

# From Light and the Universe to Light and the Brain

## What the 2026 Nobel Prizes Teach Us About Photon Science and Human Health

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Light has always shaped human life.

It allows us to see the world, measure our surroundings, communicate information, and explore places far beyond the reach of the human eye. Yet modern science is revealing something even more remarkable: light can also serve as a highly sensitive tool for detecting subtle physical events, studying living cells, measuring biological processes, and investigating how the brain works.

The 2026 Nobel Prizes in Physics and in Physiology or Medicine offer two striking examples of this expanding scientific role of light.

The 2026 Nobel Prize in Physics recognized Francis Halzen for his contributions to the IceCube Neutrino Observatory and the discovery of high-energy neutrinos of astrophysical origin. The 2026 Nobel Prize in Physiology or Medicine recognized Karl Deisseroth, Peter Hegemann, and Georg Nagel for discoveries that helped establish optogenetics, a research technology that uses light-sensitive proteins to study and control selected neurons.

These discoveries belong to very different areas of science. Neither should be interpreted as evidence for any particular wellness product or therapeutic technology.

Taken together, however, they illustrate a broader scientific theme:

**Light is becoming much more than something we simply see. It is increasingly a tool for detecting, measuring, understanding, and interacting with complex natural and biological systems.**

That broader perspective is relevant to several rapidly developing fields, including biophotonics, ultraweak photon emission, photobiomodulation, neurophotonics, and the study of brain function.

### 1. Detecting the Universe Through Extremely Weak Light Signals

The story begins far from biology.

Neutrinos are extraordinarily small elementary particles that interact only weakly with ordinary matter. Enormous numbers of them can pass through the Earth without leaving a detectable trace.

Because neutrinos interact so rarely with matter, they are exceptionally difficult to study. At the same time, their ability to travel enormous distances makes them valuable messengers from some of the most energetic events in the universe.

The IceCube Neutrino Observatory approached this challenge in an extraordinary way: scientists transformed approximately one cubic kilometer of deep Antarctic ice into a giant particle detector.

When a high-energy neutrino occasionally interacts with matter in the ice, the resulting charged particles can produce faint flashes of Cherenkov light. Highly sensitive optical detectors embedded in the ice record these signals.

From the timing and spatial pattern of that light, scientists can reconstruct information about the neutrino that produced it.

The lesson extends beyond astrophysics:

**Extremely weak optical signals can contain meaningful information when they can be reliably detected, measured, and interpreted.**

The light detected by IceCube has nothing to do with health or wellness. It is a physical signal used to study neutrinos.

But the achievement illustrates an important principle of modern science: phenomena that were once too faint to observe can become scientifically meaningful when measurement technology becomes sufficiently sensitive.

This principle also inspires questions in biology.

Could living systems themselves produce extremely weak optical signals that reveal something about their biochemical state?

Research into **ultraweak photon emission** is exploring exactly that question.

## **2. From Observing the Brain to Using Light to Study Neural Circuits**

The 2026 Nobel Prize in Physiology or Medicine brings the story of light much closer to biology.

Researchers Peter Hegemann and Georg Nagel helped characterize light-sensitive proteins known as channelrhodopsins. These proteins can respond to light by changing the movement of ions across a cell membrane.

Karl Deisseroth and other researchers subsequently developed ways to use these molecular tools in neurons, helping establish the field now known as **optogenetics**.

Optogenetics allows researchers to make selected neurons responsive to light. Scientists can then use carefully controlled light to activate or inhibit those neurons with remarkable temporal precision.

This has transformed neuroscience.

Before technologies such as optogenetics, researchers could often observe an association between activity in a brain region and a particular behavior.

But association alone does not establish causation.

Optogenetics made it possible to ask much more precise experimental questions:

**Select a defined population of neurons**

→ **control their activity with light**

→ **observe what changes**

→ **study the function of the neural circuit**

This approach has contributed greatly to scientific understanding of neural pathways involved in movement, memory, sleep, sensation, emotion, and behavior.

The broader lesson is important:

**Under the appropriate biological conditions, light can interact with cells through specific molecular mechanisms.**

But an equally important scientific distinction must be maintained:

**Optogenetics is not photobiomodulation.**

Optogenetics generally depends on introducing or expressing specific light-sensitive proteins in selected cells.

Photobiomodulation investigates different biological interactions involving externally delivered light and naturally occurring cellular molecules and signaling processes.

The two fields demonstrate the extraordinary versatility of light in biology, but their mechanisms should not be confused.

### **3. Biophotons: Living Systems Also Produce Extremely Weak Light**

Light does not travel only from the outside world into living organisms.

Living cells and tissues can also emit very small numbers of photons.

This phenomenon is generally known as **ultraweak photon emission**, or **UPE**, and is sometimes described as **biophoton emission**.

These emissions are extremely faint—far below the level visible to the human eye.

Scientific studies have associated UPE with biochemical processes involving cellular metabolism, oxidation-reduction reactions, reactive oxygen species, and lipid oxidation.

This leads to a fascinating but scientifically careful observation:

**Living systems do not merely interact with light; biological processes can also generate photons.**

At present, one of the most defensible scientific interpretations of UPE is that it may provide information about aspects of cellular metabolic and oxidative activity.

Researchers are studying whether these signals could eventually have additional value as noninvasive indicators of biological states.

More speculative questions have also been raised.

For example:

Could ultraweak photons participate in biological signaling?

Could photon emission patterns contain information beyond their relationship with oxidative metabolism?

Could neural activity be associated with measurable changes in ultraweak photon emission?

These are legitimate scientific questions, but they remain active areas of research.

It is therefore important to distinguish between what has been observed and what remains hypothetical.

**Scientific evidence supports the existence of ultraweak photon emission from living systems.**

That observation alone does **not** establish that naturally occurring biophotons provide long-range cellular communication, regulate whole-body physiology, or produce health benefits.

Those questions require further research.

#### **4. Photobiomodulation: Studying How Light Interacts with Living Cells**

A related but distinct scientific field is **photobiomodulation**, commonly abbreviated PBM.

While UPE research asks:

##### **What light do living cells produce?**

PBM research asks:

##### **What happens when externally delivered light interacts with living cells and tissues?**

PBM research frequently examines low-intensity red and near-infrared light under defined experimental conditions.

Scientists have investigated a number of possible cellular mechanisms, including interactions involving mitochondrial function, cellular photoacceptors, redox signaling, ATP, nitric oxide, reactive oxygen species, calcium signaling, and downstream cellular pathways.

A simplified research framework might be expressed as:

##### **Light**

→ **interaction with biological molecules**

→ **cellular signaling**

→ **changes in cellular activity**

The details are much more complex.

Biological responses can vary according to wavelength, intensity, exposure duration, total energy, tissue characteristics, and many other experimental variables.

For this reason, responsible discussion of PBM should avoid simplistic statements such as “light is always beneficial” or “more light produces a greater effect.”

Instead, PBM is best viewed as an active field of biophysics and biomedical research examining how defined optical exposures interact with living systems.

Importantly, findings from PBM research should not automatically be transferred to another light-related technology or product.

Different light sources, wavelengths, intensities, delivery methods, and biological environments may produce very different effects.

## **5. Why Scientists Are Interested in Light and the Brain**

The human brain is one of the body's most metabolically active organs.

Neurons continuously use energy to maintain membrane potentials, transmit electrical signals, release neurotransmitters, maintain synapses, and support normal cellular activity.

Mitochondria therefore play an important role in normal neuronal energy metabolism.

This relationship—

**mitochondrial activity → cellular energy → normal neuronal function**

—has contributed to scientific interest in the interaction between light, cellular metabolism, and neuroscience.

Researchers are studying a wide range of optical approaches to understand the brain, including:

- optical imaging,
- optogenetics,
- functional spectroscopy,
- photoacoustic methods,
- photobiomodulation research,
- and other forms of neurophotonics.

Some research groups are also investigating transcranial applications of light.

These studies face substantial scientific and engineering challenges. Light delivered outside the head must encounter the scalp, skull, blood, cerebrospinal fluid, and other tissues before reaching deeper structures.

Accordingly, rigorous studies must consider questions such as:

**What wavelength is being used?**

**What intensity is delivered?**

**How long is the exposure?**

**How much light penetrates the tissue?**

**What biological molecules interact with it?**

**What measurable physiological changes occur?**

These questions illustrate why photon science is becoming increasingly quantitative.

The future of the field will depend not simply on showing that light and biology interact, but on accurately determining **how, where, when, and under what conditions those interactions occur.**

## **6. Optogenetics, PBM, and Biophotons: Related by Light, Different in Mechanism**

Because all three fields involve photons, it can be tempting to combine them into a single explanation.

Scientifically, that would be inappropriate.

They address different questions.

### **Optogenetics**

Uses defined light-sensitive molecular tools to investigate or control selected cells, particularly neurons.

### **Photobiomodulation**

Investigates how externally applied light under defined conditions interacts with endogenous biological molecules and cellular processes.

### **Biophoton / UPE Research**

Studies the extremely weak photons naturally emitted by living cells and tissues.

These fields share a common theme—**the interaction between photons and biological systems**—but they are not interchangeable.

Evidence supporting one field should not automatically be presented as proof of another.

This distinction is especially important when basic science is communicated to the public.

## **7. One of the Most Fascinating Unanswered Questions**

Modern research has established two intriguing observations.

First:

**Living systems can absorb light and respond to photons through specific biological mechanisms.**

Second:

**Living systems can themselves generate ultraweak photon emissions.**

That naturally leads to a fascinating scientific question:

**Could naturally generated ultraweak photons have biological functions beyond being products of cellular chemistry?**

Scientists do not yet have a definitive answer.

The emissions are extremely weak, and establishing biological signaling would require demonstrating that a signal can be generated, transmitted, detected by another biological system, distinguished from background noise, and linked reproducibly to a physiological response.

Those are demanding experimental criteria.

A useful way to describe the current evidence is therefore:

**Well established:**

Living cells and tissues can generate ultraweak photon emission.

**Well established:**

Specific biological molecules can interact with specific wavelengths of light.

**Well established:**

Under appropriately engineered experimental conditions, light can precisely influence selected neuronal activity, as demonstrated by optogenetics.

**Actively being investigated:**

The biological significance of endogenous ultraweak photon emission.

**Not established by these observations alone:**

That altering an ultraweak photon environment necessarily produces specific health or therapeutic outcomes in humans.

That final distinction is essential to responsible scientific communication.

## **8. From Photon Science to the Future of Health Research**

The phrase “**photon medicine**” can be inspiring, but it should not be interpreted as referring to one technology, device, mechanism, or therapy.

A broader and more scientifically useful concept is:

**The use of photons to observe, measure, image, investigate, and—in appropriate scientific or medical contexts—modulate biological processes.**

This broader field already includes many technologies:

**Optical imaging**

**Laser technologies**

**Photodynamic approaches**

**Optogenetics**

**Photoacoustic imaging**

**Photobiomodulation research**

**Retinal photostimulation**

**Ultraweak photon detection**

**Molecular optical probes**

**Neurophotonics**

These technologies differ substantially in their mechanisms and applications.

What connects them is not a single medical claim.

What connects them is the growing ability of science to use light with extraordinary precision.

We are gradually moving:

**from observing organs to studying cells,**

**from observing structure to studying function,**

**from detecting visible signals to measuring extremely weak ones,**

**and from broad observations to increasingly precise biological measurements.**

## **9. What the 2026 Nobel Prizes Really Teach Us**

At first glance, detecting a high-energy neutrino deep inside Antarctic ice and controlling selected neurons with light seem to have very little in common.

Yet both achievements demonstrate how scientific progress can emerge when researchers develop new ways to detect or use light.

IceCube shows that:

**A very weak optical signal can reveal information about processes occurring far beyond our direct perception.**

Optogenetics shows that:

**Precisely controlled light, combined with the appropriate molecular biology, can reveal how neural circuits function.**

Biophoton research asks:

**What can the ultraweak photons naturally emitted by living systems tell us about biology?**

Photobiomodulation research asks:

**How can defined wavelengths and exposures interact with cellular processes?**

Each question represents a different scientific field and a different level of evidence.

They should not be merged into a single mechanism.

But together they illustrate a remarkable scientific frontier:

**From using light to observe the world,  
to using light to understand life.**

And perhaps, as science advances, toward increasingly precise ways of using photons to measure and interact with biological systems.

The most exciting future for photon science does not require attributing mysterious properties to light.

Quite the opposite.

Its promise lies in making light increasingly **measurable, quantifiable, reproducible, and scientifically understandable.**

That is where physics, biology, neuroscience, engineering, and health science increasingly meet.

And that intersection may become one of the most fascinating areas of scientific discovery in the decades ahead.

### **Scientific and Wellness Information Notice**

This article is provided for general scientific and educational purposes. It discusses published areas of research involving photons, optogenetics, biophotonics, ultraweak photon emission, photobiomodulation, and neuroscience.

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