Glossary of Terms

Specific to the general field of Light Therapy

Absorption:

When light quanta travel through tissue, the energy is eventually absorbed by some component within the tissue. When energy is absorbed by water or some organic molecule the energy is dissipated as heat and removed through the body's cooling system.

When energy is absorbed by a biological chromophore, the energy is transferred to a molecule (e.g., chromophore, cell membrane lipid, amino acid, or nucleic acid). Transfer of photon energy can cause,

- **A Change in the energy state of an electron** (mitochondrial electron transport chain) catalyzing a chemical reaction,
- **Donation of an electron** to a re-dox molecule (Cytochrome oxidase, hemoglobin, melanin, serotonin, porphorin ring, amino acid, nucleic acid etc.,) activating or inhibiting a biological response, or
- **Ionization of a chemical bond** (ion or protein channel on the cell, mitochondrial or nuclear membrane) producing a chemical reaction, which changes a cell's homeostatic set point.

Heat is not transferred to the tissue

Biological Amplification:

When photobiomodulation occurs, the photon activates a chromophore, amino acid, nucleic acid, or molecule. Activation of a single enzyme molecule rapidly catalyzes thousands of other chemical reactions amplifying the signal to the cell.

This is similar to the well known, calcium regulated, 2nd messenger cAMP cascade. B**iological amplification** explains how systemic, cellular, and clinical effects can occur almost instantaneously after exposure to light therapies.

Biomodulation:

The process of changing the natural biochemical response of a cell or tissue within the normal range of its function, stimulating the cell's innate metabolic capacity to respond to a stimulus. A cell can heal itself by this basis.

Chromophores:

Chromophore literally means, "Color lover" (***L. chromo*** = color; *L. Phore* = to seek out, to have an affinity for, to love). Chromophores are generally pigmented molecules that accept **photons** within living tissue. When the chromophore accepts a photon, it causes a **biochemical** change within an atom, molecule, cell or tissue. If this change increases cellular function, it is said to have activated the tissue. If this change decreases cellular function it is said to have inhibited the tissue. Biomodulation occurs in both cases.

Dose:

The term dose is an estimate of a ***therapy***, traditionally a drug, which produces a desired therapeutic action without harmful side effects. The **therapeutic dose** (safe and effective) range is defined by clinical evaluation of the response of a sufficient number of patients, generally 50 percent who improve without toxicity.

Drugs are evaluated at doses to which 20%, 70% or any percentage to which a subject responds.
It is customary to calculate:

Median Effective Doses or ED_{50}, the dose that gives rise to a response in 50 % of the subject

Median Toxic Dose or TD_{50} is the dose that manifests toxic side effects in 50 % of the subjects

Median Lethal Dose
or LD_{50} is the dose that gives rise to the death of 50% of the subjects

In general a therapy (traditionally a drug) is considered safe when the harmful LDR region of the side effects is much greater than the therapeutic dose range, expressed by:
Therapeutic Index: TI = TD 50/ED50
Medical Principles of Pharmacology, 1990

Frequency Biomodulation:

Biomodulation caused by specific frequencies produced by therapeutic light devices is called frequency biomodulation.

Infrared:

Wavelengths above 760 *nm* are considered lower than red or infrared wavelengths. They carry or transfer heat from one object to another. They have been utilized for thermal applications for many years in the medical field as infrared lamps.

Irradiation Dose *(J/cm²)*:

Irradiation dose is defined by the product of the power density (mW); exposure time divided by area irradiated and is reported as Joules of energy per square centimeter (*J/cm²*).

ID (*J/cm²*) = P (*mW*) X T (*sec*) / A (*cm² /sec*)

LASER:

L**ight **A**mplification** *by* ***S**timulated **E**mission** *of* ***R**adiation; refers to the specific qualities and methods by which lasers produce light. Originally theorized and defined by Albert Einstein in 1917, it could not be produced until the 1950s. Laser light is *Coherent, has a Monochromatic wavelength, is Collimated, and Polarized*. These four characteristics differentiate Laser's form LED, SLED, IR, and UV light therapies.

LED:

***L**ight **E**mitting **D**iode*: There are thousands of different types of diodes that can emit light ranging in power density and bandwidths of wavelength. All semiconductor lasers produce light from a diode, LED. However, not all LED's are Lasers. A laser can have an LED in it (color of the light produced). However not all LED's can produce **LASER** LIGHT which is coherent, monochromatic, collimated, and polarized light.

Milliwatt (*mW*):

A unit of power equal to one thousandth (10^{-3}) of a watt or. Treatment lasers commonly utilize from < 5 *mW* to 100,000 *mW* of power.

Nanometer *(nm)*:

One nanometer is one billionth of a meter. 10^{-9} meters or .000000001 meter = 1 *nm*.

Neuroplasticity:

Neuroplasticity represents the brain's ability to reorganize itself by forming new neural connections throughout life. Neuroplasticity provides a way for nerve cells (neurons) in the brain to respond and compensate for injury and disease and adjust neuronal activity in response to a new situation or to changes in the environment.

Reorganizing the brain occurs by the mechanism of "axonal sprouting" where damaged axons grow new nerve endings to reconnect neurons whose links were injured or severed. Undamaged axons can also contribute new nerve endings and connect with other undamaged nerve cells, forming new neural pathways to accomplish a needed function. In order for neurons to reconnect or form new connections, the neurons need active stimulation.

Neuroplasticity, represent unlimited potential to retrain the brain after injury. However, Neuroplasticity can also contribute to impairment. For example, deaf individuals may suffer from continual ringing in the ears (tinnitus), which results from faulty rewiring of the brain cells starved for sound. For beneficial neural connections to form, neurons must be stimulated correctly.

Neuroplasticity represents a new rapidly evolving approach to healing. *Given any trauma, realizing all traumas involve the central nervous system recognizing the trauma (consciously or subconsciously), quick response with activity neuronal stimulation, could theoretically maintain, repair, retain most CNS functions (learning, memory, speech, emotional distress, movement, balance etc.)*

Even the simplest memory stimulates complex neural networks at several different sites in the brain. The content (what happened) and meaning (how it felt) of an event are laid down in separate parts of the brain. The goal of neuroplastic therapy is to connect these sites to resolve the damaged, disjointed, dysfunctional nervous systems.

"…It's not magic, it's malleable"

Penetration:

Propagation of light though tissue is regulated by three properties, ***Reflection, Penetration, and Absorption.*** Penetration refers to the distance an energy wave travels into the tissue before it is absorbed and dissipated as heat or molecular vibration. Penetration is a physical and thermal phenomenon, not a therapeutic phenomenon.

Pharmacological Dose:

A pharmacological dose of any therapy is the dose necessary to produce and maintain desired effect. The goal is to have a drug or therapy to stay above or at the threshold level for effective therapeutic action but below the toxic level.
Therefore;

- A pharmacological dose always contains risk and WILL DO HARM.
- A pharmacological dose seldom improves health on its own merit.
- A pharmacological dose will generally be predictable and consistent for symptomatic response because it is measuring a response to a concentration, exposure, etc. mostly independent of the body – overrides the normal physiology of the patient.

Photobiomodulation:

When biomodulation occurs from a photon transferring its energy to a chromophore it is called photobiomodulation. Photobiomodulation can occur three ways:

- The absorbed photon **changes the energy state of an electron** (mitochondrial electron transport chain),
- The absorbed photon **donates an electron** to a re-dox molecule (Cytochrome oxidase, hemoglobin, melanin, serotonin, porphorin ring, amino acid, nucleic acid etc.),
- The absorbed photon **ionizes a chemical bond** (ion or protein channel on the cell, mitochondrial or nuclear membrane) thereby producing a cellular response which changes the cell's homeostatic set point.

Photon:

The **photon** is an elementary particle, or a particle that cannot be split into anything smaller. **Photons** have no electrical charge or mass, but they do have energy and momentum, which allows photons to transfer energy to an atom, molecule, cell, or tissue when the photon collides with them.

Physiological Dose:

A Physiological Dose of any therapy is designed to stimulate production of, or provide to the body what it needs to normalize and heal itself through biomodulation. The symptomatic response to a physiological dose of therapy is dependent of the capacity of the patient's body to respond to the therapy. The physiological dose of any treatment has specific advantages.

- A **physiological response** represents the body's own response to a stimulus (e. g., adrenaline in response to a "fight or flight" challenge) and is generally safe and will **DO NO HARM**.
- A physiological dose generally improves the patient's health.
- A physiological dose will always be less predictable and consistent than a pharmacological dose for symptomatic response because it depends upon an interaction with the individual patient's entire body system.

Power Density *(mW)*:

Power density is synonymous with the Watts of power produced by the light source. *P = mW*

Quanta *(q)*:

According to the quantum **theory**, electromagnetic energy is transmitted in discrete amounts (i.e., in units or packets) called **quanta**. A single unit or quanta (*pl*. **quantum**) of electromagnetic energy can also be referred to as a photon.

Reflection:

Propagation of light though tissue is regulated by three properties, Reflection, Penetration, Absorption. When energy waves strike the skin of any tissue, they will either pass through or reflect off the tissue. A skin can be defined as the outer surface of any tissue, the body, the cell, the nucleus, mitochondria, organs, etc. The energy's ability to pass through a surface tissue is dependent on the collimation, coherency, wavelength and polarization of the light. Reflected energy has no therapeutic effect to the internal tissue and is a natural *in vivo* defense mechanism developed by which the body to protect itself against radiation (e.g., sunlight, IR, UV radiation)

SLD:

Super **L**uminescent **D**iode; is a specific type of LED that has a higher emission of energy than typical LEDs. All other aspects are the same as other LEDs.

Ultraviolet *(UV)*:

Wavelengths below 380 *nm* are considered above violet or ultraviolet wavelengths. This wavelength of energy causes non-thermal burns and destruction of organic substances. It is commonly used as a non-thermal antiseptic for topical infections such as acne or to sterilize products such as your toothbrush.

Visible light:

Wavelengths between 760 *nm* and 380 *nm* are visible to the human eye and defined as visible light. Wavelengths within the visible range, 600 to 720 *nm*, are reportedly produce ***peak*** photobiomodulation through photon energy transfer to an atom, molecule, cell membrane or biological chromophores.

Wavelength *(nm)*:

Electromagnetic energy travels in peaks and lows of energy. The distance between waves of peak energy determines the wavelength. The wavelengths of energy range from as long as many miles to as small as a single atom.

Frequency *(Waves per Second - f)*:

Light travels in excess of 186,000 miles per second. The number of waves that pass any given point in one second or, waves per second, also called the frequency of energy. The energy *(E)* carried by each photon is proportional to its frequency (wavelength) through this equation: $E = hf$ where $F = 1/nm$