LIGHT AND HUMAN HEALTH

Imagine something that could speed healing, enhance brain function, reduce inflammation throughout the body, boost cellular energy production, improve athletic performance, help you lose fat and build muscle, improve your metabolic health and immune function, and even slow the aging process. All without significant side effects. Something so remarkable that if it existed in pill form, pharmaceutical companies would race to patent it, doctors worldwide would prescribe it to millions, it would generate billions in revenue, and it would be widely regarded as a miracle drug. This "drug" already exists—but not as a pill. It is red and near-infrared (NIR) **light.**

Researchers have published more than 6,000 studies on the remarkable health benefits of red and NIR light therapy (photobiomodulation, or PBM)**. Despite it being one of the most significant health discoveries of the last 50 years, most people have never heard of it. This skepticism reveals a crucial gap in our understanding of human biology.**

All humans, from our earliest ancestors until recent generations, have lived most of their lives under open skies, their bodies moving through daily cycles of bright sunlight and fire lights glow. This ancient relationship with light shaped far more than just surface level changes like tanning or pupil dilation; it built essential mechanisms into our cellular machinery that control everything from energy production to immune function, cellular regeneration, hormonal health, DNA repair, and metabolic health.

Many people are familiar with the basic concept that sunlight leads to vitamin D synthesis in our bodies, through ultraviolet light interacting with compounds in our skin. There is also expanding awareness of the role of light, particularly the blue wavelengths of light, entering the eyes and influencing our circadian rhythms. But the relationship between light and human health runs far deeper than this.

Every cell in your body is, directly or indirectly, influenced by light in your environment, either through immediate interactions or slower biological effects that manifest over minutes, hours, and days. Light penetrates our skin and influences our cells—playing a vital role in human health. This isn't some fringe theory or crazy New Age idea.

Humans are far more dependent on light for optimal biological function than it's been previously understood. This isn't speculation—it's grounded in hard science, now documented in thousands of peer reviewed studies. Just as a plant withers without sunlight, humans also rely on light to be healthy, though in less obvious ways.

Our cells require regular exposure to specific wavelengths of light to function optimally, and though it's less outwardly obvious than in a plant, when we are deprived of that light, it takes a profound toll on our health, nonetheless.

If we get poor proportions of nutrients in our diet and consume too much junk food, we become unhealthy. An essential nutrient is a substance that the body absolutely requires to function properly but cannot synthesize on its own (or cannot make it in sufficient quantities)**, meaning it must be obtained from external sources like food or the environment.**

When we lack an essential nutrient, we develop specific deficiency symptoms that can only be resolved by obtaining that particular nutrient—for instance, without vitamin C, we develop the scurvy, without essential amino acids, we can't build proteins properly, and without iron, we can't produce healthy red blood cells.

What makes a nutrient essential isn't just that it's beneficial, but that it's absolutely required for life, causes clear deficiency symptoms when lacking, and serves a unique biological role that cannot be filled by other substances.

Most of us are unaware that just as our body depends on certain nutrients from food—proteins, vitamins, minerals, fatty acids—it also requires specific wavelengths of light to be healthy. We could call these "light nutrients," and like essential nutrients, our bodies need them in certain amounts to function properly. These wavelengths trigger unique biological effects that cannot be replicated by any other stimuli—making them as essential to our cellular health as vitamin-C or Omega-3s are to for overall wellness.

Our ancestors didn't have to think about this, because their outdoor lives provided ample exposure to sunlight during the day. But in just a few generations, we've dramatically altered this relationship, and the magnitude of this light deficiency and modern environments is staggering. Step outside on a sunny day, and your body is bathed in 10,000 to 100,000 lux of full spectrum light. Step into your office, home, or school, and that drops to a mere 100 to 500 lux—a reduction of up to 1000-fold.

Today we spend 97% of our lives on average indoors in artificial environments, resulting in an enormous reduction in light exposure, compared to what our ancestors had. And that's just considering overall light intensity—it says nothing of the differences in exposure to specific wavelengths of light, like red and an IR, blue, far infrared (FIR)**, and ultraviolet** (UV) **light, between outdoor and indoor light.**

Modern artificial lighting provides a severely-impoverished spectrum of light, lacking many of the wavelengths our bodies have evolved to use for specific biological functions. Fluorescent lights and light emitting diodes (LED)**, while energy efficient, emit and unnatural spectrum that bears little resemblance to the sunlight our body's expect and need.**

Even more challenging, we've completely inverted our natural light exposure patterns. Our ancestors spent their days under bright, full-spectrum sunlight and their evenings in the warm, red wavelength glow of fires.

In contrast, we spend our days in dimly lit buildings under artificial lighting that lacks vital wavelengths, then expose ourselves to bright, blue-rich light from screens and LED lighting, well into the night. This inversion of our natural light dark cycles disrupts our circadian biology at a fundamental level, throwing off the intricate timing mechanisms that coordinate countless biological processes.

The vast majority of people living in the modern world are suffering from chronic male illumination and aren't even aware of it. This has widespread effects on our brain and organ function, immune system, energy levels, mood, neurotransmitter balance, hormone levels, metabolic health, and virtually every major system of our bodies.

Like a diet of processed junk food that leaves us over-fed yet under-nourished, our modern lighting environment bombards us with artificial light, while depriving us of the specific wavelengths our bodies need to function properly we get too much of the wrong kinds of light, too little of the right kinds, and receive it at the wrong times. The mal-illumination affects every aspect of our biology, from brain function and neurotransmitter production to hormonal signaling, immune system function, and cellular energy production.

Sunlight deficiency has been linked with numerous diseases, such as:

- **Neurodegenerative diseases like Alzheimer's, dementia, multiple sclerosis, and Parkinson's**
- **Dozens of types of cancers**
- **Obesity**
- **Diabetes**
- **Metabolic syndrome**
- **Heart disease**

Low levels of sun exposure are a risk factor for human health equivalent to that of being a cigarette smoker! Women with the lowest sun exposure have a twofold higher rate of death compared to the women with the most sun exposure, a similar magnitude of increased mortality risk as smokers have compared to nonsmokers!

Adding insult to injury, our evening exposure to artificial light actively compounds these problems. The blue-rich light from our phones, tablets, computers, TV's, and LED lighting doesn't just keep us awake—it triggers a cascade of biological disruptions here in artificial light exposure at night have been linked with numerous diseases, like:

- **Several types of cancers**
- **Depression and many mood disorders**
- **Fat gain, obesity, diabetes, and metabolic syndrome**
- **Insomnia and poor sleep**

This crisis of mental illumination represents one of the most significant yet underappreciated public health challenges of our time. the artificial lighting environments we've created in our homes, workplaces, and schools are fundamentally incompatible with their biological needs, creating a form of environmental mismatch that rivals poor nutrition and its impact on human health.

Most people's light exposure habits in the modern world are the equivalent of eating an all-McDonald's diet—chronically deprived of essential elements needed for optimal health.

While most people are familiar with vitamin D deficiency from lack of sun exposure, and many have heard about blue light's effect on sleep, these well-known issues are merely the visible tip of a much larger iceberg of biological disruption.

The field of photobiology—the study of light's effects on living systems—has transformed our understanding of how light interacts with human biology. Over the past several decades, as nutritional science revealed the crucial role of various food nutrients in human health, photobiology is unveiling the essential nature of specific light wavelengths for human health and healing.

Photobiomodulation (PBM) (modifying biology with light)**, a branch of photobiology focusing on the therapeutic effects of light, has emerged as one of the most significant health discoveries of the last 50 years. Specific wavelengths of light can trigger beneficial biological effects, from enhanced cellular energy production to accelerated healing.**

The idea that light could penetrate our skin and influence our cellular machinery seems almost like science fiction. But again, this isn't just theory—we now have a mountain of scientific evidence elucidating the intricate mechanisms by which these effects occur. But to talk of "light" having effects on human biology is somewhat nebulous—just as it would be to talk of the effects of food on the human body. What kind of food are we talking about? Broccoli or doughnuts, fish or French fries, blueberries or Twinkies? These things act in different ways.

Similarly, light of the wrong type, in the wrong place, wrong dose, or wrong timing, can have damaging effects (from DNA damage in the skin, to macular degeneration in the eyes, to artificial light at night causing metabolic and hormonal havoc)**. Specific wavelengths can also have profoundly beneficial effects on our cellular function and overall health.**

Think of yourselves as sophisticated solar panels, each containing different types of specialized light sensitive components. These cellular structures have evolved over millions of years to capture and utilize specific wavelengths of light in distinct ways. All forms of electromagnetic radiation-- from radio waves to visible light to gamma rays-- interact with matter and specific ways. Our bodies are no exception. We've evolved sophisticated mechanisms to detect, respond to, protect ourselves from, and benefit from various parts of the electromagnetic spectrum.

These wavelengths interact with our cells in remarkably specific ways. When we have deficiencies or excesses of certain wavelengths or when light exposure is mistimed, it can trigger cascades of biological effects that influence everything, from cellular energy production to systemic inflammation, to overall metabolic health, to hormone levels, power and much more.

Inadequate exposure to red and NIR light is perhaps one of the most problematic of these light nutrient imbalances. These wavelengths of light play crucial roles in cellular energy production, tissue repair, and systemic inflammation—processes that affect every aspect of our health.

One reason why reading NIR light deficiencies have been so easily overlooked is that the effects are extremely subtle, despite being widespread throughout every cell in the body. When you get on inadequate ultraviolet exposure, you develop measurable vitamin D deficiency, with the established and well understood harmful effects.

When you get too much blue light exposure at night and insufficient amounts during the day, you were noticeably more tired, irritable, foggy headed, hungry, and negatively affected in a host of other systemic ways by circadian mismatch or dysregulation.

Yet, when you get inadequate red and NPR light exposure, the effects are more subtle, generalized, and insidious, gradually affecting cellular and systemic health, without being immediately noticeable. Red and NIR light play a crucial role in mitochondrial function, supporting energy production, reducing oxidative stress, and promoting cellular repair.

Without adequate exposure, the body's ability to maintain optimal cellular health declines over time. You may not experience obvious symptoms right away and there's no specific biomarker associated with Red and IR light exposure, (as is the case with vitamin D and sunlight)**, but the cumulative impact could manifest as slower recovery, chronic fatigue, reduced resilience to stress, impaired immune function, or over accelerated aging.**

Because these effects impact the body at a cellular level, rather than through a single, easily identifiable deficiency or system, they are harder to directly associate with the lack of red and IR light. This makes it easier for both individuals and healthcare systems to overlook their significance, even though they quietly underlie many aspects of systemic health.

Basically, the absence of adequate red and NIR light doesn't create dramatic immediate dysfunction but subtly chips away at the body's capacity to thrive.

Let's explore the broader context of the full electromagnetic spectrum. The spectrum spans an enormous range—from the infinitesimal wavelengths of gamma rays (0.0001 nanometer [nm]) **to the long waves of radio signals stretching over meters.**

Light, the part of the spectrum we can see, occupies just a tiny slice of this range--roughly 400 to 700 nanometers. Pass sunlight through a prism and you'll see it split into the familiar colors of the rainbow—red, orange, yellow, green, blue, indigo, and violet. These visible wavelengths span from 400 to 700 NM.

At the lowest end of the visible light spectrum are the deep violets around 400 NM, with ultraviolet (UV) **radiation existing below that less than 400 NM. If the lowest end of the visible light spectrum is red light, which goes from a little over 600 to approximately 700 nm.**

Below the visible light spectrum is near infrared, from about 700 to 1400 nanometers but the therapeutic PBM, the focus is typically on the shorter end, from 700 to 1000 nm. Beyond that comes mid-infrared and then far-infrared (FIR) **energy.**

Specific ranges of electromagnetic radiation can powerfully influence human biology. Each of these bioactive wavelengths interacts with our cells in different ways. UV light, particularly in the range of 290 to 400 nanometers, has biological effects that extend far beyond its well-known role in vitamin D synthesis. When UV light strikes the skin, it triggers a complex series of photochemical reactions that begin with the conversion of *7-dehydrocholesterol* to pre-vitamin D3. But this is just the beginning.

UV exposure also modulates the production of numerous other compounds, including beta- endorphins, nitric oxide, and various immunomodulatory molecules. Recent research has revealed that UV exposure influences composition and function of the skin microbiome, affects the production of antimicrobial peptides, and modulates systemic immune responses.

Moving into the visible spectrum, blue light, (ranging from 380 to 500 nm)**, serves as the primary regulator of our circadian rhythm, but its effects extend far beyond simple sleep-wake cycles. When blue light strikes specialized melanopsin-containing retinal ganglion cells, it triggers a cascade of biological events that influence the entire endocrine system.**

These cells connect directly to the supra chiasmatic nucleus—our master biological clock—which then orchestrates the timing of countless physiological processes. The implications are profound: blue light exposure patterns influence everything from hormone production and neurotransmitter balance to metabolic rate and immune function. Proper timing of blue light exposure can enhance cognitive performance, improve mood, and even influence weight regulation through its effects on metabolic hormones.

Having much longer wavelengths, FIR light (3000 to 15,000 nm) **adds another dimension to light nutrition through its thermal and non-thermal biological effects. This wavelength range influences tissue function primarily through its interaction with water molecules affecting cellular water structures and molecular bonds. These effects extend beyond simple heating, influencing blood-flow patterns, cellular metabolism, and the expression of heat shock proteins that play crucial roles in cellular protection and repair.**

FIR exposure can improve cardiovascular function, enhance detoxification processes sweating is a key pathway of detoxification, and influence mitochondrial function through mechanisms distinct from those of red and NIR light.

Among all bio active wavelengths, red light and NIR light hold a unique distinction: they can penetrate far deeper into human tissue than any other wavelength. This ability exists because of what is called the "optical window" or "therapeutic window" in human tissue—a specific range of wavelengths, roughly from 600 to 1000 nm. This window exists because of the unique interaction between different wavelengths of light and the major molecules in our tissues.

Its shorter wavelength light is strongly absorbed or scattered by hemoglobin in our blood and melanin in our skin. At longer wavelengths, water becomes the dominant absorber. But in between—precisely where red and IR light fall—there is a window where light can pass through these barriers much more easily, traveling several centimeters into the body to reach deep tissues.

Once in those deeper tissues, red and NIR light trigger unique and powerful biological effects—interacting with the mitochondria of the cells, altering gene expression, and other mechanisms that enhance cellular repair mechanisms, reduce inflammation, improve collagen synthesis, and accelerate wound healing, among other health benefits.

These unique effects of red and IR light aren't just a coincidence of physics; it's the result of millions of years of evolution. The fact that our bodies maintained this "window" of transparency to red and NIR light, combined with the presence of cellular mechanisms that respond specifically to these wavelengths, these kinds of light played a crucial role in our biological development.

Just as our eyes evolved to see visible light as that was most useful for survival, our deeper tissues evolved this transparency to red and NIR light because these wavelengths provided important biological benefits.

The therapeutic applications of these effects are remarkably broad, from enhancing muscle recovery and athletic performance to improving brain function and metabolic health to enhancing wound healing, all working through natural biological mechanisms that our bodies have evolved to utilize over millions of years.

The field of photobiology has revealed that human biology requires specific wavelengths of light to function properly. Yet our modern lifestyle has created a state of mental illumination. We're not only deprived of essential wavelengths, but we're also exposed to excessive amounts of the wrong types, at the wrong times.

Red and NIR light have remarkable therapeutic effects on human biology. While the sun has been our ancestral source of these wavelengths, modern science has allowed us to harness them more precisely through specific devices for PBMs.

The remarkable effects of this therapy aren't arbitrary—they stem from millions of years of evolution, during which every cell in our bodies developed sophisticated mechanisms to capture and utilize these specific wavelengths of light. These aren't just beneficial wavelengths—they are "essential nutrients" that our cellular machinery depends on, just as it depends on oxygen and glucose.

Just as we would never expect a plant to thrive in darkness, or our bones to stay strong without vitamin D, our cells cannot function optimally without adequate exposure to these specific wavelengths of light. When we apply red and NIR light therapeutically, we're essentially correcting a deficiency—one that affects nearly every person living in the modern indoor world.

The recognition of light as an essential nutrient represents a fundamental shift in our understanding of human health. It forces us to reconsider our modern indoor lifestyle, where we've inadvertently created a state of chronic light malnutrition. These wavelengths and their therapeutic application can have such profound effects on human health and healing.

Through precise application of these wavelengths and therapeutic doses, we can now go beyond and simply correct deficiencies. Modern PBM technology allows us to leverage these ancient cellular mechanisms to achieve an astounding range of benefits, thoroughly documented by scientific research:

Cellular Health and Regeneration

- **Enhance mitochondrial function and cellular energy production**
- **Accelerate healing and tissue repair**
- **Stimulate stem cell proliferation**
- **Reduce systemic inflammation**

Physical Performance and Recovery

- **Enhance strength, muscle mass, and athletic performance**
- **Speed muscle recovery and reduce exercise related soreness accelerate healing from injuries**

Anti-aging and Aesthetics

- **Reduce wrinkles and improve skin tone through increased collagen production,**
- **Promote hair growth**
- **Improved body composition**

Brain and Metabolic Health

- **Enhance cognitive function and mood**
- **Support brain health and sleep quality**
- **Improve metabolic and cardiovascular health**
- **Strengthen immune system response**