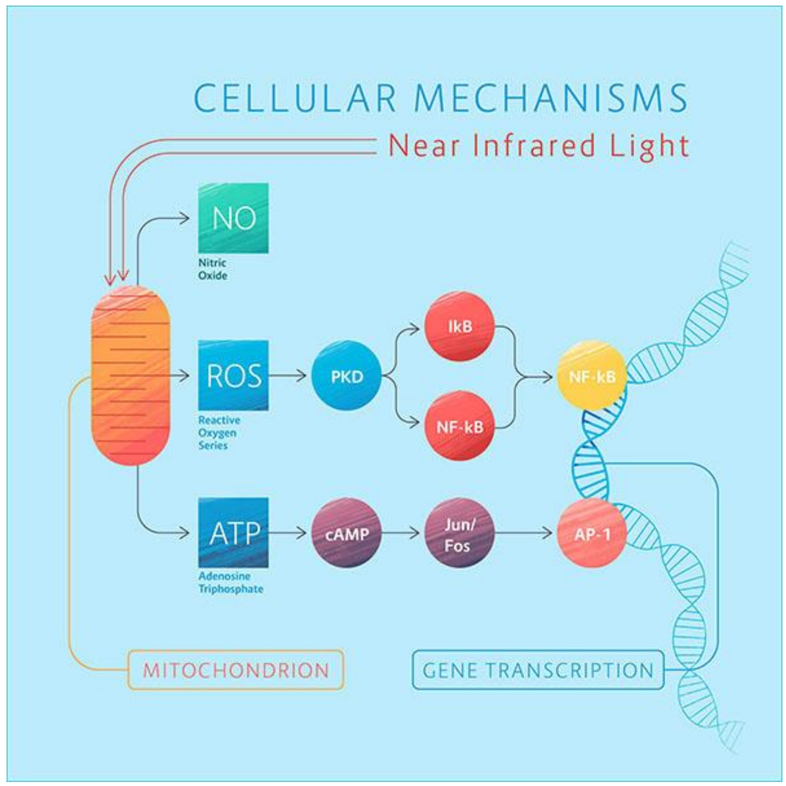
What is Photobiomodulation?

Photobiomodulation therapy is defined as the utilization of non-ionizing electromagnetic energy to trigger photochemical changes within cellular structures that are receptive to photons.

Mitochondria is particularly receptive to red and near-infrared (NIR) photons. At the cellular level, visible red and near infrared light energy are absorbed by mitochondria, which perform the function of producing cellular energy called “ATP”.

The key to this entire process is a mitochondrial enzyme called cytochrome oxidase c, a chromophore, which accepts photonic energy of specific wavelengths when functioning below par.



The effects of red to NIR light energy on mitochondria
Ref: Original: “Basic Photomedicine”, Ying-Ying Huang, Pawel Mroz and Michael R. Hamblin, Harvard Medical School. Current design: Vielight Inc.

Read a published study (May 2022) using the Vielight Neuro Alpha on the way that living cells, cellular structures, and components such as microtubules and tubulin respond to near-infrared PBM: Link: https://www.frontiersin.org/articles/10.3389/fmedt.2022.871196/full

What are the Mechanisms of Photobiomodulation?

There are three bioenergetics pathways in photobiomodulation.

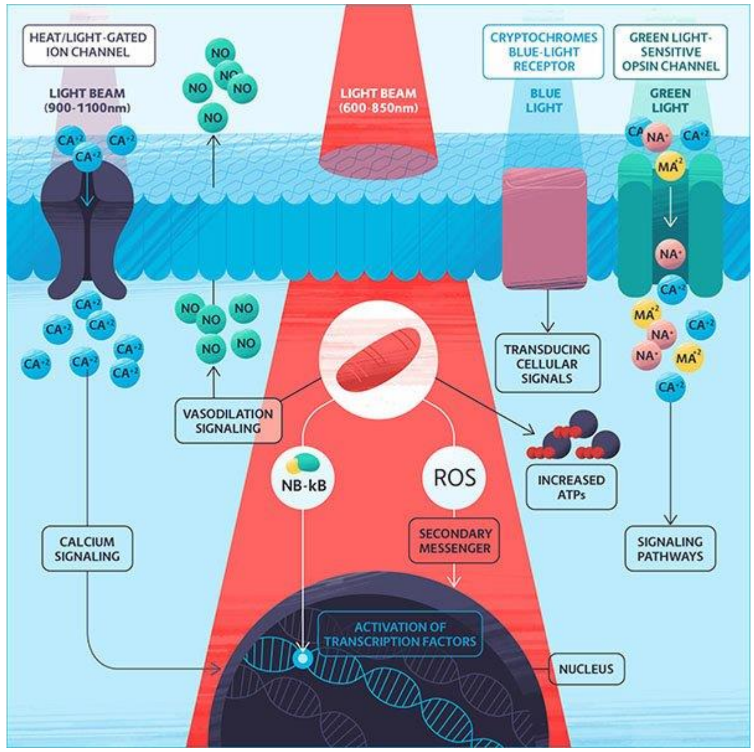
Firstly, low level visible red to near infrared light (NIR) energy is absorbed by mitochondria and converted into ATP for cellular use.

Secondly, the process creates mild oxidants (ROS), which leads to gene transcription and then to cellular repair and healing.

Lastly, the process also unclogs the chain that has been clogged by nitric oxide (NO).[1] The nitric oxide is then released back into the system.

Nitric oxide is a molecule that our body produces to help its 50 trillion cells communicate with each other.

This communication happens by transmission of signals throughout the entire body. Additionally, nitric oxide helps to dilate the blood vessels and improve blood circulation.



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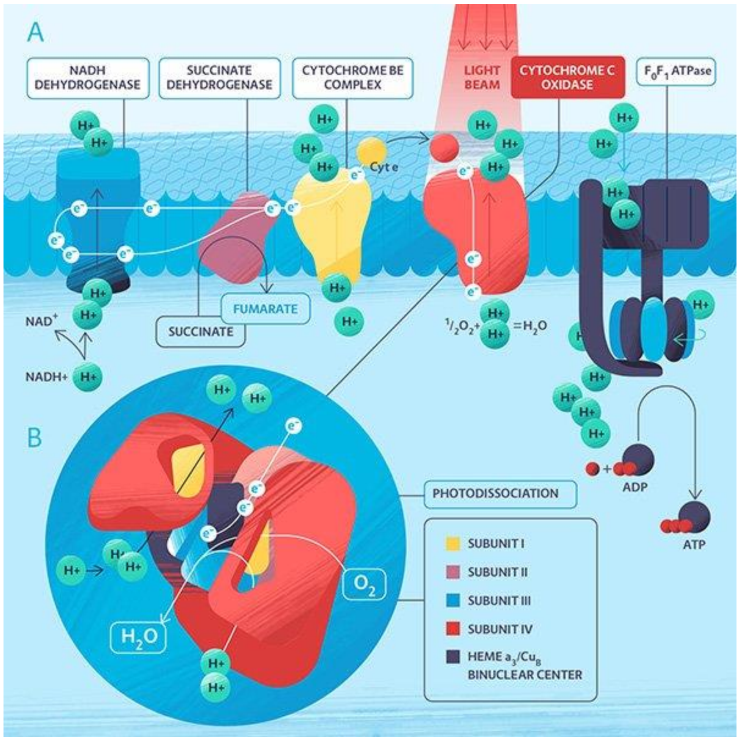
What are the Pathways of Photobiomodulation?

- ATP (Adenosine Triphosphate) → cAMP (catabolite activator protein) → Jun/Fos (oncogenic transcription factors) → AP-1 (activator protein transcription factor stimulates gene transcription)
- ROS (Reactive Oxygen Series) → PKD (gene) → IkB (Inhibitor κB) + NF-κB (nuclear factor κB) → NF-κB (nuclear factor κB stimulates gene transcription)
- NO (Nitric Oxide)

What is Photobiology?

Photobiology is the study of the effects of non-ionizing radiation on biological systems. The biological effect varies with the wavelength region of the radiation. The radiation is absorbed by molecules in skin such as DNA, protein or certain drugs. The molecules are changed chemically into products that initiate biochemical responses in the cells.

Biological reaction to light is nothing new, there are numerous examples of light induced photochemical reactions in biological systems. Vitamin D synthesis in our skin is an example of a photochemical reaction. The power density of sunlight is only 105 mW/cm2 yet when ultraviolet B (UVB) rays strikes our skin, it converts a universally present form of cholesterol, 7-



Photon absorption by cytochrome c oxidase (CCO)
Ref: Original: “Basic Photomedicine”, Ying-Ying Huang, Pawel Mroz and Michael R. Hamblin, Harvard Medical School. Current design: Vielight Inc.

dehydrocholesterol to vitamin D3. We normally experience this through our eyes which are obviously photosensitive. Our vision is based upon light hitting our retinas and creating a chemical reaction that allows us to see. Throughout the course of evolution, photons have played a vital role in photo-chemically energizing certain cells.

PBM Parameters

The correct wavelength for the target cells or chromophores must be employed (633-810 nm). However, if the wavelength is incorrect, optimum absorption will not occur. Thus, as the first law of photobiology, the Grotthus-Draper law, states — without absorption there can be no reaction.[2]

The photon intensity, i.e., spectral irradiance or power density (W/cm2), must be adequate, or absorption of the photons will not be sufficient to attain the desired result. However, if the intensity is too high, the photon energy will be transformed to excessive heat in the target tissue, and that is undesirable.[3]

Finally, the dose or fluence must also be adequate (J/cm2). Consequently, if the power density is too low, then prolonging the irradiation time to achieve the ideal energy density, or dose, will, most likely, not give an adequate final result. This happens because the Bunsen-Roscoe law of reciprocity, the 2nd law of photobiology, does not hold true for low incident power densities.[4]

Brain Bioenergetics

Near-infrared light (NIR) stimulates mitochondrial respiration in neurons by donating photons that are absorbed by cytochrome oxidase. This is a bioenergetics process called photoneuromodulation in nervous tissue. The absorption of luminous energy by the enzyme results in increased brain cytochrome oxidase enzymatic activity and oxygen consumption. Since the enzymatic reaction catalyzed by cytochrome oxidase is the reduction of oxygen to water, acceleration of cytochrome oxidase catalytic activity directly causes an increase in cellular oxygen consumption.[6] Increased oxygen consumption by nerve cells is coupled to oxidative phosphorylation. Hence, ATP production increases as a consequence of the metabolic action of near-infrared light. This type of luminous energy can enter brain mitochondria transcranially, and — independently of the electrons derived from food substrates — it can directly photostimulate cytochrome oxidase activity.

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References

[1] – “Biphasic Dose Response in Low Level Light Therapy”; Sulbha K. Sharma (PhD), Ying-Ying Huang (MD), James Carroll, Michael R. Hamblin (PhD)

[2, 3, 4] – “Is light-emitting diode phototherapy (LED-LLLT) really effective?”; Won-Serk Kim (PhD, MD), R Glen Calderhead (PhD)

[5, 6, 7] – “Augmentation of cognitive brain functions with transcranial infrared light”; Francisco Gonzalez-Lima (PhD), Douglas W Barrett (MD)