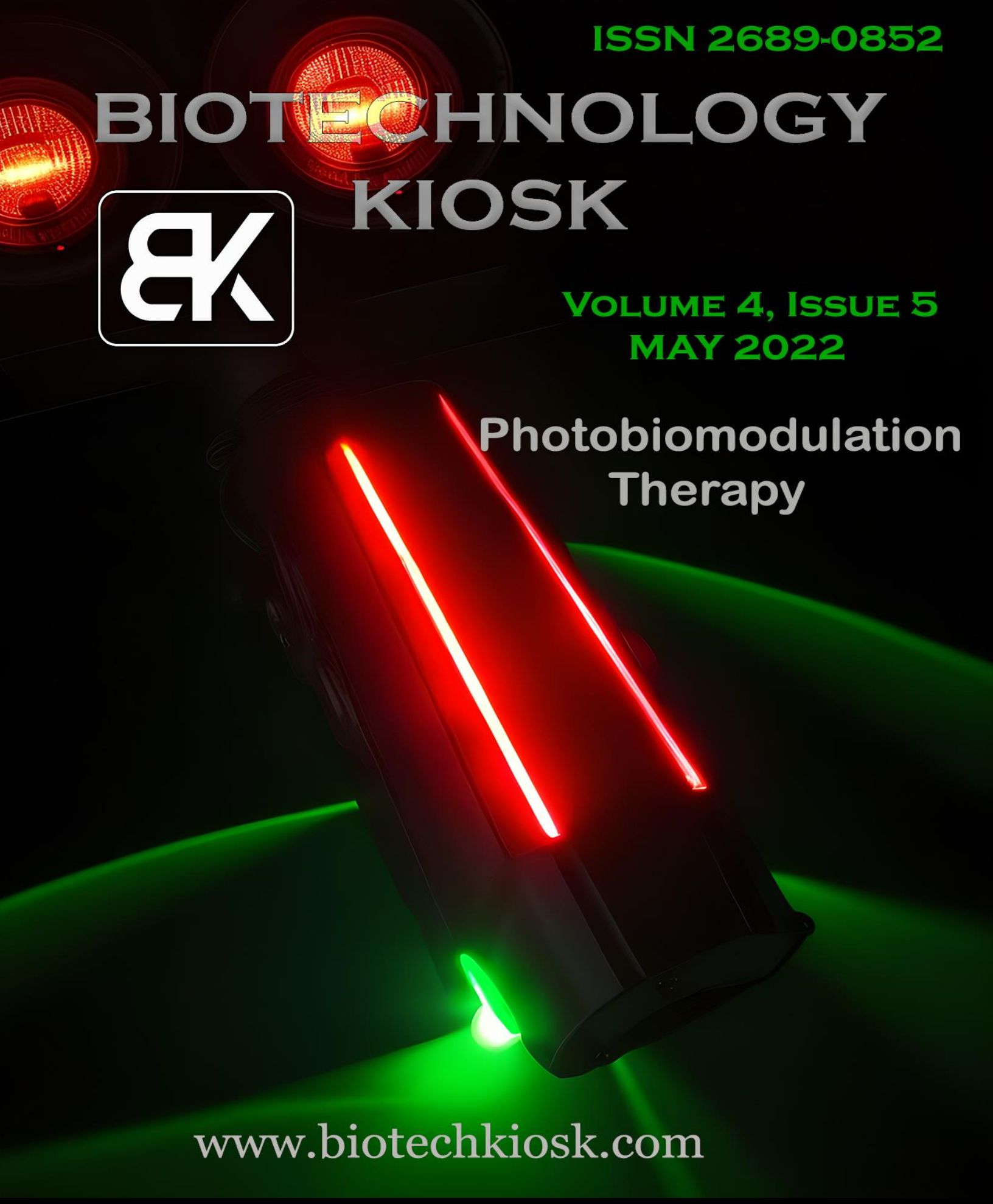
ISSN 2689-0852

BIOTECHNOLOGY KIOSK

VOLUME 4, ISSUE 5
MAY 2022

Photobiomodulation Therapy



www.biotechkiosk.com

Biotechnology Kiosk

www.biotechkiosk.com

Executive Publishers

Megha Agrawal, PhD

(Biotechnology)

Publisher and Editor

Expertise:

Neuroscience, Stroke, Pharmacology, Toxicology, Microbiology, Antiaging, Gene Therapy and Immunology

Email: megha@biotechkiosk.com
meghaagra@gmail.com

Shyamasri Biswas, PhD

(Biotechnology)

Publisher and Editor

Expertise:

Structural Biology, Enzyme Technology, Protein Crystallography, Molecular Biology and Mass Spectrometry

Email: shyabiswas@biotechkiosk.com
shyabiswas@gmail.com

Editorial, Sales & Circulation Office

1330 NW 6th Street
Suite A2, Gainesville
FL-32601, USA
Phone: 386-518-9411
Email: usappg22@gmail.com
publisher@biotechkiosk.com

www.biotechkiosk.com
ISSN 2689-0852
One stop shop for all things biotech

From the Publisher's Desk

Welcome to Biotechnology Kiosk!

The May'2022 issue of BK is now live for our readers with the regular features. This issue includes a perspective on photomodulation therapy and the regular section on editor picks.

We hope our readers will enjoy reading these news and views on the current cutting-edge topics that include latest research breakthroughs in different areas of medicine and biotechnology.

We look forward to receiving your feedback. We do hope that you will enjoy reading this issue of Biotechnology Kiosk. Please do write to us with your comments.

Your suggestions are always appreciated.

Dr. Megha Agrawal & Dr. Shyamasri Biswas.

Editors-in-Chief, Biotechnology Kiosk

Biotechnology Kiosk

www.biotechkiosk.com

Contents

Volume 4, Issue 5 **May 2022**

Editor's Picks: Biotechnology Advances around the World

Biotechnology Kiosk

www.biotechkiosk.com

Photobiomodulation Therapy to Combat Complex Biomedical Problems

Pallavi Tripathi

Intertek Pharmaceutical Services, Hexagon Towers, Crumpsall Vale, M9 8 GQ, Manchester, UK

Abstract

Photobiomodulation (PBM) therapy employs red or near-infrared (NIR) laser. PBM therapy is a rapidly emerging approach that uses a combination of multiple disciplines comprising lasers, high and ultra-high vacuum technologies, biomedical science and engineering and medicine, to name a few. PBM is currently gaining attention for its promise to combat complex medical problems such as cancer, brain disorders, tissue generation etc. Further, PBM technology allows to explore new therapeutic avenues to restore or stimulate healing, reduce pain, increase athletic performance, and improve general wellness. Moreover, recent studies have shown that the ability to stimulate multiple physiological processes can help repair damage caused by injury or disease. In this perspective, we have described some of the notable advances in PBM therapy.

Keywords: Photobiomodulation therapy, brain disorders, burn injuries, skin defects, tissue engineering.

* Corresponding author: Dr. Pallavi Tripathi
E-mail address: paltrip@googlemail.com

DOI: https://doi.org/10.37756/bk.22.4.5.1
Article type: *Perspective*
Received: *March 20, 2022*
Revised: *April 19, 2022*
Accepted: *April 20, 2022*

Please cite this article as: *Tripathi P, Photobiomodulation Therapy to Combat Complex Biomedical Problems, Biotechnol. kiosk, Vol 4, Issue 5, PP: 1-8 (2022); DOI: https://doi.org/10.37756/bk.22.4.5.1.*

Introduction

Photobiomodulation (PBM) therapy is rapidly emerging as a very promising approach to be employed in supportive cancer care, age-related macular degeneration and also battling against Alzheimer's disease (AD). Additionally, low-dose PBM therapy has been considered to speed up recovery from burns and reduce inflammation. Such low-dose therapy involves a non-ionizing laser source, which is usually placed near or on top of the skin that allows photons to penetrate tissue. This is followed by the interaction with chromophores that are located on cells that results in photophysical and photochemical reactions. Studies have shown that these photon-induced reactions can be leveraged to alter the molecular, cellular, and tissue levels in the body [1].

The cellular and molecular mechanisms of PBM therapy are considered the key aspects for the beneficial effects of PBM. Mainly, the beneficial effects have been suggested to result from the photostimulation of the mitochondrial electron transfer chain (ETC). Previous studies have also shown that application of PBM at optimum fluences (i.e. energy densities) and certain specific wavelengths can result in therapeutic effects that are produced in the target organs without causing any adverse effects. For example, it has been shown that PBM therapy increases cerebral blood flow (CBF), and also augments brain energy metabolism that in turn increases antioxidant defenses [2]. Further, researchers have also demonstrated the ability of PBM to promote neuronal protection and survival. Studies have suggested that such protective mechanisms occur through modulation of anti-apoptotic and pro-apoptotic mediators along with inflammatory signaling molecules along with the stimulation of neurotrophic factors. Moreover, in addition to the beneficial therapeutic effects of PBM at the molecular level, studies have presented evidence of changes occurring also at the behavioral level that include cognitive-enhancement, antidepressant effects and improved sleep [2].

Several studies conducted on PBM (red and NIR spectrum) have shown the resulting photo dissociation of nitric oxide (NO) from the binuclear center (a3/CuB) of cytochrome c oxidase (CCO). Such dissociation of NO has been shown to increase the mitochondrial membrane potential (MMP) as a result of inhibition of NO electron transport in the ETC. This produces an increase in oxygen consumption that ultimately leads to proton gradient and an increase in ATP production [2]. These events lead to the production of reactive oxygen species (ROS) that results in releasing of Ca^{2+} as versatile second messengers. This subsequently triggers activation of transcription factors and signaling mediators such as NF-κB and resulting in long-lasting effects on cells (Figure 1) [2].

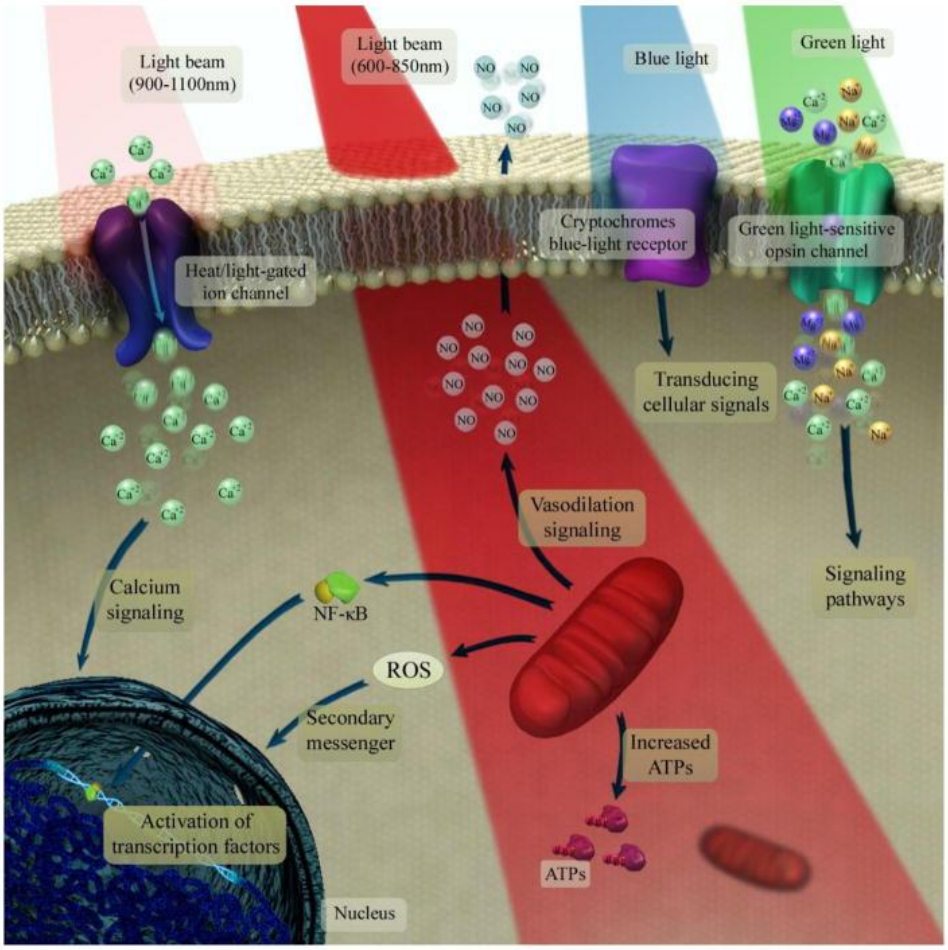


Figure 1: *The underlying mechanisms of photobiomodulation at the cellular and molecular levels are depicted. In this process, laser at 600–850 nm is initially absorbed by the mitochondrial electron transfer chain that leads to upregulation of the neuronal respiratory capacity. The NIR laser at range of 900–1100 nm is then absorbed by structured water clusters that are formed in or on a heat/light-gated ion channels. This allows modulation of intracellular Ca2+ levels. Further, the absorption of green laser by neuronal opsin photoreceptors (OPN2–5) can activate transient receptor potential channels. This results in non-selective permeabilization to Ca2+, Na+ and Mg2+. Subsequently, the cryptochromes, which is considered a class of flavoprotein blue-light signaling receptors can absorb blue light. This activates the transducing cellular signals through the optic nerve to the suprachiasmatic nucleus in the brain that regulates the circadian clock [Source: Mol Neurobiol (2018)].*

In this perspective, we will describe some notable applications of PBM therapy that have been suggested in some of the most challenging medical problems.

PBM Therapy for Combatting Brain Disorders: Providing Neuroprotection via Anti-Inflammatory and Antioxidant Biological Signaling

Recently, application of red to NIR lights (600–850) for brain PBM therapy has been considered due to the fact that neural tissues contain large amounts of mitochondrial CCO. In some studies,

it has been suggested that PBM therapy could be effective for the treatment of a wide range of neurological and psychological disorders that affects various cerebral structures. To this end, studies on clinical brain PBM therapy have focused on conditions such as Alzheimer's disease 'AD', Parkinson's disease 'PD', traumatic brain injury 'TBI' and ischemic stroke. In addition to these medical conditions, the application of PBM as a non-invasive modality is also considered in perfectly healthy individuals for the enhancement of their cognitive abilities [2].

Experimental results suggest that irradiation in the wavelength range between 980 nm and 1100 nm can result in different mechanisms of action. This includes stimulation of ion channels and water molecules. Further, it has been shown that PBM that combines with red/NIR lasers could potentially lead to significantly improved cerebral metabolic function, stimulated neurogenesis and synaptogenesis. This could also be beneficial in regulating neurotransmitters, and providing neuroprotection via anti-inflammatory and antioxidant biological signaling that are considered the most important effects of brain PBM therapy (Figure 2) [2]. Extensive preclinical and clinical studies on PBM have been carried out with modest levels of red and NIR lasers. The results have suggested that brain could induce bio stimulatory effects without any thermal damage. This could be highly beneficial to improve neurobehavioral deficits associated with many brain disorders that include depression and anxiety and other psychiatric disorders such as schizophrenia, autism, bipolar, attention-deficit hyperactivity and obsessive–compulsive disorders [2].

Healing of Third-Degree Burns: Overcoming Inflammation and Promoting Tissue Generation

Burn injuries are complex medical conditions and it has been estimated that such injuries affect over 6 million people per annum worldwide. Related studies have shown that morbidity involving infections and scarring could result in a high percentage of mortality from burn injuries. To address the issues, clinicians and medical professionals have recommended aggressive clinical management guidelines based on the severity of burns including total body surface area, depth, and co-morbidities. All these procedures and methodologies are based on fundamental burn injury pathophysiology including a range of thermal and cellular stress damage responses along with a prominent inflammatory sequela [3-9].

In a recent study, researchers employed one of the PBM molecular mechanisms of PBM treatments that involved photo activation of latent TGF-β1. The objective was to promote tissue healing and regeneration [9]. They investigated

the efficacy of PBM treatments in a full-thickness burn wound healing in C57BL/6 mice. The PBM protocol was optimized by monitoring tissue surface temperature and histology. The dynamic irradiance surface temperature-monitored was then noted. It was reported that PBM protocol improved burn wound healing in mice with elevated TGF-β signaling (phospho-Smad2) while reducing inflammation-associated gene expression (Figure 3) [9]. Further, investigative analysis was conducted on specific contributions of TGF-β1 signaling in the PBM-burn wound healing by using a chimeric TGF-β1/β3 knock-in (TGF-β1Lβ3/Lβ3) mice. An activation of endogenous latent TGF-β1 following PBM treatments was suggested to play a key role in burn wound healing. The new mechanistic insights that were developed in the study could play important roles in improving the safety and efficacy of clinical translation of PBM treatments for tissue healing and regeneration [9].

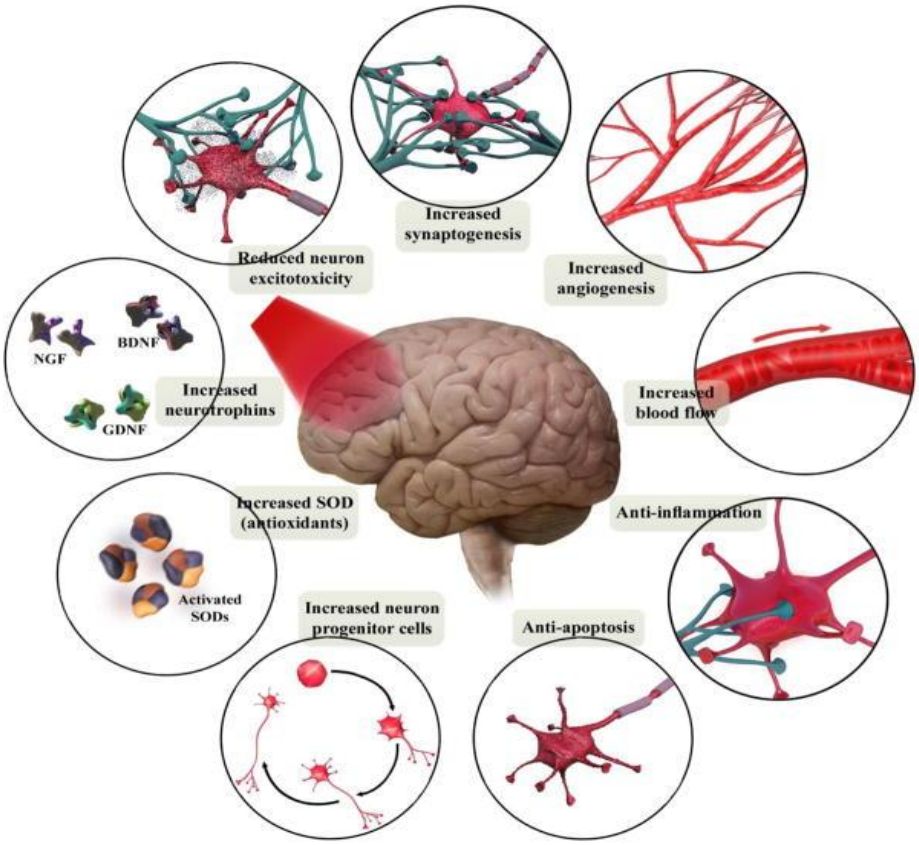


Figure 2: *The brain tissue-specific functional processes is schematically illustrated. Brain PBM therapy on a cellular level can reduce apoptosis and excitoxicity while increasing antioxidants, neurotrophins and stimulate neuroprogenitor cells. Whereas, PBM therapy done on a tissue level has been shown to increase blood flow and angiogenesis. This has been shown to result in reducing inflammation and helping neurons to form new connections (BDNF, brain-derived neurotrophic factor; GDNF, glial-derived neurotrophic factor; NGF, nerve growth factor; SOD, superoxide dismutase). [Source: Mol Neurobiol. (2018)].*

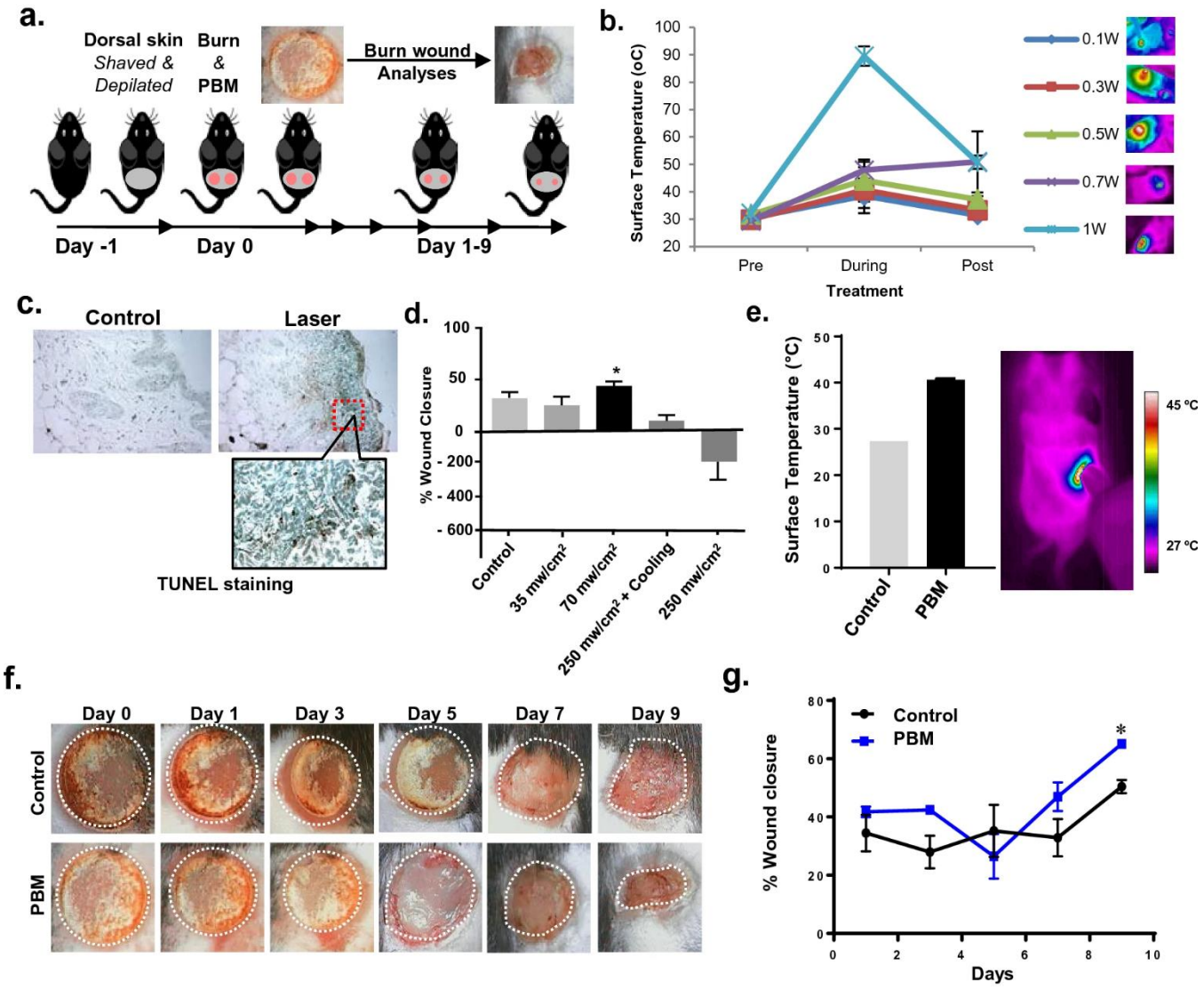


Figure 3: PBM treatment modality is illustrated that improves burn wound healing. (a) A scheme of wound healing experiment is shown that includes photographs of burn wounds obtained every other day up to day 9. (b) Monitoring of tissue surface temperature is conducted during laser treatments with increasing irradiances with a thermal camera. (c) Assessment of tissue damage is done in these tissues with TUNEL staining that indicates phototoxicity at skin temperature above 45 °C. (d) A chart showing burn wound healing following PBM treatments at increasing doses and concomitant surface cooling. (e) Optimal PBM dose treatments are shown that ensure skin surface temperature to be > 45 °C using a dynamic irradiance protocol assessed with thermal imaging (left) and quantitation (right). (f) Photographs of PBM treatments on burn wounds obtained every other day for up to 9 days and compared to untreated controls. (g) Wound areas are digitally quantitated and the results are expressed as means and SDs [Source: Sci. Rep. (2021)].

This study could pave the way for future applications of PBM treatments and the biological rationale for its clinical application in mitigating burn injury and wound healing [9-10].

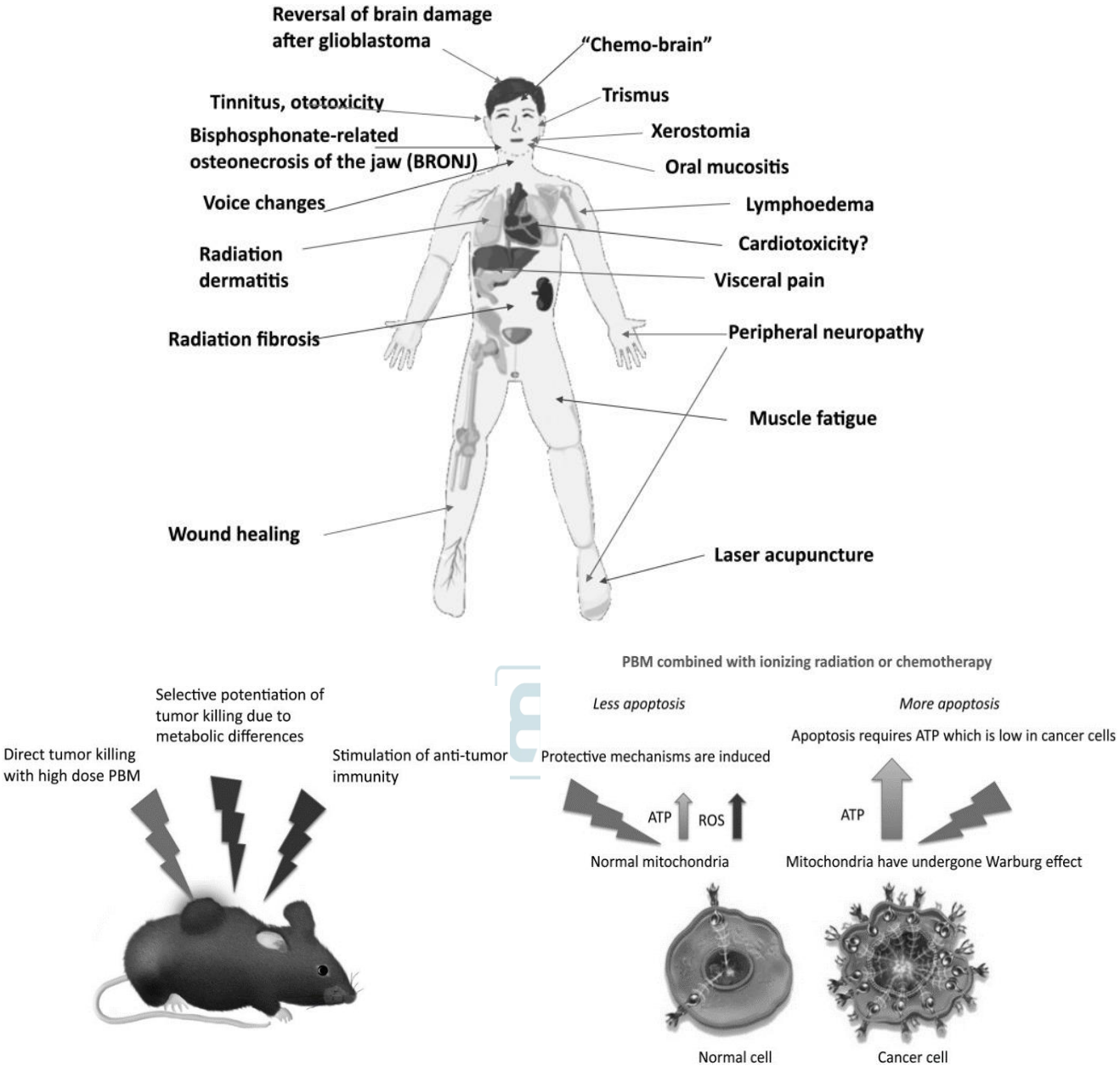


Figure 4: *(Top) Schematic depiction of cancer therapy side effects and possible treatment by PBM. (Left) Suggested mechanisms of PBM that could be applied against cancer. (Right) Mechanisms of selective potentiation of cytotoxicity are shown against cancer cells while preserving normal cells [Source: Photomedicine and Laser Surgery (2018)].*

Conclusion

Near infrared (NIR) and red lasers assisted photobiomodulation (PBM) therapy has shown a very promising therapeutic pathway for the effective prevention or treatment of complex medical conditions. The field of PBM therapy is rapidly evolving that represents a truly multidisciplinary area of research involving

vacuum technology and lasers along with biomedical engineering, medicine and biotechnology. Further developments in PBM therapy in the near future is anticipated that could enable to have new therapeutic avenues for many complex diseases.

References

1. Lopes Silva R S D, Pessoa D R, Mariano R R, Castro A B S, de Oliveira R A, Ferraresi C. Systematic Review of Photobiomodulation Therapy (PBMT) on the Experimental Calcaneal Tendon Injury in Rats. *Photochemistry and photobiology*. **2020,** *96* (5), 981-997. DOI: http://doi.org/10.1111/php.13262.
2. Salehpour F, Mahmoudi J, Kamari F, Sadigh-Eteghad S, Rasta S H, Hamblin M R. Brain Photobiomodulation Therapy: a Narrative Review. *Mol Neurobiol*. **2018,** *55* (8), 6601-6636. DOI: http://doi.org/10.1007/s12035-017-0852-4.
3. Yadav A, Verma S, Keshri G K, Gupta A. Role of 904 nm superpulsed laser-mediated photobiomodulation on nitroxidative stress and redox homeostasis in burn wound healing. *Photodermatology, photoimmunology & photomedicine*. **2020,** *36* (3), 208-218. DOI: http://doi.org/10.1111/phpp.12538.
4. Mosca R C, Ong A A, Albasha O, Bass K, Arany P. Photobiomodulation Therapy for Wound Care: A Potent, Noninvasive, Photoceutical Approach. *Advances in skin & wound care*. **2019,** *32* (4), 157-167. DOI: http://doi.org/10.1097/01.ASW.0000553600.97572.d2.
5. Keshri G K, Yadav A, Verma S, Kumar B, Gupta A. Effects of Pulsed 810 nm Al-Ga-As Diode Laser on Wound Healing Under Immunosuppression: A Molecular Insight. *Lasers in surgery and medicine*. **2020,** *52* (5), 424-436. DOI: http://doi.org/10.1002/lsm.23156.
6. Cancio L C, Salinas J, Kramer G C. Protocolized Resuscitation of Burn Patients. *Critical care clinics*. **2016,** *32* (4), 599-610. DOI: http://doi.org/10.1016/j.ccc.2016.06.008.
7. Gould L J, May T. The Science of Hyperbaric Oxygen for Flaps and Grafts. *Surgical technology international*. **2016,** *28*, 65-72.
8. Kantak N A, Mistry R, Varon D E, Halvorson E G. Negative Pressure Wound Therapy for Burns. *Clinics in plastic surgery*. **2017,** *44* (3), 671-677. DOI: http://doi.org/10.1016/j.cps.2017.02.023.
9. Khan I, Rahman S U, Tang E, Engel K, Hall B, Kulkarni A B, Arany P R. Accelerated burn wound healing with photobiomodulation therapy involves activation of endogenous latent TGF-beta1. *Scientific reports*. **2021,** *11* (1), 13371. DOI: http://doi.org/10.1038/s41598-021-92650-w.
10. Hamblin M R, Nelson S T, Strahan J R. Photobiomodulation and Cancer: What Is the Truth? *Photomedicine and laser surgery*. **2018,** *36* (5), 241-245. DOI: http://doi.org/10.1089/pho.2017.4401.

Biotechnology Advances around the World

Editor's Picks

Every issue of Biotechnology Kiosk presents select latest research news picked by the editors-in-chief on significant research breakthroughs in different areas of biotechnology around the world. The aim is to promote further R&D in all of these cutting-edge areas of biotechnology. The editors have compiled and included the following innovations and breakthroughs to highlight the latest biotechnology advances.

Dr. Megha Agrawal
Co Editor-in-Chief

Dr. Shyamasri Biswas
Co Editor-in-Chief

Neurobiology and Gut Microbiota

Communication between brain and gut microbiota

The gut is known to be the body's largest reservoir of bacteria. Studies have suggested the degree of interdependence between hosts and their gut microbiota that emphasizes the importance of the gut-brain axis. It has been shown that gut microbiota by-products circulate in the bloodstream that regulate host physiological processes including immunity, metabolism and brain functions.

In a recent study, scientists from the Institut Pasteur (a partner research organization of Université Paris Cité), Inserm and the CNRS have reported that hypothalamic neurons in an animal model directly detect variations in bacterial activity and adapt appetite and body temperature accordingly. Their research was published in Science (Bacterial sensing via neuronal Nod2 regulates appetite and body temperature. Science, 2022; 376 (6590) DOI: 10.1126/science.abj3986).

In this study, the scientists focused on the NOD2 (nucleotide oligomerization domain) receptor (found inside of mostly immune cells). This receptor is known to detect the presence of muropeptides that are the building blocks of the bacterial cell wall.

This study has shed light on the impact of muropeptides on hypothalamic neurons and metabolism that raises questions on their potential role in other brain functions. This may help understand the link between certain brain diseases and genetic variants of NOD2. This discovery paves the way for future studies involving interdisciplinary projects at the intersection of neurosciences, immunology and microbiology. These findings demonstrate that a direct communication between the gut microbiota and the brain that can lead to new therapeutic approaches to brain diseases and metabolic disorders such as diabetes and obesity.

Antimicrobial Resistance

Multipronged approach needed to counter antimicrobial resistance

It is known that antimicrobial resistance occurs when bacteria, viruses, fungi and parasites change over time. At this point, it no longer responds to medicines. Thus, it makes infections more difficult to treat that leads to the increasing risk of disease spread and ultimately severe illness and death. It affects health, social and economic well-being, and spreads as a result of actions taken across human, animal, agricultural and environmental systems. According to a new study by researchers in Canada, counteracting antimicrobial resistance needs a multipronged approach, including training, labeling food products, working with the media and changing mindsets (Factors influencing antimicrobial resistance in the European food system and potential leverage points for intervention: A participatory, One Health study. PLOS ONE, 2022; 17 (2): e0263914 DOI: 10.1371/journal.pone.0263914).

The study conducted by researchers at the University of Waterloo in collaboration with

scientists from Canada, Sweden and Switzerland, focused on identifying the factors influencing antimicrobial resistance in the European food system and places to intervene. To achieve the goals, researchers conducted workshops over two days with participants representing perspectives from government, non-government and healthcare organizations, as well as industry and private consultants. Participants identified 91 factors across the One Health spectrum that influence antimicrobial resistance, with 331 connections between them and many feedback loops. Additionally, they also identified possible places within this system to target their interventions, which were then classified as shallow or deep.

The study emphasizes the complexity of antimicrobial resistance problem that points to the need for global collaboration and coordinated multi-level and multipronged interventions targeting different sectors to effectively and sustainably address the antimicrobial resistance crisis.

Compiled and Edited by Dr. Megha Agrawal and Dr. Shyamasri Biswas.


VACUUM TECHNOLOGY & COATING
Claim Your Free Digital Subscription to VT&C
Vacuum Technology & Coating Magazine has been the only publication dedicated exclusively to the Vacuum Processing and Thin Film Deposition industries since it was founded in 2000.
Each monthly issue includes columns focused on Thin Film Deposition, Vacuum Processing, Characterization of Thin Films, Nanotechnology and Biotechnology, often with guest editorial by scientists and manufacturers in the industry.
Monthly Product Showcases introduce the latest products with a wide range of topics including: Deposition and Coating Equipment, Furnaces, Ovens, Chillers and Cryosystems, Vacuum Hardware, Gas Handling and Gas Analytical Systems, Measurement and Metrology, Materials, and Vacuum Pumps, and many more.
Subscribe to Vacuum Technology & Coating Magazine Today!
Print or Digital
http://www.vtcmag.com/subscribe.html
vacuum TECHNOLOGY & coating
www.vtcmag.com

For all production related questions or sending your ads, please e-mail or call our production department: E-mail: sales@biotechkiosk.com; Phone: 386-518-9411.

THANK YOU!