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Exploring Benefits of Different Wavelengths of Light in Photobiomodulation

Analysis by Dr. Joseph Mercola | November 26, 2026

STORY AT-A-GLANCE

- Photobiomodulation therapy utilizes specific light wavelengths — including 660 nanometers (nm), 850 nm, and 1,050 nm — to stimulate biological processes, each offering unique tissue penetration and therapeutic benefits
- The optical window (600 to 1,100 nm) allows effective light penetration into tissues by minimizing absorption from hemoglobin, melanin, and water, optimizing PBM efficacy
- Red light at 660 nm may support skin health, wound healing, and cellular energy (ATP), and early research suggests it may ease neuropathic pain, with uses in dermatology and wound-healing applications
- Near-infrared light at 850 nm penetrates deeper and is being studied for muscle recovery, pain, and inflammation, with uses in sports medicine and rehabilitation
- Light at 1,050 nm reaches deep tissues and is used in eye imaging. Early studies of nearby wavelengths (1,060 to 1,080 nm) suggest it may support cognitive function

Photobiomodulation (PBM) therapy, also known as low-level laser therapy (LLLT), is a noninvasive therapeutic modality that utilizes light within specific wavelengths to stimulate beneficial biological processes in living tissues.[1]

This article explores the benefits and penetration depths of three distinct wavelengths: 660 nanometers (nm), 850 nm, and 1,050 nm. These wavelengths have unique properties and applications in diverse fields.

Understanding the Optical Window

More than half the wavelengths that come from the sun — 54% — are near-, mid-, and far-infrared. Each of these wavelengths has important health benefits. Solar rays can be divided into three categories:

1. Ultraviolet (UVA, UVB, and UVC), which account for 7% of the solar spectrum
2. Visible light (violet, indigo, blue, green, yellow, orange, red), ranging from 400 to 700 nm, which accounts for 39% of the spectrum
3. Invisible infrared (near-, mid-, and far-infrared) light, ranging from 700 to 10,000 nm, which accounts for 54% of the spectrum

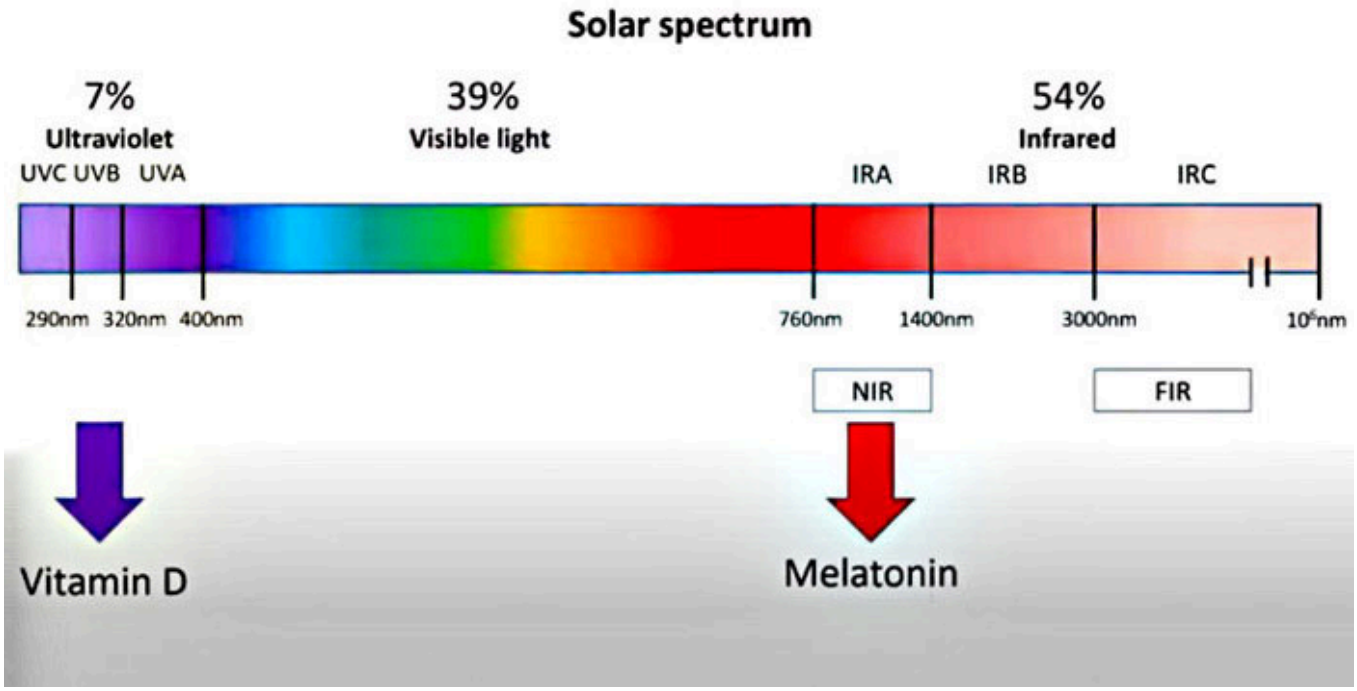

Figure 1. Infrared makes up 54% of the solar spectrum, visible light 39%, and ultraviolet 7%.

- **There's a term in biophysics called the optical window —** This ranges from approximately 600 nm to 1,100 nm; 600 nm is red-orange. Around 700 nm, you get into near-infrared, which becomes invisible and tops out roughly at 1,500 nm.

- **The ideal optical window is between about 600 and 900 nm —** Within this optical window, the wavelengths are long enough to penetrate into the body and reach deep into the tissues, but they're not readily absorbed by hemoglobin, melanin, and water.
- **Below 600 nm, the rays don't penetrate very deep —** What does get into the body gets absorbed by hemoglobin and melanin. The optical window sweet spot is around 800 to 810 nm, which is classic near-infrared. However, research suggests there are benefits at other wavelengths as well.

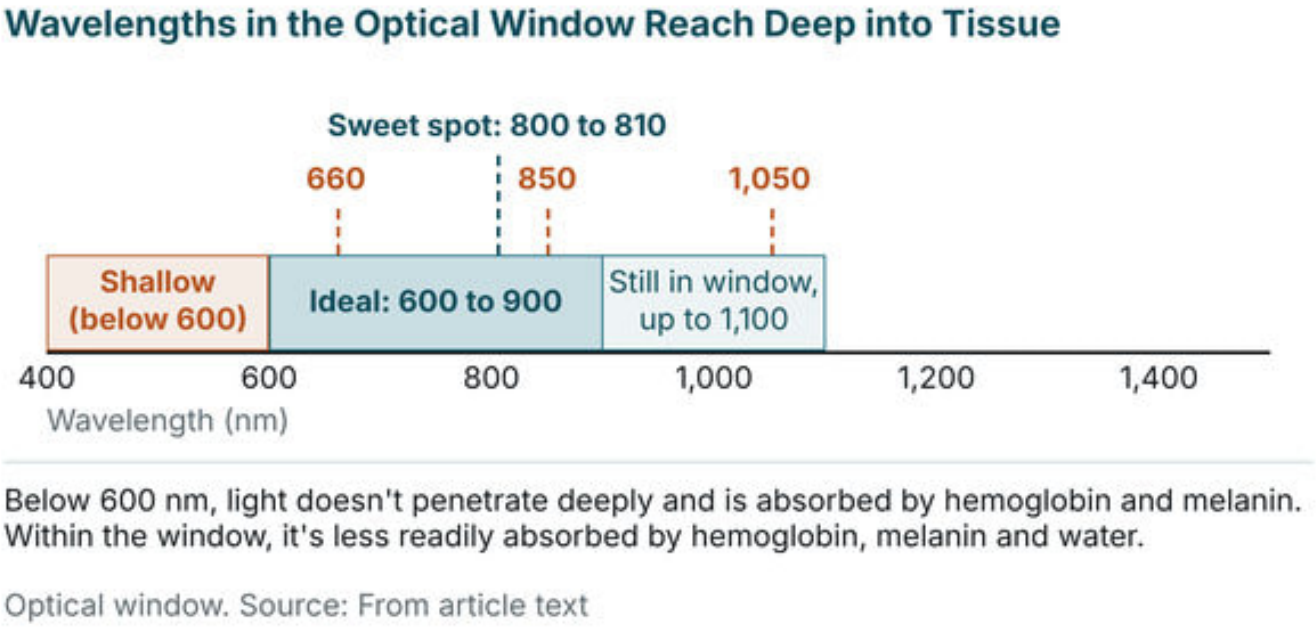

Figure 2. The optical window runs from about 600 to 1,100 nm, with the ideal range at about 600 to 900 nm and a sweet spot around 800 to 810 nm.

What Are the Benefits of the 660 nm Wavelength?

Red light at 660 nm penetrates several millimeters into tissue, effectively reaching the epidermis, dermis, and hypodermis layers of the skin, as well as some underlying tissues.[2,3] This wavelength is largely absorbed in the skin, which makes it a focus of skin health research.[4]

- **The depth of penetration of 660 nm light is influenced by several factors —** These include irradiance (power density), tissue thickness, gender, and bone and muscle composition.[5,6] While light penetration was unaffected by skin tone, it increased with irradiance and relative bone/muscle composition, and decreased with greater tissue thickness and in males. Tissue penetration depths were greater for females than for males.*[7]

- **The 660 nm wavelength offers a range of benefits, particularly for skin health and wound healing —** It has been studied for skin rejuvenation and reducing the appearance of wrinkles.*[8] Additionally, in animal studies, it has sped wound healing and reduced inflammation in the wound.**[9]

Further, early research suggests 660 nm light may reduce neuropathic pain*[10] and increase cellular energy by boosting production of adenosine triphosphate (ATP) in mitochondria.[11] Combining 660 nm with 850 nm near-infrared (NIR) light could have additional benefits, delaying muscle fatigue and enhancing skeletal muscle performance.*[12] This suggests there may be synergistic effects when using multiple wavelengths. Additional benefits of 660 nm light include:

- Increases cellular energy (ATP), which may help cells regenerate[13]

- Accelerates wound healing by increasing the formation of new blood vessels and enhancing collagen deposition in animal studies**[14]

- Stimulates fibroblast differentiation, which is important for wound healing, in lab studies**[15]

- Promotes proliferation in human adipose-derived stem cells, which is considered beneficial in regenerative medicine, in lab studies**[16]

What Are the Benefits of the 850 nm Wavelength?

Near-infrared light (NIR) at 850 nm penetrates deeper into tissues than 660 nm light,[17] and estimates in the literature range up to 50 mm, although intensity drops sharply with depth.[18] This may allow it to reach muscles and joints.[19] Further, 850 nm light is thought to stimulate mitochondrial activity and enhance cellular energy production, promoting tissue repair and regeneration.[20]

- **It has also been shown to enhance M1-related cytokine release —** In a lab study of immune cells, fluid from the cells treated with 850 nm light increased fibroblast proliferation, and the same study found that the light played an anti-inflammatory role by decreasing TNF-α levels.**[21] Separately, in a clinical trial, red light improved skin complexion and collagen density, and broadband light that included 850 nm worked about as well.*[22]

- **The 850 nm wavelength offers a broader range of benefits compared to 660 nm —** Its benefits extend beyond skin health to include muscle recovery and pain management. Its deeper penetration allows it to address issues related to muscles, joints, and deeper tissues, making it a focus of research for athletes and people with chronic pain.

- **It is also being studied for hyperpigmentation —** In lab studies, 850 nm light significantly reduced melanin production and tyrosinase expression, suggesting possible applications in treating hyperpigmentation and melanin-overproducing skin conditions.**[23]

What Are the Benefits of the 1,050 nm Wavelength?

Near-infrared light at 1,050 nm can reach deep into tissues and influence brain structures. This wavelength range is thought to influence cellular processes, including the activation of cytochrome c oxidase, a key enzyme in the mitochondrial respiratory chain, also known as the electron transport chain. In a study of 11 healthy adults, 1,064 nm light applied to the forehead increased cytochrome c oxidase activity in the brain.*[24]

- **The 1,050 nm wavelength offers unique benefits —** These benefits are related to its deep penetration capabilities, particularly in the context of brain health and ophthalmic applications. Early research using 1,060 to 1,080 nm light suggests it may support cognitive function, making it a promising area of research for conditions like dementia.*[25] Additionally, its use in ophthalmic imaging suggests potential for improved diagnosis of eye conditions.[26]

- **Hormesis is relevant to 1,050 nm light therapy —** This is a concept where maximal responses are observed at intermediate doses.[27] This suggests that optimal therapeutic effects are likely achieved with moderate doses.

Meanwhile, animal studies of other near-infrared wavelengths suggest PBM may support the brain's waste-clearance (glymphatic) system.**[28]

Diverse Applications of 660 nm, 850 nm, and 1,050 nm Light

The 660 nm, 850 nm, and 1,050 nm wavelengths of light in photobiomodulation each exhibit unique properties and applications in various fields.

- **660 nm appears most effective for skin health and wound healing —** This is linked to its effects on collagen deposition and cell regeneration in studies. This has implications for dermatology, cosmetic surgery, and wound care.

- **850 nm offers a broader range of benefits due to its deeper penetration into tissues —** These include muscle recovery and pain management. This wavelength holds promise for sports medicine, pain management clinics, and rehabilitation settings.

- **1,050 nm shows promise in brain health and ophthalmic applications —** It can reach deep into tissues and influence brain structures. This has implications for neurology, ophthalmology, and the study of neurodegenerative diseases.

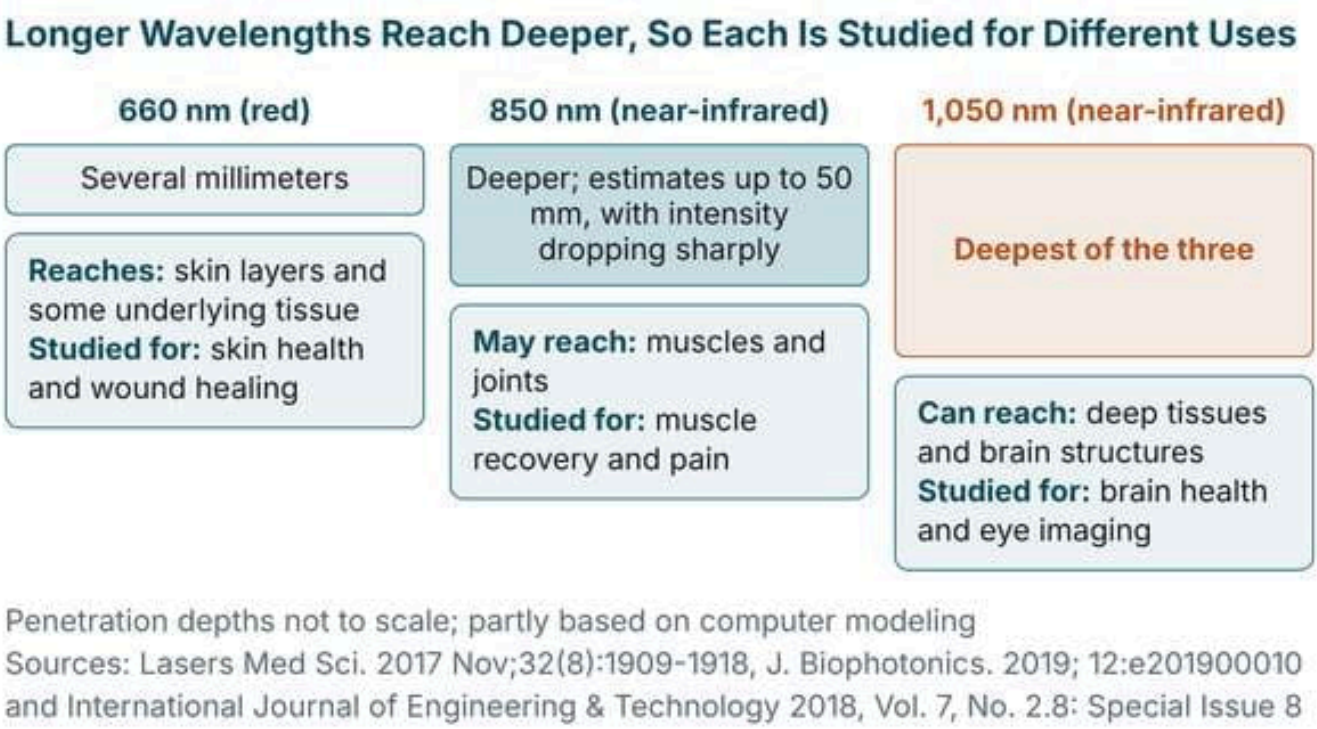

Figure 3. Red light at 660 nm reaches several millimeters into skin, 850 nm reaches deeper toward muscles and joints, and 1,050 nm reaches deepest of the three.

This highlights the versatility of PBM therapy and its ability to address a wide range of health concerns. By continuing to investigate the therapeutic ability of PBM therapy, we can unlock its full range of benefits and improve patient outcomes across various medical specialties.

**These findings are from research conducted in clinical settings. Results may not apply to all individuals.*

***These findings are from laboratory or animal research and may not directly apply to human health.*

Dosing Suggestions

Spending time outdoors provides natural near-infrared exposure, but many people don't get outside on a regular basis. Red and near-infrared therapy has also been studied for athletic performance and recovery,*[29] and a PBM device can deliver more targeted wavelengths as an addition to — not a replacement for — regular sun exposure.

- **For general health, you're looking for the Goldilocks amount of red, near-, and infrared light —** With too little, you don't get a biological effect. With too much, you get into an inhibitory zone. So, what's an ideal dose, in terms of an individual session? Most of the scientific literature uses anywhere from 5 joules to 50 joules. (A joule is a unit of energy equal to 1 watt delivered for 1 second.)

- **As general guidance, get as much full-spectrum sunlight from the outdoors as you can —** If you've been eating seed oils, avoid high-intensity sun until you've been off them for four to six months, then start going into the sun at solar noon. Afterward, use a dose of 25 joules, and take a day off every now and then. With a large panel, that would equate to 10 minutes on the front and 10 minutes on the back, for a total of 20 minutes.

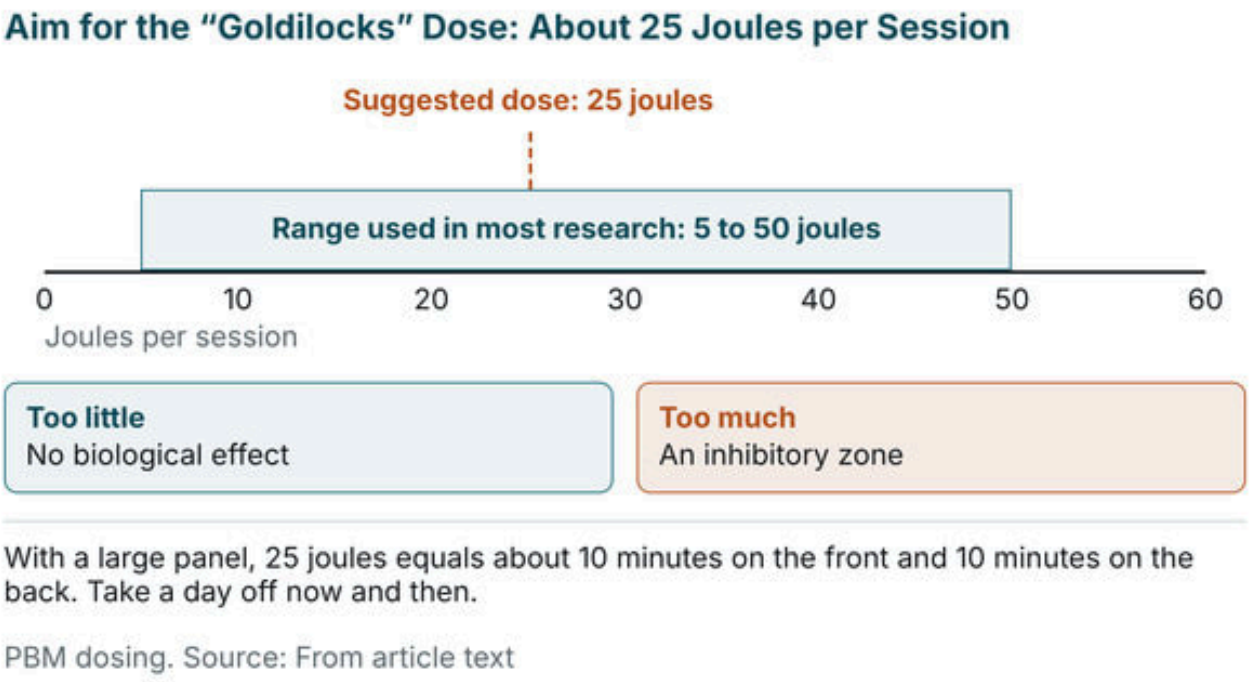

Figure 4. Most research uses 5 to 50 joules per session, and the suggested dose is about 25 joules, which is roughly 10 minutes per side with a large panel.

- **There are no hard rules to go by when it comes to selecting a device —** In general, red is not going to penetrate as deep and is typically used more for skin. Near-infrared will penetrate deeper, which makes it popular for muscle recovery and of

interest for cognitive enhancement. A mixed device gives you the best of both worlds, but you'll need to spend about 50% more time using it, compared to a pure near-infrared device.

The effectiveness of PBM varies depending on factors such as wavelength, power density, and treatment duration. When considering PBM for various health concerns, consult with a health care provider experienced in this therapy. They will help determine the most appropriate parameters for your specific condition and guide you on how to integrate PBM for the best results.

Frequently Asked Questions (FAQs) About Photobiomodulation

Q: What is photobiomodulation (PBM), and how does it work?

A: Photobiomodulation (PBM), also known as low-level laser therapy, uses specific wavelengths of red and near-infrared light (660 nm, 850 nm, and 1,050 nm) to stimulate biological processes, enhance cellular energy (ATP), and may support healing, pain relief, and tissue regeneration.

Q: What is the significance of the "optical window" in PBM therapy?

A: The optical window (600 to 1,100 nm) allows light to penetrate tissues effectively with less absorption by hemoglobin, melanin, or water. This window maximizes therapeutic benefits by targeting deeper tissues for healing and regeneration.

Q: What are the key benefits of the 660 nm wavelength?

A: The 660 nm red light may support skin health, wound healing, and cellular energy, and early research suggests it may ease neuropathic pain. It's mainly used in dermatology, skin rejuvenation, and tissue repair.

Q: How does the 850 nm wavelength differ from 660 nm in its effects?

A: The 850 nm near-infrared light penetrates deeper and is being studied for muscle recovery, joint pain, and inflammation. It's used in sports medicine and rehabilitation.

Q: What makes the 1,050 nm wavelength unique in PBM?

A: The 1,050 nm wavelength penetrates the deepest of the three, and early studies of nearby wavelengths suggest it may support cognitive function. It shows promise in neurology, ophthalmology, and research on neurodegenerative conditions.

This article is for informational purposes only and does not constitute medical advice. Consult a qualified healthcare provider before making changes to your health regimen.

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