MEDLASER™ FOUNDATION PHOTOMEDICINE THERAPY TRAINING PROGRAM, TABLE OF CONTENTS

MODULE I – THE GENESIS OF PHOTOMEDICINE

INTRODUCTION & OUTLINE

- The Genesis of Photomedicine (Laser) Therapy
- Photomedicine (Laser) Therapy Terminology
- Photomedicine (Laser) Therapy Contraindications

LEARNING OBJECTIVES

Upon completion of this module, you should be able to:

1. Know and comfortably use common photomedicine (laser therapy) terminology
2. Understand the nature of energy and matter, and the conservation principle
3. Understand simple physical laws as they apply to photomedicine
4. Understand the difference between allopathic medicine and the Einsteinian approach
5. understand the basic mechanics involved in photomedicine
6. Understand the relevance of the Reciprocity Rule to photomedicine
7. Understand how cold laser therapy, or Low-Level Laser Therapy is ineffectual in Producing a positive clinical outcome

NOTE: information in this document is based on randomized clinical double-blind research studies and peer-reviewed papers published https://www.ncbi.nlm.nih.gov/, the National Center for Biotechnology Information, which advances science and health by providing access to biomedical and genomic information.

The Nature of Matter

Matter is the "stuff" of the universe — the atoms, molecules and ions that make up all physical substances. Matter is anything that has mass and takes up space. Energy is matter, and matter is energy. Energy is the capacity to cause change in matter. Energy cannot be created or destroyed; it can only be conserved and converted from one form to another.

Present day medical views are deeply rooted in a Newtonian approach called allopathic medicine (traditional, or conventional Western medicine.). According to Dr. Richard Gerber (author of *Vibrational Medicine*), "physicians often conceptualize the body as a type of machine which is controlled by the central computer (the brain and central nervous system); the ultimate biological computer." Newtonian ways of thinking were initially conceptualized in the industrial revolution - more than one hundred years ago. Present-day physicians see the body as a complex machine, in which the heart is a mechanical pump that delivers nutrients and oxygen to the various parts of the system; the body being a series of tubes and wires. Today, physicians can replace, create, and even synthesize organs and systems of the body. Doctors have become the mechanics and even architects of the various systems of our bodies.

Is there a better approach to healing?

ALL MATTER (INCLUDING BIOLOGICAL MATTER) IS ENERGY

The Einsteinian paradigm is the opposite of the Newtonian model. Dr. Gerber states, “energy medicine sees human beings as networks of complex energy fields and vibrating bits of energy that interface with the physical/cellular systems.

Energy medicine in laser therapy uses quantum packets of energy to stimulate systems in the body that are either lacking energy or filled with chaotic energy that is uncoordinated due to diseased states or injury. Energy medicine repairs the body by inducing absorption of vibrational bits of stimulated energy provided by photon generators (another name for therapy lasers). Stimulated energy is delivered via therapeutic wavelengths in the so-called optical window (infrared - between 605nm and 1200nm).

Lasers

The term laser refers to **L**ight **A**mplification via **S**timulated **E**mission of **R**adiation. Light, or photonic energy, is the basic force carrier of the universe, consisting of basic (quantum) bits of energized matter that in turn makes up everything in our universe. Photomedicine consists of stimulated energy emissions from therapy lasers that transfer energy to targeted areas, increasing cellular energy, rapidly repairing of sick and injured tissues.

The human body is uniquely designed to absorb infrared energy via chromophores (light-energy absorbing particles found in our mitochondrial DNA and other substances in the body, fluid in the body’s tissues, melanin, blood, and plasma). We will learn more about chromophores in Module II of the Laser Therapy Training Program). Mitochondria absorb infrared energy particles which are then converted to ATP (adenosine triphosphate), the primary energy source of the body. Additionally, a virtual cascade of other biophysical reactions occur that benefit targeted tissues in many ways.

LASER HISTORY

Before Common Era (BCE)

Light has been recognized as a healing source of energy since the early days of recorded time. Ancient Greeks, Romans, and Egyptians, practice Heliotherapy, or the use of sunlight to treat various ailments. To this day even, jaundiced infants are still placed in sunlight to resolve the condition.

PRESENT DAY

1672

In the 17th century, Sir Isaac Newton identified the visible spectrum when he separated light into many colors with a prism.

1916

Albert Einstein first theorized stimulated emission of light energy in 1916 - this became the basis for the design and production of lasers.

1960

In the nineteen forties through the nineteen fifties, scientists and engineers worked to produce devices based on the principles of stimulated emissions of energy called MASERs, which stood for microwave amplification by stimulated emission of radiation. These devices were useful for their immediate application in microwave communication systems. Additionally, optical MASERs were conceived, devices that created powerful beams of light using higher frequency energy to stimulate what was termed the lasing medium. As a result, the first laser was invented in 1960 by Theodore Maiman at the Hughes Research Laboratory using a ruby gemstone as a laser medium.

1967

In 1967 the biological benefits of stimulated light energy in living tissues (including an instant wound healing) was discovered by Hungarian physician and surgeon Endre Mester, considered the first pioneer of laser medicine. By the nineteen seventies, Mester was applying low level laser therapy to treat people with skin ulcers. In 1974, Mester founded the laser research Center at the Semmelweis medical University in Budapest, and continued working there for the remainder of his life. His sons continued his work and brought it to the United States.

By 1987 low-level laser manufacturers were claiming that they could treat pain, rheumatoid arthritis, and accelerate healing of sports injuries, but there was little evidence available to prove the various claims. Mester had initially called this approach laser biostimulation; with the adaptation of light emitting diodes by those studying Mester's applications it became known as low level light therapy. with the advent of light emitting diodes or LEDs, production of lasers became much simpler and less expensive. It was at that time that the term Photobiomodulation became a traditional descriptor for low level laser therapy.

Since that time, scientists and physicians have come to understand more about the nature of stimulated light energy and the need to provide adequate dosages in order to stimulate the desired outcomes, all the while developing new techniques and devices for the use of lasers in medicine.

Numerous examples exist of light induced photochemical reactions in biological systems; For example, vision is based upon light interacting with photosensitive cells in the retina called photoreceptors. When light is absorbed by these cells, a photochemical reaction occurs converting light energy into electrical signals that are transmitted to the visual processing centers of the brain. Another example is vitamin D synthesis; this is a photochemical reaction that occurs when the ultraviolet B (UVB) wavelength in sunlight is absorbed through the skin, converting a ubiquitous form of cholesterol 7-dehydrocholesterol to vitamin D3. Two well-known examples of this concept include seasonal affective disorder (SAD) and lack of vitamin D production leading to rickets.

Under the medical subject heading low level light therapy, many additional terms are now accepted as alternatives: LLLT, photobiostimulation, PBMT, photomedicine, phototherapy, low level laser therapy, low power laser irradiation, low power laser therapy, etc. More specific applications include additional terminology, for example laser acupuncture when applied to acupuncture points, and transcranial laser therapy when applied to the head.

2002

With the advent of higher levels of laser energy in photomedicine from 2002 onward, other alternate terms for laser therapy have been added including HILT high intensity laser therapy, HVLT or high-volume laser therapy and so on. Since that time, it was discovered that appropriate dose level requirements were primarily governed by various tissue factors, including body mass index, skin color, tissue age and health, tissue hydration levels, and more. Although many low power device manufacturers still cling to the idea that only very low-level power output and dosage parameters are appropriate, the laws of physics plus empirical and anecdotal evidence tells us otherwise. Although little evidence of low-level laser therapy benefits in the treatment of musculoskeletal, neurological, vascular and autoimmune conditions exists, variably higher dose levels based on tissue variability factors provide ample evidence of pain relief and tissue healing.

As with any energy treatment, the ability to heal with therapeutic laser energy is only equaled by its corresponding ability to harm tissues. In other words, in order for any kind of energy healing therapy to stimulate a radical change to targeted tissues it must have a comparable ability to damage the same tissues. this has proven by several physical laws including the Bunsen Roscoe Law of Reciprocity, the Grotthuss–Draper Law, the Stark-Einstein Law, and the Beer-Lambert Law. Physiological absorption and conversion of stimulated infrared wave energy in the body is therefore governed by the following:

The Reciprocity Rule in Photomedicine, Bunsen Roscoe Law

The Reciprocity Rule states that specific biochemical and energy field interactions that occur in the body are directly proportional to the total energy dose received and governed by specific tissue variability factors; in this document, we define those factors and identify appropriate energy dosages required to effectively stimulate the desired tissue interactions.
http://www.photobiology.com/reviews/bunsen/index.htm

Grotthuss–Draper Law

"Only radiation absorbed in a system can produce a chemical change."
The Grotthuss–Draper Law (also called the Principle of Photochemical Activation) states that only that light which is absorbed by a system can bring about a photochemical change. This law provides a basis for fluorescence and phosphorescence; the law was first proposed in 1817 by Theodor Grotthuss and in 1842, independently, by John William Draper.
http://www.newworldencyclopedia.org/entry/Photochemistry

Stark–Einstein Law

"Number of activated molecules = number of quanta of radiation absorbed."
The Stark–Einstein law is named after German-born physicists Johannes Stark and Albert Einstein, who independently formulated the law between 1908 and 1913, and is also known as the Photochemical Equivalence Law. It says that every photon that is absorbed will cause a (primary)

chemical or physical reaction; the photon = one unit of radiation; therefore, this is a single unit of EM radiation that is equal to Planck's constant (h) times the frequency of light. This quantity is symbolized by γ, hν, or ħω.
http://ccb.rutgers.edu/sites/default/files/coursefiles/courses_sp10/512/Handout_I_Photochemistry_I.pdf

The Beer-Lambert Law (or Beer's law) is the linear relationship between absorbance and concentration of an absorbing species. The general Beer-Lambert law is usually written as: A = a(lambda)*b*c, where A is the measured absorbance, a(lambda) is a wavelength-dependent absorptivity coefficient, b is the path length, and c is the analyte concentration. When working in concentration units of molarity, the Beer-Lambert law is written as: A = epsilon * b * c, where epsilon is the wavelength-dependent molar absorptivity coefficient with units of M -1 cm -1.
http://www.pci.tu-bs.de/aggericke/PC4/Kap_I/beerslaw.htm

TISSUE VARIABILITY FACTORS

Additionally, further consideration of established values in biological (patient) factors needs to be considered for satisfactory results in photomedicine; we call these values **P**rimary **T**issue **V**ariability **F**actors or P.T.V.F. We list these values here - they will be more thoroughly covered in MODULE II:

P.T.V.F. - Primary Tissue Variability Factors™

The following Primary Tissue Variability Factors™ have been established for setting and adjusting optimal laser therapy treatment dosages:

1. **Tissue Type**: blood, fat, nerve, muscle, skin, tendon, cartilage, bone
2. **Tissue Structure**: Simple, stratified, pseudostratified, transitional
3. **Tissue Density**: adiposity index or BMI (Body Mass Index)
4. **Tissue Permeability** (ability of wave energy to pass through, or be absorbed by tissue structures)
5. **Tissue Proximity**: (depth of tissue (shallow vs. deep)
6. **Tissue Pigmentation**: six levels, from white to black (Fitzpatrick Scale)
7. **Tissue Hydration**: hydrated or dehydrated (typical = Min. 54.8% to Max. 78.1%)
8. **Tissue Stress**: bio-behavioral factors that can induce cell damage (cortisol levels, etc.)
9. **Tissue Age**: from atrophic to neoplastic
10. **Tissue Function/malfunction:** Equilibrium, Entropy, & Homeostasis

These factors will be more thoroughly discussed in MODULE II, MAJOR BENEFITS.

PHOTOMEDICINE THERAPY TERMINOLOGY, DEFINITIONS

The following photomedicine (laser) therapy terms are provided in alphabetical order:

1. Ablation: Removal of a segment of tissue using thermal energy; also termed vaporization or thermal decomposition

2. Absorption: The transfer of radiant beam energy into the target tissue resulting in a change in the targeted tissue

3. Active Medium: Any material within the optical cavity of a laser that, when energized, emits photons (radiant energy)

4. Attenuation: The decline in the energy or power as a beam passes through an absorbing or scattering medium

5. Average Power: An expression of the average power emission over time expressed in Watts; total amount of laser energy delivered divided by the duration of the laser exposure. For a pulsed laser, the product of the energy per pulse (Joule) and the pulse frequency (Hertz)

6. Beam: Radiant electromagnetic rays that may be divergent, convergent, or collimated (parallel)

7. Chopped Pulse: See Gated Pulse Mode

8. Collimation: A collimated laser beam propagates in a homogeneous medium (e.g. in air) with a low beam divergence, so that the beam radius does not undergo significant changes within moderate propagation distances (the beam is the same size whether one inch or one foot or more away from the target
9. Chromophore: A substance or molecule exhibiting selective light-absorbing qualities, often to specific wavelengths

10. Class IV Laser: A surgical laser that requires safety personnel to monitor the nominal hazard zone, eye protection, and training. This class of laser poses significant risk of damage to eyes, any nontarget tissue, and can produce plume hazards

11. Coagulation: An observed denaturation of soft tissue proteins that occurs at 60˚C.

12. Contact Mode: The direct touching/contact of the laser delivery system to the target tissue

13. Continuous Mode: A manner of applying the laser energy in an uninterrupted (non-pulsed) fashion, in which beam power density remains constant over time; also termed continuous wave, and abbreviated as ‘CW.’ Contrast with ‘Pulsed Mode’, or ‘Phased Mode’

14. Energy: The ability to perform work, expressed in Joules. The product of power (Watts) and duration (seconds). One Watt second = one Joule; 1 J = 1 Watt x 1 second

15. Energy Density: The measurement of energy per area of spot size, usually expressed as Joules per square centimeter; also known as fluence

16. Fluence: See Energy Density

17. Free-Running Pulse Mode: A laser operating mode where the emission is truly pulsed or phased and not gated. A light-emitting diode (LED) is used as the external energy source so that noticeably short pulse durations and peak powers of thousands of Watts are possible; a laser operated in continuous wave

18. Gated Pulse Mode: A laser operating mode where the emission is a repetitive on-and-off cycle. The laser beam is actually emitted continuously, but a mechanical shutter or electronic control 'chops' the laser beam into pulses. This term is synonymous with chopped pulse mode, phase mode, or multi-phasic mode

19. Intensity: See Power Density

20. Irradiance: See Power Density

21. Joule(J): See Energy(E) or Watt(W). A unit of energy or work equal to an exposure of one Watt of power for one second
22. Low-Level Laser Therapy (LLLT): See Photobiomodulation (PBM); simply stated, a therapy laser device producing extraordinarily little power output, or therapeutic doses of extraordinary little energy. In most cases, LLLT is inadequate when attempting to stimulate tissue in an in-vivo environment; often used to describe devices that are super-luminous but not stimulated (i.e., not a laser)

23. Non-contact Mode: A laser technique in which the delivery system is used without touching the target tissue; light radiation made be defocused or focused, depending on operator's technique and procedure. NOTE: this technique is not as efficient as Contact-Mode

24. Photobiomodulation (PBM): The use of stimulated light radiant energy to elicit biological responses in living cells, typically in a Petri dish in vitro; NOTE: radiation output power and volume can be adjusted to any level that is not harmful to the patient – PBM is used to describe laser therapy at extraordinarily low dosage, often inadequate to produce a tissue response in most situations.

25. Peak Power: The highest power achieved in each pulse

26. Plume: The smoke produced for aerosolization of by-products due to laser tissue interaction; composed of particulate matter, cellular debris, carbonaceous and inorganic materials, and potentially biohazardous products

27. Power(P): The amount of energy delivered per unit time, expressed in Watts (Joules per second). 1 Watt = 1 Joule x 1 Second

28. Power Density: The measurement of power per area of spot size, usually expressed as Watts per square centimeter; also known as intensity, irradiance, and radiance

29. Pulse Duration: A measurement of the total amount of time that a pulse is emitted; also known as pulse width

30. Pulse Width: see Pulse Duration

31. Pulsed Mode (or phased mode): Laser radiation that is emitted intermittently as short bursts or pulses of energy rather than in a continuous fashion. Contrast with 'Continuous Mode.'

32. Repetition Rate: Number of pulses per second, also known as pulse rate; usually expressed in Hertz (Hz) or pulses per second (PPS)
33. Scattering: An interaction as the laser beam disperses in a non-uniform manner throughout targeted tissue

34. Super-pulse (intense-pulsed light): A variation of gated pulsed mode in which the pulse durations are noticeably short, producing high peak power w/LOW-ENERGY transfer; also termed very short pulse
35. Thermal Effect: Increased temperature in targeted tissues; for lasers, the absorption of radiant beam energy by tissue producing an increase in temperature (see First Law of thermodynamics)

36. First Law of Thermodynamics
The First Law of Thermodynamics as it applies to photomedicine states that heat is a form of energy, and thermodynamic processes are therefore subject to the principle of conservation of energy. This means that heat energy cannot be created or destroyed. It can, however, be transferred from one location to another and converted to and from other forms of energy. In Photomedicine, this means that when stimulated light energy is transferred from the laser to targeted tissues, some energy will be absorbed by the surrounding atmosphere. The corresponding loss of energy by the targeted tissues is converted to heat energy. For every Joule of light energy absorbed by the atmosphere, a thermal increase equal to the same will occur in targeted tissues

$$\Delta U = Q - W$$

37. Thermal Relaxation Time: The amount of time required for temperature of the tissue that was raised by absorbed laser irradiation to cool down to one half of that value after the laser pulse

38. Vaporization: The physical process of converting a solid or liquid into a gas; for laser procedures, it describes conversion of fluids in tissue into vapor

39. Watt(W): See Power(P) and Joules(J)

PHOTOMEDICINE CONTRAINDICATIONS

Contraindications are generally based on prudence rather than empirical or anecdotal data, and are presented as precautions for overall safe and effective treatment and care. Please note that the information contained herein should not be construed as empirical medical scientific data; contraindications/indications will vary according to individual cases.

TYPES OF CONTRAINDICATIONS TO LASER THERAPY INCLUDE:

1. ABSOLUTE
2. RELATIVE
3. ANECDOTAL/UNPROVEN
4. PRECAUTIOUS

1. ABSOLUTE CONTRAINDICATIONS FOR LASER THERAPY INCLUDE:

- Eye exposure
- Over cancer or tumor
- Over the ovaries or testicles for prolonged periods
- Never point the laser at a person's eyes
- All persons present in the operatory must wear safety goggles when the laser is in operation
- Over thyroid (see below: fact versus fiction)
- malignant neoplasms of any location;
- benign with a tendency to progression; systemic blood diseases, leukemia;
- pregnancy in all terms, hyperplastic processes in the uterus, benign tumors of the genitals;
- acute infectious diseases;
- infectious processes caused by anaerobic bacteria;
- severe uncompensated endocrine pathology;
- severe diseases of the cardiovascular system (hypertension, heart failure stage III); • acute stroke; lung disease with symptoms of pulmonary disease stage III; liver and kidney failure decompensation;

•photodermatitis and photodermatosis, porphyrin disease, discoid and systemic lupus erythematosus, rosacea (primarily due to thermal effects of laser - treatment at very low power levels multiple times a day would be indicated provided thermal effects are taken into account, with a condition such as this, there must be no thermal effects, the lens of the handpiece must reside at least 2 inches off the skin, treatment should be on pulse mode only with 50% duty cycle or less, maximum power 1.5 Watts)

2. RELATIVE CONTRAINDICATIONS FOR LASER THERAPY INCLUDE:

- Autoimmune disorders
- Encephalopathy
- Hypersensitivity to powerful light energy
- Over tattoos
- Patients using IR photosensitizing medications
- Patients using steroids
- Renal failure (severe)

3. UNPROVEN CONTRAINDICATIONS FOR LASER THERAPY INCLUDE:

• Epilepsy - flashing lights at 5-10 Hz may induce seizure, when treating someone epilepsy always use pulse mode 30% duty cycle or less with frequency over 40 Hz
• Multiple Sclerosis - laser therapy is proven to be beneficial when treating almost all types of nervous system disorders - this should not be considered a contraindication
• Patients with Pacemaker - see below, Fact Versus Fiction
• Systemic infections - laser therapy has proven to be beneficial in dealing with systemic infections, as laser energy is inherently antimicrobial
• Un-united Epiphyseal Plate
• Un-united Fontanelles

4. PRECAUTIOUS CONTRAINDICATIONS FOR LASER THERAPY INCLUDE:

• Dark skin
• Hairline sensitivity
• Iodine treated wounds
• Patients using anticoagulants
• Steroid therapy
• Through dark clothing - laser energy is 'pigment oriented', darker clothing will absorb laser energy at a faster rate, leading to possible thermal hazards and will block the energy from targeted tissues

Contraindications are presented as precautions for overall safe and effective treatment and care; An adequate history should be taken from the patient to determine if any contraindications to treatment are present. Following CORRECT treatment protocols for laser dosage will prevent some, if not all of the potential adverse responses to treatment; mild adverse reactions with normal treatment protocols may occur.

Some patients may report increased pain after the initial treatment or within 24 hours; mild bruising also may occur from pressure of the laser wand into cutaneous tissues using the laser tip in conjunction with deep tissue myofascial techniques. Mild temporary dizziness may rarely occur, most likely from the peripheral vasodilatory effect and a mild drop in blood pressure.

Laser therapy is commonly utilized for symptomatic treatment, and is contraindicated when analgesia may mask progressive pathology. Laser therapy should not be employed in certain situations when the clinician would normally avoid the use of any other analgesia in order to retain the beneficial aspects of pain.

Class IV lasers are potentially harmful to the retina, though accidental retinal damage is highly unlikely. Both patient and practitioner must wear laser safety eyewear appropriate for the NIR wavelength.

Do not employ laser therapy over the pregnant uterus; it may be used elsewhere as indicated for conditions commonly treated by laser therapy (may be considered relative contraindication, see below)

Laser therapy should not be applied over the thyroid gland (may be considered relative contraindication, see below)

Laser-mediated vasodilatation may worsen an existing hemorrhage (may be considered relative contraindication, see below)

LASER THERAPY AND PHARMA

I. Patients may suffer an increase of symptoms after treatment in conjunction with a recent steroid injection; consequently, laser therapy should not be employed within 7-days of a recent steroid injection at or near the injection site. In addition, research has suggested that it is a net zero gain for laser therapy and steroid use, because both suppress prostaglandin E-2. In addition, vasodilatation from laser treatments may cause release of the steroid from the localized injection site. Laser therapy can also accelerate the inflammatory process in a chronic condition, which is counter-productive to the use of steroids.

II. Photosensitivity reactions from certain drugs (including many antibiotics), may be heightened by laser therapy treatments. It is recommended that patients with a history of such reactions be patch-tested for the minimum recommended treatment time.

III. Laser therapy can stimulate immune system function; immunosuppressant drugs may be counter-productive and may minimize the beneficial effects of laser therapy.

IV. Anti-inflammatory medications taken by mouth may potentially decrease the effectiveness of laser therapy; therefore, the reduction or discontinuation of anti-inflammatory medications may need to be considered to allow for the full benefits of laser treatment. In addition, patients using topical or systemic steroids or N.S.A.I.D's for pain or skin conditions may experience mild exacerbation of their symptoms; if such a reaction occurs, laser therapy should be discontinued, or applied at lower dosages.

V. Some clinical evidence suggests that certain holistic remedies, such as St. John's Wort, may elicit hypersensitivity to laser therapy; consequently, smaller laser doses should be initially applied, with a gradual increase in dosage over the next several treatments.

VI. Iodine based products may also make tissue more sensitive to light when treating wounds, requiring a lower dose.

LASER THERAPY CONTRAINDICATIONS – FACT VS. FICTION

Of the relatively few contraindications for the use of therapeutic laser, many are relative rather than absolute and a skilled clinician, together with careful patient selection, should minimize any risks.

Pacemakers

The use of therapeutic laser over internal pacemakers (illustrated in Figure 1) is mistakenly considered to be contraindicated. They are encased in metal and cannot be influenced by photons. The only exception is any light therapy device that also uses electrical stimulation.

Pregnancy

Pregnancy is an anecdotal/unproven contraindication largely because extreme caution has historically been exercised with any modality during pregnancy—especially during the first trimester. It would be prudent to avoid large doses over the pregnant uterus. However, there is no evidence to support the idea of there being any risk in treating isolated regions of the body relative to the uterus.

While researchers observed cell damage in chicken embryos after irradiation with a HeNe laser through an opening in the egg, it is important to keep in mind that the dosage represented a very high dose of laser irradiation for the size and weight of the chicken egg compared with a human fetus inside a pregnant abdomen of an adult female. Nevertheless, it would be wise to note that if any complication occurred subsequent to the use of a therapeutic laser, it would automatically be suspect and leave the clinician with the burden of proof.

Epileptic Seizures

It is known that pulsing visible red light in the 5–10 Hz range can trigger epileptic seizures. Many light therapy devices utilize flashing visible light so it should be used with extreme caution in epileptics. There is nothing in the scientific literature on the subject of pulsing invisible light therapy such as infrared—except for one study by Simunovic. He observed a patient that could only tolerate frequencies below 800 Hz with a GaAs laser.

Thyroid Gland

The thyroid gland is a very delicate structure; it is prudent to avoid treating over the thyroid with photomedicine. Rat studies have demonstrated the development of thyroid disorders in rats treated with large doses of light radiation. Some studies found that GaAs laser therapy reduced mRNA levels of thyro-globulin, changes in the cytoskeleton of thyroid cells and a reduction in thyroid hormone plasma levels. This was associated with an increase in thyroid-stimulating hormone (TSH).

An interesting study utilized an 890 nm infrared laser in treating 42 patients with autoimmune thyroiditis. Each patient received 10 treatments at 2.4J/cm2. The thymus projection, vascular junction, and thyroid itself were irradiated. A control group of similar size was given 100mg of L-thyroxin. The clinical effect in all laser-treated patients was a decreased feeling of squeezing in the field of the thyroid, as well as a decrease in facial edema. The thyroid gland became palpably soft and decreased in size as observed on ultrasound. The number of winter colds decreased. The immunoregulatory index (Th/Ts) normalized decreasing from 7.5 to 4.2%. These effects were still observable in 78% of the patients after four months. Other studies have shown that photomedicine can be a viable therapeutic regimen for thyroiditis and other thyroid disorders.

Children

There is concern over the treatment of children with therapeutic laser, especially over bone growth plates. Cheetham irradiated healthy growth plates in young rats. One knee of each animal in the experimental group was irradiated three times/week at 5J/cm2. The animals were examined histologically after 6 to 12 treatments. There were no observable differences between the treated group and the control group.

Renstrom successfully treated 30 children with Osgood Schlatter disease (aged 11 to 15). Their knees and lower legs were treated with a 60 mW GaAs laser at 30 Hz and 0.1J/cm2 dosage.
Paolini also successfully treated 15 children with Osgood-Schlatter disease with 30 sessions of GaAs laser. These patients were compared with 15 patients who underwent conventional care including surgery. The laser group obtained the best results.

Cancer

Cancer should not be treated by anyone but an licensed oncologist or other appropriate specialist. Laser therapy is commonly considered to be contraindicated in patients undergoing radiation therapy, yet recent scientific research paints a more positive view. Tamachi studied the effect of therapeutic laser on cytoxin, 5-florouracil (5-FU) uptake in various experiments on rats. The rats received 6J/cm2 of HeNe laser. They demonstrated a greater uptake of cytoxin, 5-FU than a group that only received cytoxin, 5-FU. The laser irradiation caused blood vessel to dilate allowing more chemotherapy to accumulate in the lesion. This may allow lower doses of anti-cancer drugs.

Podalskaya has used an HeNe laser on post-radiation reactions and injuries on lips and oral mucosa. This treatment has had better results than any previous treatment approaches.
Soldo studied the effect of GaAs laser irradiation on murine sarcoma. There was an anti-tumor effect on small tumors probably due to increased immune defense.

Funk investigated cytokine production after HeNe laser irradiation to cultures of human PMN cells, which were irradiated for various periods at selected intensities then stimulated with various mitogens. When these cells were stimulated after irradiation at 18.9J/cm2, significantly higher levels of all cytokines were observed. Cells that received 37.8J/cm2 of laser irradiation showed significantly decreased cytokine levels.

Diabetes

There has been debate about whether or not diabetes is a contraindication for therapeutic laser. Several studies have shown positive results in diabetic patients.
Radelli performed an experiment on rats utilizing a 904nm GaAs laser. There was no observable effect on insulin-glycemic balance.

Schindl carried out thermographic studies on patients with microanginopathic disorders. Blood flow began to improve within 15 minutes after the initiation of laser therapy and persisted for 45 minutes after ending the treatment session. A maximum temperature in-crease of 2.5 degrees was observed.

INDICATIONS FOR LASER THERAPY

GENERAL DISORDERS

- Inflammatory Conditions
- Bursitis
- Carpal Tunnel Syndrome
- Edema
- Effusion
- Epicondylitis
- Inflammation
- Muscle Spasms
- Myofasciitis
- Paresthesia
- Plantar Fasciitis
- Primary Diagnosis Pain
- Radicular Pain
- Restricted Rom / Stiffness
- Rheumatoid Arthritis

PAIN MANAGEMENT

- Bursitis
- Cervical/Neck Pain
- Edema
- Effusion
- Fasciitis
- Fibromyalgia
- Inflammation
- Low Back Pain
- Muscle Spasms
- Myofascial Pain
- Myofasciitis
- Primary Diagnosis Pain
- Restricted ROM / Stiffness

CONNECTIVE TISSUE DISORDERS

- Edema
- Effusion
- Inflammation
- Muscle Spasms
- Myofasciitis
- Primary Diagnosis Pain
- Radicular Pain
- Restricted Rom / Stiffness
- Sprains
- Strains
- Tendon Ruptures
- Tendonitis

MUSCLE DISORDERS

- Edema
- Inflammation
- Muscle Bruises, Contusions
- Muscle Contractures
- Muscle Ruptures
- Muscle Spasms
- Myofasciitis
- Myositis
- Primary Diagnosis Pain In Joint
- Restricted ROM / Stiffness

JOINT DISORDERS

- Dislocations
- Edema
- Effusion Of Joint
- Inflammation
- Ligament Injury
- Osteoarthritis
- Primary Diagnosis Pain in Joint
- Restricted Rom Stiffness
- TM Disorders

NEUROLOGICAL DISORDERS

- Crush Injuries
- Decreased Rom / Stiffness
- Edema
- Effusion
- Inflammation
- Muscle Spasms
- Myofasciitis
- Neuritis
- Paresthesia
- Primary Diagnosis
- Prolapsed Disk
- Radicular Pain
- Ruptured Disk

SKIN CONDITIONS

- Burns
- Edema
- Inflammation
- Joint Pain as Primary Diagnosis
- Scars, Restricted Range of Motion
- Skin Grafts
- Skin Ulcers
- Surgical Incisions

MODULE I - THE GENESIS OF PHOTOMEDICINE QUIZ

1. **What is a more correct synonymous term for laser therapy?**
   a. Photomedicine Therapy
   b. Photobiomodulation Therapy
   c. Photobiostimulation Therapy
   d. Quantum Energy Therapy
   e. All the above

2. **What is the difference between energy and matter according to Einstein?**
   a. Energy is matter, and matter is energy
   b. Energy is the capacity to cause change in matter
   c. Energy cannot be created or destroyed
   d. Energy can be conserved, transferred, and converted from one form to another
   e. All the above

3. **What is the difference between the Newtonian or allopathic approach and the** Einsteinian approach in modern medicine?
   a. The term 'allopathic' refers to the Newtonian approach
   b. The Newtonian approach represents modern medicine
   c. The Einsteinian Approach sees human beings as machines with parts
   d. The Einsteinian approach sees human beings as a collection of vibrating bits of energy and complex energy fields
   e. The human body is a 'machine' and doctors are 'mechanics'

4. **How does energy medicine repair the body?**
   a. By using quantum packets of energy to stimulate systems in the body
   b. By inducing absorption of vibrational bits of stimulated energy
   c. By stimulating body systems that are filled with chaotic energy
   d. By transferring energy to the body to repair sick or injured tissues
   e. All of the above

5. **What does the term laser refer to?**
   a. Very bright LEDs
   b. A light that is very bright but does not contain energy
   c. A light therapy device
   d. Light Amplification via Stimulated Emission of Radiation
   e. All very bright lights are lasers

6. **What do you call specific elements in the human body that absorb IR (infrared) and near-IR (near infrared) energy at a very high rate?**

a. Photons
b. Chromophores
c. Electrons
d. Neutrons
e. Acupuncture points

7. When was light first recognized as a healing source of energy?
a. 1967
b. 1916
c. Before the common era
d. 1672
e. 2002

8. Who initially theorized stimulated emissions of light as a source of high energy?
a. Sir Isaac Newton
b. Tony Stark
c. Albert Einstein
d. Carl Sagan
e. Stephen Hawking

9. Who is considered the 1st pioneer of laser medicine?
a. Endre Mester
b. Sir Isaac Newton
c. Albert Einstein
d. Albert Schweitzer
e. Bruce Banner

10. What is the Grotthus-Draper Law, and why is it relevant in laser therapy?
a. E = mc2
b. Only radiation absorbed in a system can produce a chemical change
c. The same as the Photochemical Equivalence Law
d. vision is based upon light interacting with photosensitive cells
e. Change in the internal energy of a system equals the net heat transfer into the system minus the net work done by the system

11. What is the Stark Einstein law and how does it apply to laser therapy?
a. Every photon that is absorbed will cause a (primary) chemical or physical reaction
b. Only that light which is absorbed by a system can bring about a photochemical change
c. Biochemical and energy field interactions that occur in the body are directly proportional to the total energy dose received

d. Established values in biological (patient) factors needs to be considered for satisfactory results in photomedicine
e. All the above

12. What is the Reciprocity Rule and why is it relevant in laser therapy?
a. Every photon that is absorbed will cause a (primary) chemical or physical reaction
b. Only that light which is absorbed by a system can bring about a photochemical change
c. Biochemical and energy field interactions that occur in the body are directly proportional to the total energy dose received
d. Established values in biological (patient) factors needs to be considered for satisfactory results in photomedicine
e. All the above

13. What does PTVF stand for?
a. Permeable Type Value Factors
b. Proximity Tissue Valuation Formula
c. Primary Tissue Variability Factors
d. Proximal Tissue Vaccination Factor
e. Patient Tissue Variability Form

14. What represents a primary tissue factor in laser therapy?
a. Red blood cells
b. White blood cells
c. Body mass index
d. Muscle cells
e. Nerve cells

15. What are some of the alternative terms for low level
(cold)
laser therapy (less than 1/2 Watt of average power output)?
a. Low power laser therapy
b. Low level laser therapy
c. Cold laser therapy
d. Light Therapy
e. All of the above

16. What are some of the alternative terms for laser therapy when all appropriate levels of power output are utilized, rather than just cold laser (below 1/2 Watt)?
a. Laser therapy
b. Photomedicine

c. Quantum energy medicine
d. Photobiostimulation
e. All of the above

17. Which is the most successful method of delivering effective laser therapy treatments?
a. Low power laser therapy
b. LLLT
c. Cold Laser Therapy
d. Low level laser therapy
e. None of the above

18. According to the Reciprocity Rule in Photomedicine (Bunsen Roscoe Law), Grotthuss–Draper Law, Stark–Einstein Law, Beer-Lambert Law, and other applicable physical laws, and considering Primary Tissue Variability Factors, what parts of the body may require more than 30Watts of output power for successful laser therapy treatments?
a. The back
b. The knee
c. The shoulder
d. The hips
e. All of the above

19. What parts of the body listed below will respond favorably to cold laser therapy (applied at 1/2 Watt or less)?
a. The back
b. The knee
c. The shoulder
d. The hips
e. None of the above

PHOTOMEDICINE THERAPY TERMINOLOGY, DEFINITIONS QUIZ

1. What is the meaning of the term absorption in photomedicine?
a. Energy transfer
b. A manner of applying laser energy
c. the transfer of radiant beam energy into targeted tissue resulting in a change in the targeted tissue
d. The output of radiant beam energy
e. Concentration of energy in the laser

2. What is the meaning of the term attenuation in photomedicine?
a. Beam energy that diverges when emitted by the laser

b. Energy absorption
c. Energy that is reflected by a shiny surface
d. Decline in energy as an energy beam passes through an absorbing or scattering medium
e. An increase in energy as it passes through an absorbing medium

3. **What is a chromophore?**
a. Electromagnetic energy beam
b. Stimulated light radiation that can be adjusted
c. The amount of energy that can be delivered per unit time
d. A measurement of the total amount of time that a pulse is emitted
e. A substance or molecule exhibiting selective light-absorbing qualities, wavelengths

4. **What is meant by average power in photomedicine?**
a. total amount of laser energy delivered divided by the duration of the laser exposure
b. A measurement of the total amount of time that a pulse is emitted
c. The highest power achieved in each pulse
d. The measurement of energy per area of spot size
e. A laser operating mode where the emission is a repetitive on-and-off cycle

5. **What is meant by Continuous Mode, or Continuous Wave Mode?**
a. A laser technique in which the delivery system is used without touching the target tissues
b. The use of stimulated light radiation to elicit biological responses in living cells
c. A laser operating mode where the emission is a repetitive on-and-off cycle
d. A manner of applying the laser energy in an uninterrupted (non-pulsed) fashion, in which beam power density remains constant over time
e. A laser operating mode where the emission is truly pulsed or phased and not gated

6. **What is meant by free-running pulse mode?**
a. The highest power achieved in each pulse
b. A laser operating mode where the emission is truly pulsed or phased, and noticeably short pulse durations and peak powers of thousands of Watts are possible
c. A laser technique in which the delivery system is used without touching the target tissue
d. Number of pulses per second, also known as pulse rate; usually expressed in Hertz (Hz) or pulses per second (PPS)
e. Laser radiation that is emitted intermittently as short bursts or pulses of energy rather than in a continuous fashion

7. What is fluence?

a. Any material within the optical cavity of a laser that, when energized, emits photons (radiant beam energy)
b. Increased temperature in targeted tissues; for lasers, the absorption of radiant beam energy by tissue producing an increase in temperature
c. The ability to perform work, expressed in Joules
d. The measurement of energy per area of spot size, usually expressed as Joules per square centimeter; also known as fluence
e. A measurement of the total amount of time that a pulse is emitted; also known as pulse width

8. What is the meaning of the term power density?

a. Power intensity
b. The measurement of power per area of spot size, usually expressed as Watts per square centimeter
c. Irradiance
d. Radiance
e. All of the Above

9. What is meant by 'gated pulse mode'?

a. The emission is a repetitive on-and-off cycle - the laser beam is actually emitted continuously, but a mechanical shutter or electronic control segments the laser beam into pulses
b. Synonymous with chopped pulse mode, phase mode, or multi-phasic mode
c. Standard pulse mode
d. In contrast to continuous mode
e. All of the above

10. What is a Joule?

a. A unit of energy or work equal to an exposure of one Watt of power for one second
b. The ability of energy to perform work, expressed in Joules; the product of power (Watts) and duration (seconds); one Watt second = one Joule; 1 J = 1 Watt x 1 second
c. The amount of power (energy) delivered per unit time, expressed in Watts (Joules per second); 1 Watt = 1 Joule x 1 Second
d. Measurement of dosage determined by Watts times duration of treatment divided by treatment area
e. All the above

11. What is the First Law of Thermodynamics as pertaining to photomedicine?

a. E is true

b. E is False
c. The inverse of E is true
d. The inverse of E is false
e. When stimulated light energy is transferred from the laser to targeted tissues, some energy will be absorbed by surrounding mediums. The corresponding loss of energy by the targeted tissues is converted to heat energy. For every Joule of light energy absorbed by the atmosphere, a thermal increase equal to the same will occur in targeted tissues

12. Do Laws of Fluid Dynamics Apply to Photomedicine?

a. In regards to intensity or power density, the smaller the aperture through which the energy flows the more intense will be the energy. Referring to spot size, this means with constant output power and duration, power density is in direct relation to aperture size. For example, 10W at 10 min. duration through a 30mm spot size will produce a beam half the power density of 10W for 10 min. with a 15mm spot size
b. A is true
c. A is False
d. The inverse of A is true
e. The inverse of A is false

13. What is Super-Pulsing in laser therapy?

a. Super-pulsing produces a very high-energy pulse that is transferred to targeted tissues
b. A variation of a gated, or 'chopped' pulse - super-pulsing produces a very high-energy pulse of very short duration (one-billionth of a second) that transfers almost no energy to targeted tissues and is therefore ineffective in pain relief or tissue repair
c. Super-pulsing is an efficient method of applying laser therapy treatment
d. 'A' and 'C' are false, 'B' is true
e. 'A' and 'C' are true, 'B' is false

14. Contact Mode vs. Non-Contact Mode

a. The handpiece emitter is more effective when the tip of the handpiece is resting on the skin during treatment
b. Due to the gaussian nature of the energy beam, it is designed to focus beneath the skin when the handpiece is resting on the skin during treatment
c. Thermal increase in the skin is highest when the handpiece tip is about 2" from the skin during treatment
d. The beam energy is most efficient when the handpiece is resting on the skin during treatment
e. All of the Above

PHOTOMEDICINE THERAPY CONTRAINDICATIONS

1. The four types of contraindications are absolute, relative, anecdotal, precautious

a. TRUE
b. FALSE
c. N/A
d. N/A
e. N/A

2. Eye exposure is what type of contraindication?
a. ABSOLUTE
b. RELATIVE
c. ANECTDOTAL/UNPROVEN
d. PRECAUTIOUS
e. None of the Above

3. Skin cancer is what kind of contraindication?
a. ABSOLUTE
b. RELATIVE
c. ANECTDOTAL/UNPROVEN
d. PRECAUTIOUS
e. None of the Above

4. Is treating a patient with any type of systemic metastasized cancer contraindicated? what type of contraindication would it be?
a. ABSOLUTE
b. RELATIVE
c. ANECTDOTAL/UNPROVEN
d. PRECAUTIOUS
e. None of the Above

5. Is treating the thyroid contraindicated? What kind of contraindication is it?
a. ABSOLUTE
b. RELATIVE
c. ANECTDOTAL/UNPROVEN
d. PRECAUTIOUS
e. None of the Above

6. Is treating over tattoos contraindicated for laser therapy? What kind of contraindication is it?
a. ABSOLUTE
b. RELATIVE
c. ANECTDOTAL/UNPROVEN
d. PRECAUTIOUS

e. None of the Above

7. What is the size of the nominal hazard zone around the laser during treatment?
a. 10′
b. 15′
c. 20′
d. 30′
e. 5′

8. During laser therapy treatments, who should be wearing laser safety goggles?
a. Only the doctor
b. Only the patient
c. The doctor and the patient
d. The doctor, the patient, and anyone else within a 6-foot radius
e. Everyone in the room

9. Which of the following is true?
a. Dark, thick hair is a relative contraindication for transcranial laser therapy
b. Laser therapy should never be applied directly over a pacemaker
c. Patients using IR photosensitizing medications is a relative contraindication
d. laser therapy should not be applied over the lymph nodes for extended periods and at higher power levels
e. laser therapy should not be applied over the ovaries or testicles at higher power levels or for extended periods
f. All the above

10. Which of the following is true?
a. laser therapy is effective against fungal infections
b. laser therapy is effective against bacterial infections
c. laser therapy is effective against bacterial infections
d. laser therapy is inherently antimicrobial
e. All of the Above

11. Which of the following is true?
a. Laser therapy is a safe and effective treatment for deep vein thrombosis (DVT)
b. laser therapy is a safe and effective treatment for cardiac ischemia
c. laser therapy is a safe and effective treatment for stroke victims
d. laser therapy is a safe and effective treatment for irritable bowel syndrome (IBS)
e. All the above

12. Which of the following is contraindicated for laser therapy?
a. Inflammatory Conditions

b. Bursitis
c. Carpal Tunnel Syndrome
d. Edema
e. Epicondylitis
f. General Inflammation
g. Muscle Spasms
h. Myofasciitis
i. Paresthesia
j. Plantar Fasciitis
k. Radicular Pain
l. Rheumatoid Arthritis
m. None of the above
n.

13. Which of the following is contraindicated for laser therapy?

a. Burns
b. Skin Grafts
c. Skin Cancer (Melanoma, Carcinoma, Basal Cell, Squamous Cell, any types)
d. Any type of Neoplasm
e. All the Above

END OF MODULE I

MODULE II UNDERSTANDING PHOTOMEDICINE THERAPY, BENEFITS

INTRODUCTION & OUTLINE

- Benefits of Photomedicine - Primary, Secondary, Tertiary Effects
- Electromagnetic spectrum
- Primary wavelengths
- What are Chromophores?
- DNA as a Chromophore
- What Human Factors Impact Photomedicine Benefits?
- What are Primary Tissue Variability Factors (PTVF)?
- Photochemical Reactions in Biological Systems
- What Happens when Photomedicine is Absorbed by Chromophores?
- What is Mitochondrial Respiration?
- What is fluorescent Resonance Energy Transfer (FRET)?
- Enhanced Cytokine Modulation
- Enhanced Immunoregulatory Response
- Heightened ATP Synthase
- Describe the First Basic Law of Photochemistry
- Explain what regenerative medicine is as related to photomedicine

LEARNING OBJECTIVES:

Upon completion of this module, you should be able to:

1. Thoroughly understand the principle of photochemical reactions in biological systems
2. Understand the connection between energy absorption and enhanced tissue function; how targeting chromophores helps to produce optimal treatment outcomes
3. Understand how Photonic Energy is absorbed, and what are optimal therapeutic wavelengths?
4. Know the top ten biological benefits of photomedicine
5. Know how photomedicine promotes analgesia and reduces inflammation
6. Understand how photomedicine accelerates wound healing
7. Understand which tissues most effectively absorbed the 1064nM wavelength
8. Know which wavelength is most readily absorbed by hemoglobin
9. Understand which wavelength corresponds to Fluid in the tissues
10. Understand how DNA acts as a chromophore
11. Understand primary tissue variability factors, and how they impact photomedicine absorption
12. Know the properties of connective tissues
13. Know the properties of muscle tissue
14. Understand what collagens are, and which wavelength is most effective in related absorption coefficients
15. Understand tissue permeability as related to photomedicine
16. Understand tissue proximity as related to photomedicine

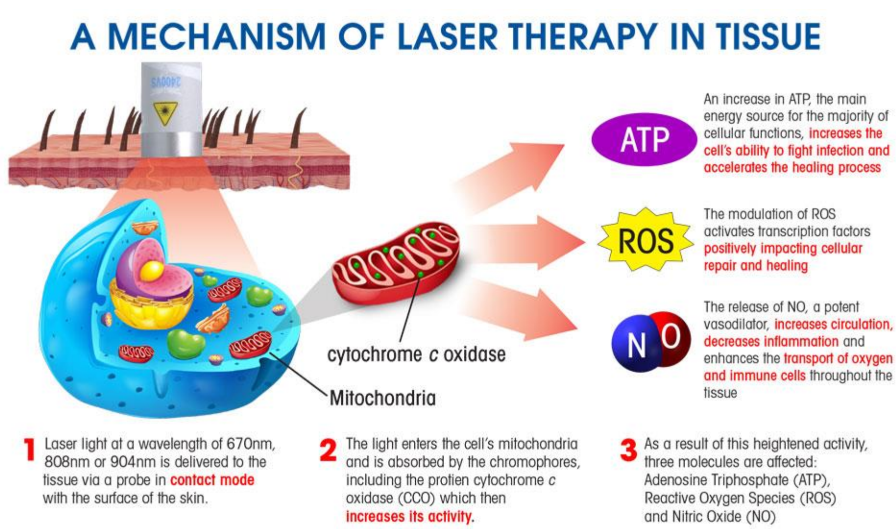
17. Know what the Fitzpatrick skin type test is and why is it is important in photomedicine
18. Understand why tissue hydration levels are important in photomedicine
19. Understand tissue stress factors as related to photomedicine
20. Know tissue age factors as related to photomedicine
21. Understand fluorescent resonance as related to photomedicine
22. Understand how photomedicine influences immune status
23. Understand how photomedicine improves nerve function
24. Know how photomedicine increases metabolic activity in targeted tissues
25. Know how photomedicine reduces fibrous tissue formation
26. Know how photomedicine reduces inflammation in the body
27. Know how photomedicine suppresses nerve signal transmission to reduce pain

Primary Response

Primary response is elicited when photons emitted by the laser reach the mitochondria and cell membranes of underlying cells such as fibroblasts, where photonic energy is absorbed by chromophores and is converted to chemical kinetic energy within the cell. Chromophores absorb photons with wavelengths between 700 and 1200 nanometers (NIR, or near infra-red), with those in the 808nm and 980nm wavelengths being the deepest penetrating.

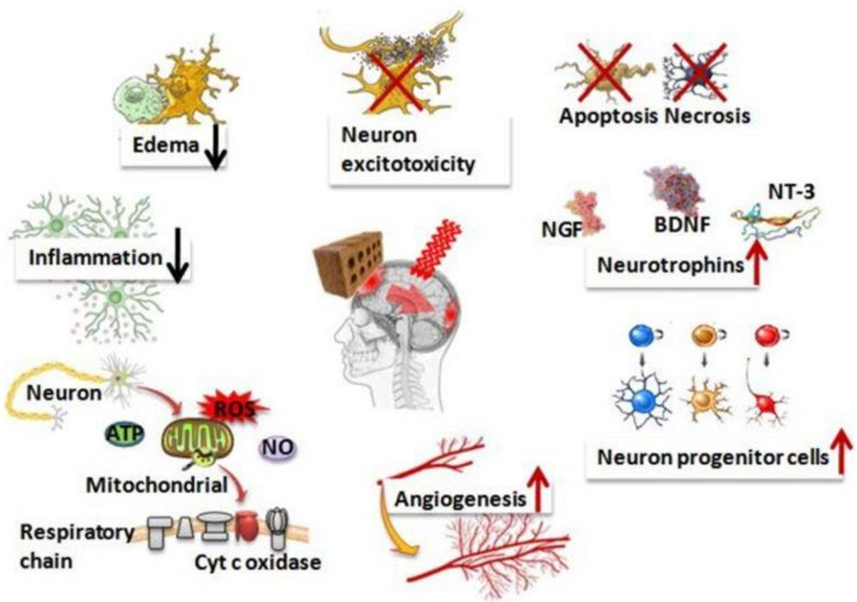
Secondary Response

Secondary reactions lead to the amplification of the primary actions. A cascade of metabolic effects results in various physiological changes at the cellular level—such as changes in cell membrane permeability. Calcium is released from the mitochondria resulting in changes of intracellular calcium levels. This stimulates cell metabolism and the regulation of signaling pathways responsible for significant events required for tissue repair such as cell migration, RNA and DNA synthesis, cell mitosis, protein secretion, and cell proliferation.

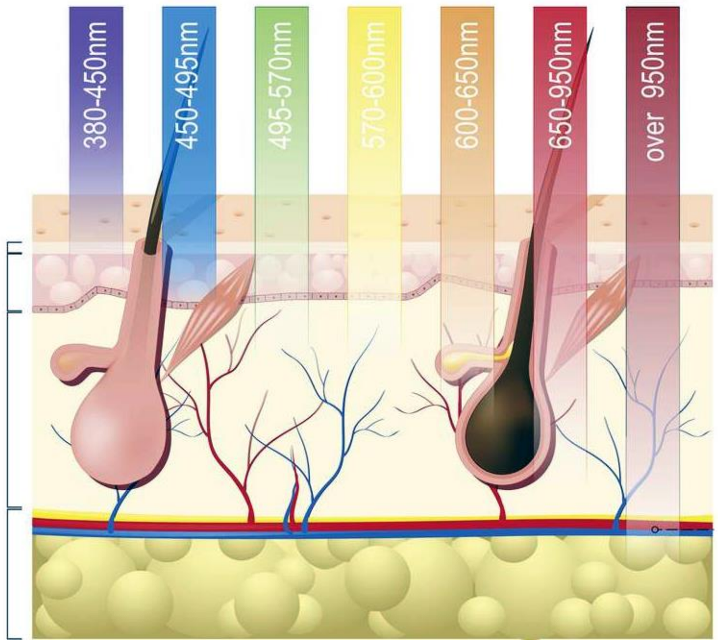


Supplemental Responses

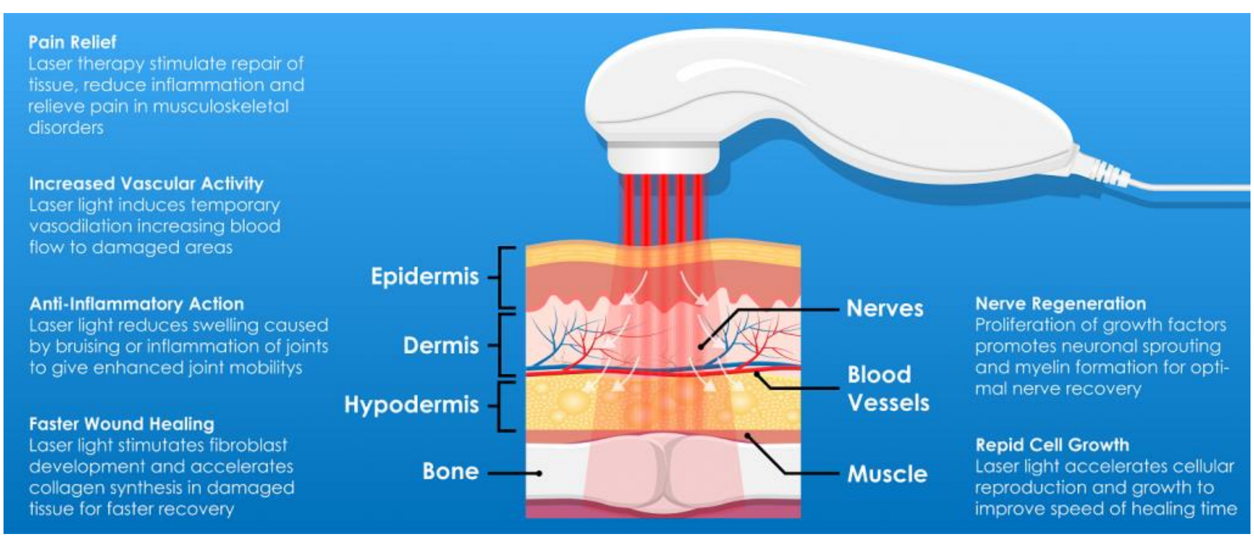
Supplementary responses are induced at a distance from the cells in which the secondary events occur. Energized (irradiated) cells communicate with each other and with nonirradiated cells through increased levels of cytokines or growth factors, along with correlating electromagnetic energy field interactions. This intercellular communication on the cellular biochemical and electromagnetic energy field levels results in an increase in (ATP) Adenosine Triphosphate production, enhanced immune response with the increased activation of T-lymphocytes, macrophages, and number of mast cells, an increase in the synthesis of endorphins, and a decrease in bradykinin results in pain relief, and a general increase in the energy levels of targeted tissues, as well as additional beneficial interactions.



Each tissue type has a different optical behavior; the laser energy beam is reflected, scattered, absorbed, or attenuated depending primarily on the wavelength and tissue according to tissue variability factors. With increasing depth, the laser energy and power attenuates and can be compensated by higher power or therapy duration in laser devices that are capable of delivering the requisite therapeutic values.

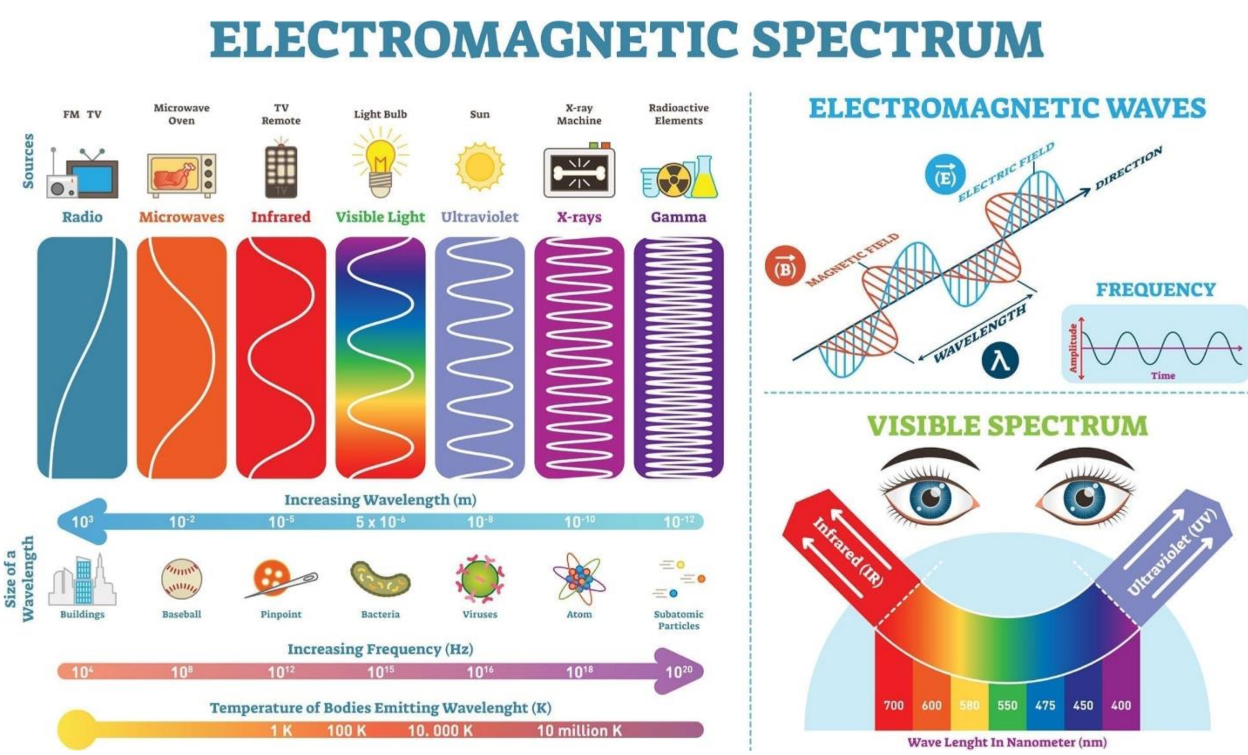


Photonic energy absorption primarily occurs through three mediums in living tissue: water, melanin, and hemoglobin. Laser energy has unique spectral absorption properties and is pigment-oriented; in other words, wave energy is attracted to like-pigmented tissues, with therapeutic wavelengths existing in what we call the optical window, which are wavelengths between 700nM to 1200nM. The primary therapeutic wavelengths consist of: 810nM - primarily absorbed by hemoglobin, and considered the "Jack of all Trades" wavelength, 915nM - primarily absorbed by water, 980nM - primarily absorbed by plasma, and the 1064nM wavelength, which is primarily absorbed by tensile, or collagenous tissues, including tendons, cartilage, and bones (see below):

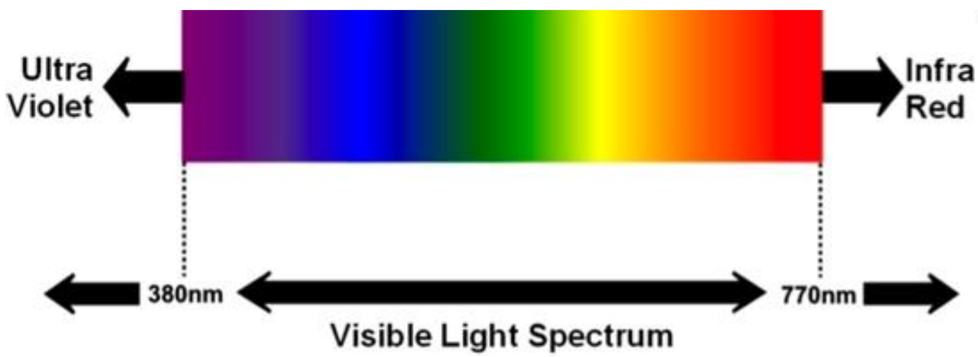


Light (Photonic Energy) is part of the electromagnetic spectrum, which ranges from radio waves on the low end to gamma rays on the high end.

Electromagnetic radiation waves, as their names suggest, are fluctuations of electric and magnetic fields, which can transport energy from one medium to another across a barrier. Visible and non-visible light is not inherently different from other parts of the electromagnetic spectrum with the exception that the human eye can detect visible waves. Electromagnetic radiation can also be described in terms of a stream of photons which are massless particles each travelling with wavelike properties at the speed of light. A photon is the smallest quantity (quantum) of energy which can be transported, and it was the realization that light travelled in discrete quanta that was the origin of Quantum Theory.



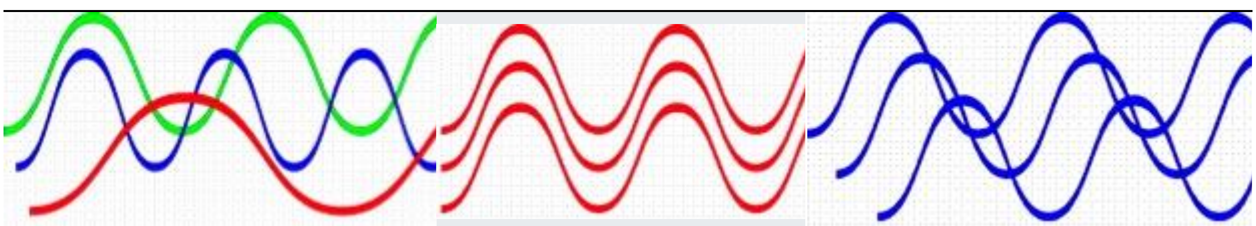
Electromagnetic radiation waves, as their names suggest, are fluctuations of electric and magnetic fields, which can transport energy from one medium to another across a barrier. Visible and non-visible light is not inherently different from other parts of the electromagnetic spectrum with the exception that the human eye can detect visible waves. Electromagnetic radiation can also be described in terms of a stream of photons which are massless particles each travelling with wavelike properties at the speed of light. A photon is the smallest quantity (quantum) of energy which can be transported, and it was the realization that light travelled in discrete quanta that was the origin of Quantum Theory.



There are several aspects of laser light energy which make it much more effective in therapeutic regimens; these include monochromacy, coherence and polarization. The following is true:

- Multiple wavelength non-coherent light sends its energy every direction
- Monochromatic non-coherent light carries little energy, but more than multiple wavelengths (white light)
- Single wavelength coherent light energy (laser) sends all of its force to the same location, and carries the most energy of any type of light

Coherent light energy is the most effective in a therapeutic form. After coherence and wavelength, monochromacy is the most important factor as some therapeutic effects have been noted in various trials with light energy which is non-coherent. Due to the principle of attenuation, therapeutic effects are eventually lost deep within tissues.



White light, multiple wavelengths non-coherent	Laser light, single wavelength, coherent	LED, SLED light, monochromatic but non-coherent

HOW IS PHOTONIC ENERGY ABSORBED, AND WHAT ARE OPTIMAL THERAPEUTIC WAVELENGTHS?

Hemoglobin-Corresponding Wavelengths 808nM to 820nM

Red blood cells (Erythrocytes), white blood cells (Leukocytes), and platelets (thrombocytes), make up 45% of blood tissue by volume, with the remaining 55% of the volume composed of plasma, the liquid component of blood. The ideal therapeutic wavelength for absorption by hemoglobin is 810nm (nanometers).

Water – Corresponding Wavelength 915nM-980nM

The liquid component (water) of the human body is contained in the tissues, the blood, the bones, and elsewhere. This water makes up a significant portion of the human body, both by weight and by volume, and ranges from maximum 78.1% to minimum 54.8%. It is made up of primarily plasma; fatty tissues contain less water content than lean tissues. Ensuring the right amount of body water is part of fluid balance, an aspect of homeostasis. The ideal therapeutic wavelength for absorption by water is 980nm (nanometers).

Epithelial Cells – Corresponding Wavelength 1057nM-1064nM

Melanin is produced within the skin in cells called melanocytes which regulates the amount of ultraviolet and infrared radiation able to penetrate the skin; most of the melanin in the body is contained in epithelial cells which are found throughout the body. Epithelial cells are often described as lying 'outside' the body as they coat the outer layer (epidermis) of the skin; epithelial cells also line the major cavities of the body and form the structures of the lung, including the alveoli or air sacs where gas exchange occurs. Epithelial cells also line most organs, including the stomach small intestine, kidneys, and pancreas. Epithelial cells have many mitochondria because these cells have high levels of energy output and require the ATP (adenosine triphosphate) produced by mitochondria. Photomedicine is particularly useful in stimulating tissues that contain mitochondria as the ATP synthase process is greatly stimulated during and after treatment.

EPITHELIAL TISSUES

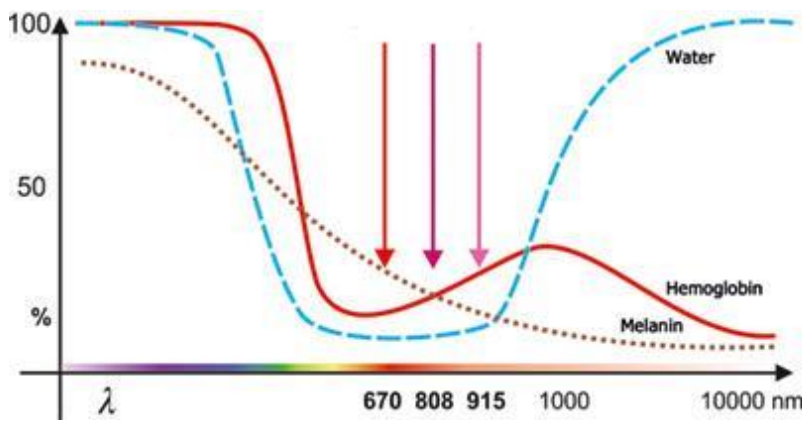
Properties of epithelial tissues include:

- One free surface open to outside or inside the body;
- Closely attached to other cells of the same type;
- Attached to underlying connective tissue;
- Has no blood vessels;
- innervated (lots of nerves in it);
- Regenerates rapidly;
- Stratified;
- Several shapes including squamous, cuboidal, columnar.

Endothelial cells lie 'inside' the body as they are located in the blood vessels. Both cell types that act like an interface between the underlying tissues and the outside environment. The key difference between epithelium and endothelium is that the epithelium is the tissue that lines the outer surfaces of organs and blood vessels, as well as the inner surfaces of cavities in many internal organs while the endothelium is the tissue that lines the interior surface of blood vessels and lymphatic vessels. Mitochondrial content in endothelial cells is modest compared with other cell types with higher energy requirements. In contrast to their role in cell types with higher energy demands, mitochondria in endothelial cells primarily function in signaling a wide variety of cellular responses to environmental cues.

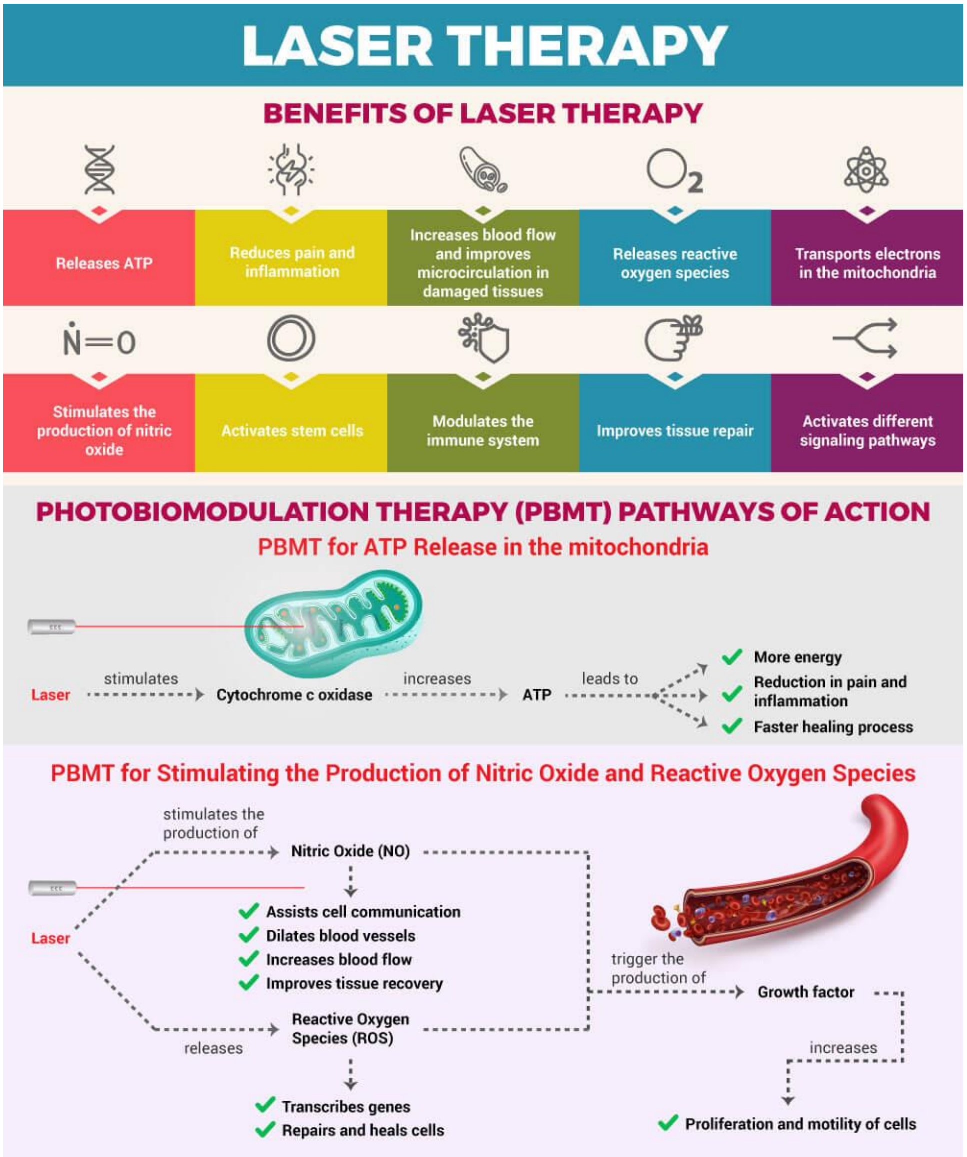
Melanin controls solar radiation's biochemical effects on the body; its content is dependent on a variety of genetic and environmental factors. The ideal therapeutic wavelength for absorption by melanin is 1064 nm (see figure below).

In addition to the above listed benefits, higher wavelengths are said to contain more energy and therefore will penetrate more deeply into living tissues. Under this scenario, the 1064nM wavelength will penetrate more deeply than the 810nM wavelength and provide overall more benefits due to its penetration abilities.



CHROMOPHORES ABSORB QUANTUM LIGHT ENERGY

Chromophores are substances present in living tissues that absorb quantum light energy (all energy from the sun is quantum energy, or energy in its purest and smallest particle form). Examples of endogenous (existing inside the body) chromophores that absorb NIR, or near infrared quantum energy are hemoglobin, oxyhemoglobin, de-oxyhemoglobin and methemoglobin (absorbed by 808nm energy), water, protein, peptide bonds (absorbed by 980nm energy), aromatic amino acids, nucleic acid, urocanic acid and bilirubin (absorbed by UV energy (10nm to 400nm). Melanin in the skin also absorbs quantum UV energy at different rates according to skin pigmentation; then acts as an 'umbrella' to protect underlying tissue substances from destructive UV rays. Exogenous (existing outside the body) compounds, like colors of tattoo ink also act as chromophores.



BILIRUBIN AS A CHROMOPHORE

For centuries, jaundiced infants have been placed near a window so sunlight can be employed to break down bilirubin in an infant's bloodstream. The yellow color in an infant's skin comes from a substance called bilirubin, a common material that comes from red blood cells when they age and die - this is also true for the elderly, and those suffering from liver failure. An average red blood cell lasts about 120 days, then most of it is recycled by the body except for bilirubin. Normally, the liver takes bilirubin out of the bloodstream and delivers it to the digestive system in the form of bile, which gets its greenish-yellow color from bilirubin.

In the womb, the mother's liver and placenta process bilirubin in an infant's blood. When the child is born and the umbilical cord is cut, there's no more assistance from the mother's liver or the placenta – the infant's own liver suddenly has to start independently processing bilirubin. Sometimes, premature and infants who have a higher birth rate are prone to a build-up of bilirubin in the blood as the liver initially struggles to catch up with its new requirements. Mothers and doctors alike have known for centuries that bilirubin, as a chromophore, rapidly absorbs quantum UV energy from the sun due to its unique coloring. UV energy, unlike NIR energy, is destructive and rapidly breaks down the bilirubin so that it can be more easily absorbed and processed by the infant's liver.

WATER AS A CHROMOPHORE

The liquid component (water) of the human body is contained in the tissues, the blood, the bones, and elsewhere; this water makes up a significant portion of the human body, both by weight and by volume, and ranges from maximum 78.1% to minimum 54.8%. It is made up of primarily plasma; fatty tissues contain less water content than lean tissues. Ensuring the right amount of body fluids is an important aspect of homeostasis; proper hydration is also very important for successful photomedicine treatments. The 980nm wavelength is primarily absorbed by tissue fluids, as well as nerve tissues, ligamentous and bony (structural tissues), white adipose tissues fatty tissues, other connective and lymphatic tissues that are lightly pigmented.

HEMOGLOBIN AS A CHROMOPHORE

Red blood cells (Erythrocytes), white blood cells (Leukocytes), and platelets (thrombocytes), make up 45% of blood tissue by volume, with the remaining 55% of the volume composed of plasma, the liquid component of blood. The 808nm wavelength is primarily absorbed by hemoglobin, vascular tissues, endothelial tissues muscle tissues. There are three types of muscle tissue: striated muscles, such as those that move the skeleton (also called voluntary muscle), smooth muscles (involuntary muscle), such as the muscles contained in the stomach and other internal organs, and cardiac muscle, which makes up most of the heart wall (also an involuntary muscle).

MELANIN AS A CHROMOPHORE

Epithelial tissue covers the body surface and forms the lining for most internal cavities – melanin is found primarily in epithelial tissues, and in the skin presents a barrier to NIR energy absorption and penetration and is readily absorbed by 1064nm as well as lower wavelengths in the UV range (10nm to 400nm). More than 60% of directed quantum energy from a therapy laser is attenuated by melanin in the skin.

DNA AS A CHROMOPHORE

DNA contains molecules that absorb and transfer quantum energy via the F.R.E.T. (Fluorescent Resonance Energy Transfer) process. Substances in DNA (receptor chromophores) are excited by quantum energy to a higher vibrational, or energy state - they then resonate, or transfer the higher energy state to acceptor chromophores (targeted substances in DNA). This process is enhanced by high volumes of excited quantum particles to direct higher energy states where it is most needed; in addition, laser energy represents a control of photochemical reactions that mimics and greatly enhances the mitochondrial functional response to natural light, much like photosynthesis in plants, algae, and many types of bacteria except at a more highly accelerated rate.

The effect of therapeutic laser energy on living tissues varies according to various human factors, including the following:

- Age
- Relative Health
- Weight (BMI, Or Body Mass Index)
- Skin Type (Used to Determine Melanin Content)
- Tissue Hydration Level
- Tissue Location
- Sensitivity To Light & Heat
- Other Patient Factors
- Other Environmental Factors

PRIMARY TISSUE VARIABILITY FACTORS™ (PTVF)

Laser energy is absorbed by chromophores (light/energy-absorbing substances within the body). Absorption coefficients are decided by the following energy/tissue human interaction factors, or Primary Tissue Variability Factors™ (PTVF):

- **Tissue Type**: blood, fat, nerve, muscle, skin, tendon, cartilage, bone
- **Tissue Structure**: Simple, stratified, pseudostratified, transitional
- **Tissue Density**: adiposity index or BMI (Body Mass Index)
- **Tissue Permeability** (ability of wave energy to pass through, or be absorbed by tissue structures)
- **Tissue Proximity**: (depth of tissue (shallow vs. deep)
- **Tissue Pigmentation**: six levels, from white to black (Fitzpatrick Scale)
- **Tissue Hydration**: hydrated or dehydrated (typical = Min. 54.8% to Max. 78.1%)
- **Tissue Stress**: bio-behavioral factors that can induce cell damage (cortisol levels, etc.)
- **Tissue Age**: from atrophic to neoplastic
- **Tissue Function/malfunction:** Equilibrium, Entropy, & Homeostasis

TISSUE TYPES/STRUCTURES, TISSUE PROPERTIES

Adipose Tissue (Found Throughout the Body in Shallow and Deep Tissues)

Adipose tissue is mostly fat cells with fibrous strings as structure, primarily found under the skin in deposits between muscles, intestines, heart, bone marrow. There are 2 types of adipose tissue, WHITE, which makes up 20% of human body weight in men, and 25% in women (metabolism & endocrine function) and is used to store energy, aids in endocrine function and metabolism, and is considered a major endocrine organ; and REDDISH BROWN, which derives its color from rich vascularization and densely packed mitochondria. Instead of serving as a substrate, the lipid in brown adipose tissue releases energy directly as heat, and for utilization of excess caloric intake via diet-induced-thermogenesis. The mechanism of heat generation is related to the metabolism of the mitochondria.

Red/Brown Adipose Tissue

Brown adipose tissue is rich in mitochondrial cells, ranges from tan to red in color, and is primarily responsible for ATP production. Photobiostimulation of red blood cells (erythrocytes), enhances the following processes:

- Hemoglobin interaction, tissue oxygenation
- plasma and platelets interaction
- mitochondrial interaction
- vascular tissue interaction

White Adipose Tissue

For pain control, treating structural damage, laser energy is absorbed by fluid/plasma/platelets in white adipose tissues, in addition to stimulation of leukocytes, lymphocyte B&C, connective tissues, tendons, ligaments, bones and nerve tissues. White adipose tissue has the following properties:

- Injured white tissue heals more slowly;
- Composed of white blood cells (granulocytes, monocytes, lymphocytes, leukocytes);
- Found in spinal discs;
- Found in tendons, ligaments, and bones.

Relationships Between Adipose Tissues and the Brain

Over the last decades, more and more data supporting the importance of the relationships between the brain and adipose tissues (white and brown) in regards of body weight regulation and energy homeostasis have been published. The brain, via the autonomic nervous system, participates to the regulation of different parameters such as the metabolic (lipolysis, lipogenesis and thermogenesis), and secretory (leptin and other adipokines) activities but also plasticity (proliferation differentiation and apoptosis) of adipose tissues. In turn the various fat pads will send information via sensory innervation of white adipose tissue as well as metabolic and hormonal signals acting directly on some brain areas. Altogether, these results show the presence of a neural feedback loop between adipose tissues and the brain, which plays a major role in the regulation of energy homeostasis according to physiological and pathological states.

Connective Tissue

Most abundant and found everywhere in the body; dense regular connective tissue includes tendons and ligaments, collagen fibers in an orderly parallel fashion, giving a tensile strength…
Loose connective tissues are fibrous, elastic, lymphoid connective tissues vary in density and cellularity; most connective tissues are lightly pigmented, some connective tissues are darkly pigmented and include special connective tissue, reticular, cartilage, bones, ligaments, tendons

and blood. Elastic and lymphoid connective tissues provide resistance to stretch forces and hold organs in place and are also found in walls of large blood vessels and certain ligaments.

Muscle Tissue

• Smooth Muscle Tissue - organ and blood vessel walls
• Skeletal Muscle Tissue - large, striated muscles packed in bundles and attached to bones for movement
• Cardiac Muscle - heart wall, involuntary striated muscle with connecting cells for synchronized contractions during heartbeat cardiac, skeletal, smooth
• Dense irregular connective tissue
dermal tissues (skin)

Collagens

Collagen is found within the many types of connective tissue. Connective tissue is made up of a material called a matrix, with cells embedded within. The matrix can be a variety of substances, including fluid or a gel-like material.

Nerve Tissues

Within the spinal cord, there is gray and white matter holding nerves in place, as well as spinal fluid and other permeable tissues, despite their comparative lack of pigmentation; the brain is also made up of gray matter as well as white matter, with nerves embedded within.

3.Tissue Density

Penetration through a medium (tissue types, including, connective, epithelial, endothelial, muscle, vascular, and nerve tissues) is inversely related to the density and directly related to the permeability of that medium, if pigmentation is not a factor.

Treatment settings related to tissue density and permeability factors: continuous wave (CW) vs. Pulse: Pulse mode is more absorbent in denser tissues because it allows for more intense micro absorption of energy with less possibility of damage from excess heat or other effects. The following statements are true when skin pigmentation is considered:

Continuous wave energy is absorbed more rapidly in the tissues, and therefore is considered to be most appropriate for more superficial conditions and more permeable tissues.
Pulsing is absorbed less rapidly with better progression through the tissues, and can therefore be more effective at greater depth and with denser tissue structures.

4. Tissue Permeability

Permeable tissues use lower dosage; denser tissues use higher dosage; Penetration through a medium (tissue types, including, connective, epithelial, endothelial, muscle, vascular, and nerve tissues) is inversely related to the density and directly related to the permeability of that medium, if pigmentation is not a factor.

Treatment settings related to tissue density and permeability factors: continuous wave (CW) vs. Pulse: Pulse mode is more absorbent in denser tissues because it allows for more intense micro absorption of energy with less possibility of damage from excess heat or other effects. The following statements are true when skin pigmentation is considered:
Continuous wave energy is absorbed more rapidly in shallow surface tissues, and therefore is considered to be most appropriate for more superficial conditions and more permeable tissues.

Pulsing is more rapidly absorbed with better progression through tissues, and can therefore be more effective at greater depth and with denser tissue structures.

5. Tissue Proximity

Tissue Proximity: proximity to skin surface (shallow adipose tissue, deep, underlying muscle, vascular, nerve, connective, structural red adipose tissue). Shallow tissues better absorb continuous wave (CW) energy output, tissues that are deeper in the body respond better to fractional, or pulsed energy; the deeper and denser the tissues, the higher the pulse (duty cycle, or ratio between beam emission and rest) for optimal clinical outcomes.

6. FITZPATRICK SCALE

The Fitzpatrick Skin Type Test is a skin classification system first developed in 1975 by Thomas Fitzpatrick, MD, of Harvard Medical School. His skin classification system and its adaptations are familiar to dermatologists and aestheticians. To determine your Fitzpatrick Skin Type, our quiz measures two components (genetic disposition and reaction to sun exposure). Types range from very fair (Type I) to the very dark (Type VI).

1. White; very fair; red or blonde hair; blue eyes; freckles; always burns, never tans;
2. White; fair; red of blonde hair; blue, hazel, or green eyes, usually burns, tans with difficulty;
3. Cream white; fair with any eye or hair color; very common, sometimes mild sunburn, tans gradually;
4. Brown; typical Mediterranean or Caucasian skin, rarely burns, tans with ease;
5. Dark brown; Middle Eastern skin type, very rarely burns, tans very easily;
6. Black; African origin, never burns, tans easily

Your eye color is:
Light blue, light gray or light green = 0
Blue, gray or green = 1
Hazel or light brown = 2
Dark brown = 3
Brownish black = 4

Your natural hair color is:
Red or light blonde = 0
Blonde = 1
Dark blonde or light brown = 2
Dark brown = 3
Black = 4

Your natural skin color (before tanning) is:
Ivory white = 0
Fair or pale = 1
Fair to beige, with golden undertone = 2
Olive or light brown = 3
Dark brown or black = 4

How many freckles do you have on unexposed areas of your skin?
Many = 0
Several = 1
A few = 2
Very few = 3
None = 4
Total score for genetic disposition: _______

How does your skin respond to the sun?
Always burns, blisters and peels = 0
Often burns, blisters and peels = 1
Burns moderately = 2
Burns rarely, if at all = 3
Never burns = 4

Does your skin tan?
Never -- I always burn = 0
Seldom = 1
Sometimes = 2
Often = 3
Always = 4

How deeply do you tan?
Not at all or very little = 0
Lightly = 1
Moderately = 2
Deeply = 3

My skin is naturally dark = 4

How sensitive is your face to the sun?
Very sensitive = 0
Sensitive = 1
Normal = 2
Resistant = 3
Very resistant/Never had a problem = 4
Score for reaction to sun exposure: ______

Add up your genetic disposition and sun exposure totals to find your Fitzpatrick Skin Type:

Genetic Disposition: ________
Reaction to Sun Exposure: _________
Total Score: _________

Type #1. (0-6) – Increase Dosage)
You always burn and never tan in the sun. You are extremely susceptible to skin damage as well as cancers like basal cell carcinoma and squamous cell carcinoma. You are also at very high risk for melanoma, the deadliest type of skin cancer. Generally, follow The Skin Cancer Foundation's prevention tips but use a sunscreen with a SPF of 30+ and clothing with a UPF rating of 30 or higher. Seek the shade whenever you are out in the sun. Check your skin head-to-toe each month, paying careful attention to any suspicious growths, and make sure you have an annual professional skin checkup.

Type #2. (7-12) – Increase Dosage)
You almost always burn and rarely tan in the sun. You are highly susceptible to skin damage as well as cancers like basal cell carcinoma and squamous cell carcinoma. You are also at elevated risk for melanoma, the deadliest type of skin cancer. Generally, follow The Skin Cancer Foundation's prevention tips but also consider using a sunscreen with a SPF of 30+ and clothing with a UPF rating of 30 or higher. Seek the shade whenever you are out in the sun. Check your skin head-to-toe each month, paying careful attention to any suspicious growths, and make sure you have an annual professional skin checkup.

Type #3. (13-18) – Slightly Increase Dosage)
You sometimes burn and sometimes tan in the sun. You are susceptible to skin damage as well as cancers like basal cell carcinoma and squamous cell carcinoma. You are also at risk for melanoma, the deadliest type of skin cancer. Be sure to apply a sunscreen with an SPF of at least 15 every day, wear sun-protective clothing, and seek the shade between 10 AM and 4 PM, when the sun is strongest. Check your skin head-to-toe each month, paying careful attention to any suspicious growths, and make sure you have an annual professional skin checkup.

Type #4. (19-24) – dosage remains the same)
You tend to tan easily and are less likely to burn. However, you are still at risk; use sunscreen with an SPF of 15+ outside and seek the shade between 10 AM and 4 PM. Follow all other Prevention Tips from The Skin Cancer Foundation as well. Check your skin head-to-toe each month, paying careful attention to any suspicious growths, and make sure you have an annual professional skin checkup.

Type #5. (25-30) - Slightly Decrease Dosage)
You tan easily and rarely burn, but you are still at risk. Use sunscreen with an SPF of 15+ and seek the shade between 10 AM and 4 PM. Acral lentiginous melanoma, a very virulent form of the disease, is more common among darker-skinned people. These melanomas tend to appear on parts of the body not often exposed to the sun, and often remain undetected until after the cancer has spread. Check your skin head-to-toe each month, paying careful attention to any suspicious growths, and make sure you have an annual professional skin checkup. Keep an eye out for any suspicious growths, especially on the palms, soles of the feet and mucous membranes.

Type #6. (31+) - Decrease Dosage)
Although you do not burn, dark-skinned people are still at risk for skin cancers, and should wear sunscreen with a SPF of 15+ and seek the shade between 10 AM and 4 PM. Acral lentiginous melanoma, a very virulent form of the disease, is more common among darker-skinned people. These melanomas tend to appear on parts of the body not often exposed to the sun, and often remain undetected until after the cancer has spread. Check your skin head-to-toe each month, paying careful attention to any suspicious growths, and make sure you have an annual professional skin checkup. Keep an eye out for any suspicious growths, especially on the palms, soles of the feet and mucous membranes.

7. Tissue Hydration
Tissue hydration level serves several distinct functions in the human body. Total body water comprises approximately 45–75% of a person's body weight. Muscle mass is 70–75% water, while water in fat tissue can vary between 10 and 40% (25); the brain and heart are composed of 73% water, and the lungs are about 83% water. Water acts as a transporter of nutrients, helps to regulate body temperature, lubricates joints and internal organs, provides structure to cells and tissues, and can help preserve cardiovascular function. Fluid deficits adversely impact physical and mental performance according to the degree of dehydration; thus, it is important to maintain adequate hydration levels. Research also indicates proper hydration levels play an important part on the effectiveness of therapeutic laser treatments - it is therefore important to consider hydration a primary factor in tissue response.

The recommended fluid intake while undergoing therapy laser treatments is around 1/2 a patient's body weight in fluid ounces of water intake daily - in other words, if the patient weighs 100 pounds, they should drink approximately 50 ounces of fluid per day, or approximately 6 ½ cups of water, with additional fluid intake needs being satisfied by food intake.

8. Tissue Stress Factors

Bio-behavioral stress factors can induce cell damage (increased cortisol levels, etc.)

- Allostasis: Capacity to Adapt to Stresses in order to achieve homeostasis;
- Minimal Stress: State of happiness (or denial);
- Acute Stress: Acute Stress: acute - most common type of stress;
- Episodic Stress: Episodic Stress: when acute stress occurs frequently;
- Chronic Stress: Chronic -most damaging for health.

Stress as a Disease

Acute, episodic, and chronic stress, or the body's instinctive response to external environmental cues, triggers a deregulation of several bodily systems including muscle tension, musculoskeletal disorders, nervous system and cardiovascular disorders including increased heart rate and blood pressure, adrenal, endocrine, and gastrointestinal system disorders including increase blood sugar levels, decreased immune system response, and bowel disorders. Other deregulatory responses included female and male reproductive system disorders.

Types of Stress that induce cell damage:

- Physical: intense exertion, manual labor, lack of sleep, travel;
- Chemical: drugs, alcohol, caffeine, nicotine and environmental pollutants such as cleaning chemicals or pesticides;
- Mental: perfectionism, worry, anxiety, long work hours;
- Emotional: anger, guilt, loneliness, sadness, fear;
- Nutritional: food allergies, vitamin and mineral deficiency;
- Traumatic: injuries or burns, surgery, illness, infections, extreme temperatures;
- Psycho spiritual: troubled relationships, financial or career pressures, challenges with life goals, spiritual alignment, and general state of happiness.

9. Tissue Age

Cells are the basic building blocks of tissues. All cells experience changes with aging. They become larger and are less able to divide and multiply. Among other changes, there is an increase in pigments and fatty substances inside the cell (lipids). Many cells lose their ability to function, or they begin to function abnormally. As aging continues, waste products build up in tissue. A fatty brown pigment called lipofuscin collects in many tissues, as do other fatty substances.

Connective tissues change as they age and becoming stiffer; this makes the organs, blood vessels, and airways more rigid. Cell membranes change, so many tissues have more trouble getting oxygen and nutrients and removing carbon dioxide and wastes. Many tissues lose mass. This process is called atrophy. Some tissues become lumpy (nodular) or more rigid. Because of cell and tissue changes, your organs also change as you age. Aging organs slowly lose function. Most people do not notice this loss immediately, because you rarely need to use your organs to their fullest ability.

Organs have a reserve ability to function beyond the usual needs. For example, the heart of a 20-year-old is capable of pumping about 10 times the amount of blood that is needed to keep the body alive. After age 30, an average of 1% of this reserve is lost each year. The biggest changes in organ reserve occur in the heart, lungs, and kidneys. The amount of reserve lost varies between people and between different organs in a single person.

These changes appear slowly and over a long period. When an organ is worked harder than usual, it may not be able to increase function. Sudden heart failure or other problems can develop when the body is worked harder than usual. Things that produce an extra workload (body stressors) include the following:
• Illness;
• Medications;
• Significant life changes;
• Sudden increased physical demands on the body, such as a change in activity or exposure to a higher altitude;
• Loss of reserve also makes it harder to restore balance (equilibrium) in the body. Drugs are removed from the body at a slower rate. Lower doses of medications may be needed, and side effects become more common;
• Medication side effects can mimic the symptoms of many diseases, so it is easy to mistake a drug reaction for an illness. Some medications have entirely different side effects in the elderly than in younger people.

Cellular Changes
• **Atrophy**: Cells shrink - if enough cells decrease in size, the entire organ atrophies. This is often a normal aging change and can occur in any tissue. It is most common in skeletal muscle, the heart, the brain, and the sex organs (such as the breasts). The cause of atrophy is unknown, but may include reduced use, decreased workload, decreased blood supply or nutrition to the cells, and reduced stimulation by nerves or hormones;

• **Hypertrophy**: Cells enlarge - this is caused by an increase of proteins in the cell membrane and cell structures, not an increase in the cell's fluid; when some cells atrophy, others may hypertrophy to make up for the loss of cell mass;

• **Hyperplasia**: The number of cells increases - there is an increased rate of cell division. Hyperplasia usually occurs to compensate for a loss of cells. It allows some organs and tissues to regenerate, including the skin, lining of the intestines, liver, and bone marrow. The liver is especially good at regeneration. It can replace up to 70% of its structure within 2 weeks after an injury. Tissues that have limited ability to regenerate include bone, cartilage, and smooth muscle (such as the muscles around the intestines). Tissues that rarely or never regenerate include the nerves, skeletal muscle, heart muscle, and the lens of the eye. When injured, these tissues are replaced with scar tissue;

• **Dysplasia**: The size, shape, or organization of mature cells becomes abnormal - this is also called atypical hyperplasia. Dysplasia is fairly common in the cells of the cervix and the lining of the respiratory tract;

• **Neoplasia**: The formation of tumors, either cancerous (malignant) or noncancerous (benign) - neoplastic cells often reproduce quickly and may have unusual shapes and abnormal function.

As you grow older, you will have changes throughout your body, including changes in:

- Hormone production
- Immunity
- The skin
- Sleep
- Bones, muscles, and joints
- The breasts
- The face
- The female reproductive system
- The heart and blood vessels
- The kidneys
- The lungs
- The male reproductive system
- The nervous system
- Tissue Health
- Tissue Sensitivity (to light & heat)

AS one ages, fibroblasts slow their production of collagen, elastin and glycosaminoglycan; when these proteins are lacking in the body, the skin loses its ability to repair itself. A history of excessive exposure to UV rays causes visible signs of aging; photo-aged skin can also exhibit a reduction in elasticity and strength. Laser therapy has anti-aging properties that penetrate the skin's surface with targeted beams of quantum energy - this energy creates microscopic zones of cellular function enhancement, stimulating the body's natural healing process which then stimulates the production of collagen and elastin, thereby causing skin to act and feel younger. Patients see improvement in overall texture, clarity and radiance of their facial skin. As the body produces new collagen and elastin, the appearance of wrinkles and fine lines is greatly reduced, and the skin regains its youthful glow.

10. Tissue Function/malfunction: Equilibrium, Homeostasis, Allostasis, and Entropy

Homeostasis is conventionally thought of merely as a synchronic (same time) servomechanism, that maintains the status quo for organismal physiology. However, when seen from the perspective of developmental physiology, homeostasis is a robust, dynamic, intergenerational, diachronic (across-time) mechanism for the maintenance, perpetuation and modification of physiologic structure and function. The integral relationships generated by cellular molecular signaling for the mechanisms of embryogenesis, physiology and repair provide describe the homeostatic principle, starting with the inception of life itself, with the advent of reproduction during meiosis and mitosis, moving forward both ontogenetically and phylogenetically through the evolutionary steps involved in adaptation to an ever-changing environment,

HOMEOSTASIS

Homeostasis is far more complex than previously considered

Homeostasis is defined as the property of a system in which variables are regulated so that internal conditions remain stable and relatively constant despite the constant change of external stimuli. Examples of homeostasis include the regulation of body temperature, and the balance between acidity and alkalinity. It is a process that maintains the stability of the organism's internal environment in response to fluctuations in external environmental conditions.

Homeostasis requires a sensor to detect changes in the condition to be regulated, an effector mechanism that can vary that condition, and a negative feedback connection between the two.

Every living organism depends on maintaining a complex set of interacting metabolic chemical reactions. From the simplest unicellular organisms to the most complex plants and animals, internal processes operate to keep their conditions within tightly regulated and controlled limits to allow these reactions to proceed. Homeostatic processes act at the level of the cell, the tissue, and the organ, as well as at the level of the organism as a whole, referred to as allostasis.

Diseases Involve Disturbances in Homeostasis

Diseases involve disturbances in homeostasis; for example, as the organism ages, the efficiency in the control of systems becomes reduced due to the loss of receptors. The inefficiencies gradually result in an unstable internal environment that increases the risk of illness, leading to the physical changes associated with aging. ¬Certain homeostatic imbalances, such as a high core body temperature, a high concentration of salt in the blood, or a low concentration of oxygen, can generate homeostatic reactions such as warmth, thirst, or breathlessness, which motivate behavior aimed at restoring homeostasis.

The life span of the organism as a continuous series of ligand-receptor interactions from morphogenesis to the maintenance of physiologic homeostasis, to the loss of homeostatic control mechanisms during aging, culminating in death has been formulated. Seen in this light, allostasis takes on a very different set of characteristics, stress having short-term effects that are physiologically beneficial for the reproductive strategy; but over the long haul, such adaptive responses can have deleterious effects that occur as unintended consequences of the optimization of the primary homeostatic mechanisms involved. In other words, acceleration of development would bring on precocious aging and death as a continuous mechanism selecting for the unicellular state.

QUANTUM ENERGY APPLICATIONS ENHANCE TISSUE REGENERATION (REGENERATIVE MEDICINE)

Systemic applications of high volumes of quantum energy can assist in controlling and redirecting the mechanisms of homeostasis in enhancement of tissue regeneration, added vigor, robustness, and more dynamic interactions throughout the full range of metabolic processes.

FRET (Fluorescent Resonance Energy Transfer) in Photomedicine

Fluorescence resonance energy transfer (FRET)*is a distance-dependent physical process by which energy is transferred from an excited molecular fluorophore (the donor) to another fluorophore (the acceptor) by means of intermolecular signaling, and represents a primary mechanism whereby photomedicine takes place.

DNA contains molecules that absorb and transfer laser therapy energy via the FRET process. Substances in the DNA (receptor chromophores) are excited by therapeutic laser energy to a higher energy state; they then transfer that higher energy to other substances in the DNA (acceptor chromophores). This process is called fluorescent resonance energy transfer, or FRET, and is used to direct stimulate energy to where it is most needed. In addition, laser energy represents a control of photochemical reactions that mimics and enhances the function of natural light, much like those that enhance photosynthesis in plants, algae, and many types of bacteria.

FRET is a function of the ATP synthase process. ATP synthase is the process that creates the energy storage and transfer molecule Adenosine Triphosphate (ATP). ATP is the most common form of energy production, storage, and transfer in the cells of most organisms; it is formed from adenosine diphosphate (ADP) and inorganic phosphate (Pi), and needs energy for its formation. Therapeutic laser energy delivers additional sources of energy for the ATP synthase process to be stimulated, thereby boosting the process whereby FRET can occur most efficiently, and providing a pathway for enhanced healing of aging, sick, injured, or malfunctioning tissues and body systems.

Mitochondrial Respiration

Laser therapy not only enhances mitochondrial respiration, but also activates the redox-sensitive NFkB signaling via generation of ROS. Expression of anti-apoptosis and pro-survival genes responsive to NFkB could explain the beneficial clinical effects of Photomedicine.

Additional evidence of the role of cytochrome c oxidase as a chromophore in photomedicine has been provided by various studies.

Enhanced Cytokine Modulation

Cytokines play a broad role in helping the immune system respond to diseases. Cytokines may be 'good' when stimulating the immune system to fight a foreign pathogen or attack tumors. Other good cytokine effects include reduction of an immune response, for example interferon β reduction of neuron inflammation in patients with multiple sclerosis. Cytokines are 'bad' when the body is no longer able to manage the higher level of production due to environmental stress, injury, or pathogenic infection, and the 'overactive' cytokine response causes inflammatory diseases, i.e. the role of tumor necrosis factor α in rheumatoid arthritis or asthma and Crohn's disease. Quantum energy loads from laser therapy can help to modulate overactive cytokine responses, strengthening the immune system and reducing the inflammatory processes that occur in an overactive cytokine response (such as autoimmune disorders).

Enhanced Immunoregulatory Response

Quantum light energy has a direct effect on immunity status by stimulation of immunoglobulins and lymphocytes. Quantum light energy, when absorbed by chromophores and other molecule enzymes within the body, activate flavomononucleotides and enhance the production of ATP (adenosine triphosphate), a major component of cellular energy and the energy source for all chemical reactions in the cells.

Heightened ATP Synthase

ATP synthase is the process that creates the energy storage and transfer molecule Adenosine Triphosphate (ATP). ATP is the most generic form of energy production, storage, and transfer in the cells of most organisms; it is formed from adenosine diphosphate (ADP) and inorganic phosphate (Pi) and needs photonic energy for its formation. Laser therapy delivers high volumes of quantum energy for the ATP synthase process to be stimulated, thereby providing an enhanced pathway for more rapid and effective healing of aging, sick, injured, or malfunctioning tissues and body systems. ATP synthase occurs in the mitochondria, which are often found in brown adipose tissues that are made up mostly fat cells with fibrous strings as structure, primarily found under the skin and in deposits between muscles, intestines, heart, bone marrow (see below).

When photomedicine is absorbed by chromophores found in the body (particularly DNA and mitochondrial cells), enhanced ATP synthase occurs. Enhanced ATP synthase produces the following tissue reactions:

1. Accelerated Tissue Repair, Healthy Cell Proliferation

Photonic energy packets from radiant beam energy (therapy laser beam) penetrate deeply into tissue and accelerate cellular reproduction and growth (see overview below). No other modality can penetrate tissues and deliver healing energy to the targeted tissues deep beneath the skin as class IV therapy lasers. Radiant laser energy beams increase cellular energy to aid in nutrient intake and removal of waste products; tissues of all types are repaired faster from exposure to therapeutic laser energy.

2. Increased Reduction of Fibrous Tissue Formation

Laser energy reduces the formation of scar tissue and acute and chronic inflammatory processes from disease/injury; this is important to note because fibrous (scar) tissue is less elastic, has poorer circulation, is more pain sensitive, is weaker, and is much more prone to re-injury and frequent exacerbation of injury.

3. Increased Anti-Inflammatory Response

Radiant Beam energy (laser energy) has an anti-inflammatory effect, producing vasodilation and enhanced activation of the lymphatic drainage system; consequently, reduction of swelling caused by biomechanical stress, trauma, overuse, or systemic conditions occurs.

4. Increased Analgesic Response

Laser therapy has a beneficial effect on pain through the suppression of nerve signal transmission over unmyelinated c-fibers that transmit pain to the brain, meaning increased stimuli is required to create an action potential within the nerve to signal pain. Another pain blocking mechanism involves the production of high levels of peptides such as endorphins and enkephalins from the brain and adrenal glands.

5. Improved Vascular Function

Laser light will significantly increase the formation of new capillaries (angiogenesis) in damaged tissue that will speed up the healing process; additionally, microcirculation increases secondary to vasodilation during laser treatment.

6. Increased Metabolic Activity

Laser energy creates higher outputs of specific proteins and enzymes, greater oxygenation, and increased food particle loads for blood cells.

7. Improved Nerve Function

Slow recovery of nerve function in damaged tissue can result in motor and sensory disturbances resulting in loss of function and pain to the affected area. Therapeutic laser energy accelerates the process of nerve cell regeneration and increases the amplitude of action potentials to optimize motor and sensory nerve functions, and stimulates the regeneration of myelin and other nerve tissues to decrease pain.

8. Enhanced Immunoregulatory Response

Laser light energy has a direct effect on immunity status by stimulation of immunoglobulins and lymphocytes. Laser light is absorbed by chromophores (molecule enzymes) within the mitochondria that react to laser energy; flavomononucleotides are activated and the production of ATP (adenosine triphosphate) increases (ATP is a major component of cellular energy and the energy source for all chemical reactions in the cells).

9. Trigger and Acupuncture Point Stimulation

Laser therapy stimulates muscle trigger and acupuncture points on a non-invasive basis, providing musculoskeletal pain relief. Additionally, a restoration of muscular tonus and balance between agonist, antagonist, and synergistic relationships improves joint biomechanics and protects them from potentially dangerous stress/strain and shear forces.

Basic Photochemistry

In basic photochemistry, we learn that light energy must be absorbed for photochemistry to occur (the First Basic Law of Photochemistry); additionally, the Bunsen Roscoe Law of Reciprocity states that a photochemical effect is directly proportional to the total energy dose, irrespective of the time or power level required to deliver the dose. What this means is, LLLT (Low Level Laser Therapy, Or Cold Laser Therapy) does not transfer enough energy to stimulate an adequate cellular reaction within a reasonable amount of time. These principles also support the fact that there is no ceiling dose for energy transference - in other words, within normal parameters, i.e., energy transference that does not cause an undue thermal response, higher dosages of energy result in more optimal treatment outcomes.

MODULE II, UNDERSTANDING PHOTOMEDICINE THERAPY & BENEFITS - QUIZ

1. What are the primary, secondary, and tertiary benefits of photomedicine?
   a) Photonic energy is absorbed by chromophores and is converted to chemical kinetic energy within the cell
   b) a cascade of metabolic effects results in various physiological benefits at the cellular level
   c) Intracellular action results in increased ATP production
   d) An increase in the production of endorphins occurs, leading to pain relief
   e) all of the above

2. **Is light a part of the electromagnetic spectrum?**
   a) True
   b) False
   c) Maybe
   d) All of the above
   e) None of the above

3. **A photon is the smallest quantity of energy which can be transported**
   a) True
   b) False
   c) Maybe
   d) All of the above
   e) None of the above

4. What are the three mediums by which photonic energy is absorbed into the body?
   a) Water
   b) Melanin, Endothelial Cells
   c) Hemoglobin
   d) All of the above

5. What are electromagnetic radiation waves?
   a) Radiation from nuclear material
   b) Magnetic energy waves that are electrified
   c) Electrical energy caused by magnets
   d) Fluctuations of electric and magnetic fields which can transport energy from one medium to another across a barrier
   e) None of the above

6. What is the ideal wavelength for absorption by hemoglobin?
   a) 770 nanometers
   b) 650 nanometers
   c) 810 nanometers

d) 1070 nanometers
e) none of the above

7. What is the ideal wavelength for absorption by water, or fluid in the tissues?
a) 650 nanometers
b) 808 nanometers
c) 915 nanometers
d) 1064 nanometers
e) 990 nanometers

8. What is the ideal wavelength for absorption by epithelial cells?
a) 810 nanometers
b) 605 nanometers
c) 980 nanometers
d) 1064 nanometers
e) 1200 nanometers

9. Which of the following are primary chromophores?
a) Bilirubin
b) DNA
c) Red blood cells
d) Brown adipose tissue
e) All of the above

10. What are the Primary Tissue Variability Factors?
a) Systemic applications of high volumes of quantum energy
b) Factors that produce homeostasis in the body
c) Treatment settings Related to tissue injuries
d) Tissue/ energy absorption coefficients that govern how laser energy is absorbed by chromophores in the body
e) A complex set of interacting metabolic chemical reactions

11. What Happens when photomedicine is absorbed by chromophores?
a) Photonic energy is converted to chemical kinetic energy within the cell
b) A cascade of metabolic effects results in various physiological changes at the cellular level
c) Regulation of signaling pathways responsible for significant events required for tissue repair such as cell migration, RNA and DNA synthesis, cell mitosis, protein secretion, and cell proliferation occur
d) Enhanced immune system response with the increased activation of T-lymphocytes, macrophages, and number of mast cells
e) All of the above

12. What is the definition of tissue density and how does it affect photomedicine?

a) Penetration through a medium (living tissue) is inversely related to the density and directly related to the permeability of that medium
b) Connective tissue is made up of a material called a matrix with embedded cells
c) Continuous wave energy is absorbed more rapidly in the tissues
d) the brain is also made up of gray matter as well as white matter, with nerves embedded within
e) None of the above

13. What is Mitochondrial Respiration?

a) When Mitochondria breathe
b) The process whereby cytochrome C oxidase absorbs light and enhances ATP synthesis
c) Stimulation of the immune system
d) Reduction of the inflammatory processes
e) The control of photochemical reactions that mimics and enhances the function of natural light

14. What is meant by enhanced cytokine modulation?

a) The reduction of an overactive immune response from an autoimmune disorder
b) Stimulation of the immune system to fight a foreign pathogen or to attack tumors
c) Modulation of an overactive cytokine response, reducing the inflammatory process that occurs in an overactive cytokine response such as an
d) +autoimmune disorder
e) Activation of body systems to fight disease and sickness
f) All of the above

15. What is the first law of photochemistry?

a) Energy must be absorbed in order for photochemical responses to occur
b) The photochemical effect is directly proportional to the total energy dose
c) Both A & B are true
d) A, B, and E are true
e) In photomedicine, the time or output power level required to deliver an adequate dose is irrelevant

16. How does photomedicine improve vascular function?

a) Laser energy enhances angiogenesis (formation of new micro-capillaries)
b) Photomedicine stimulates microcirculation, thereby increasing vasodilation and speeding up the healing process
c) The 810nM wavelength is readily absorbed by vascular tissue
d) Endothelial cells are found in abundance in vascular tissues
e) All the above

17. What is fluorescent Resonance Energy Transfer?

a) A primary signaling modality for molecules in the body
b) A means whereby energy is transferred from a stimulated, energetic molecule to another
c) Photomedicine enhances the FRET process
d) Fluorescent resonance represents a primary mechanism whereby photomedicine produces desired clinical benefits
e) All the above

18. What is ATP synthase?

a) The process that creates the energy storage and transfer molecule adenosine triphosphate
b) Is formed from adenosine diphosphate (ADP) and inorganic phosphate (Pi)
c) Needs photonic energy for its formation
d) A and B are true
e) A, B, and C are true

19. What are the primary mechanisms of pain reduction in photomedicine?

a) laser therapy accelerates the process of nerve cell regeneration
b) laser therapy increases the amplitude of action potentials to optimize motor and sensory nerve functions
c) laser therapy stimulates the regeneration of myelin, which acts as a buffer to external stimuli and protects nerves
d) A and C are true
e) A, B, & C are true

20. **What are the major differences between white and brown adipose tissue, where are** they found in the body and why are they important in photomedicine?

a) Brown adipose tissue derives its color from rich vascularization and is densely packed with mitochondria
b) White adipose tissue makes up 20% of human body weight in men and 25% in women
c) Adipose tissue is mostly fat cells with fibrous strings as structure
d) Adipose tissue is it an important part of the endocrine system
e) All of the above

21. Adipose tissues are found throughout the body in shallow and deep tissues, directly under the skin, in deposits between muscles, intestines, the heart, and bone marrow

a) True
b) False

22. **Brown adipose tissue is rich in mitochondrial cells, ranges from tan to red in color,** and is primarily responsible for ATP production
   a) True
   b) False

23. **Photobiostimulation of red blood cells (erythrocytes), enhances the following** processes:
   a) Hemoglobin interaction, tissue oxygenation
   b) plasma and platelets interaction
   c) mitochondrial interaction
   d) vascular tissue interaction
   e) All of the above

24. **The effects of therapeutic photomedicine fluctuates according to various human** factors, including the following:
   a) Age
   b) Relative health
   c) weight or body mass index
   d) skin pigmentation
   e) tissue hydration level
   f) All of the above

25. There are several types of connective tissues, including the following:
   a) Blood
   b) Bones
   c) Cartilage
   d) Connective tissue proper
   e) A, B, C, & D

26. What are some of the properties of connective tissues?
   a) Abundant and found throughout the body
   b) fibroid, elastic, collagenous fibers
   c) Some are lightly pigmented, some are darkly pigmented
   d) Found in the heart muscle
   e) All of the Above

27. **OF all the primary tissue variables that affect therapeutic energy absorption, which** is most important?
   a) Tissue Density
   b) Tissue Proximity
   c) Tissue Pigmentation

d) Tissue Hydration
e) All of the Above

28. Which of the following is true?

a) Continuous wave energy is absorbed less rapidly in shallow surface tissues
b) Pulse mode is more absorbent in denser tissues because it allows for more intense micro absorption of energy

29. **Is the following statement true or false: Continuous wave energy is absorbed more** rapidly in shallow surface tissues, and therefore is considered to be most appropriate for more superficial conditions and more permeable tissues

a) True
b) False

30. Is the following statement true or false: Pulsing is absorbed less rapidly with better progression through the tissues and can therefore be more effective at greater depth and with denser tissue structures.

a) True
b) False

31. **Is the following statement true or false: The deeper and denser the tissues, the** higher the pulse (duty cycle, or ratio between beam emission and rest) for optimal clinical outcomes.

a) True
b) False

32. How many tissue types are there in the Fitzpatrick scale?

a) Three
b) Five
c) Seven
d) Six
e) Four

33. What is not one of the tissue types in the Fitzpatrick Scale?

a) White
b) Green
c) Brown
d) Dark Brown
e) Black

34. Which skin type most rapidly absorbs laser energy?

a) White
b) Black
c) Brown
d) Dark Brown
e) Light Brown

35. **With a Fitzpatrick Score of 7-12, is more or less energy required for a standard** treatment?
a) More
b) Less
c) The same

36. **With a Fitzpatrick Score of 31+, what kind of precautions need to be considered for** laser therapy treatments?
a) Laser energy is very slowly absorbed, so higher energy dosages are required
b) Laser energy is very rapidly absorbed, so lower energy dosages are required
c) Body Mass Index is very high, so pulse mode is indicated
d) Body Mass Index is very low so continuous wave is indicated
e) None of the above

37. Should a Fitzpatrick Scale analysis be performed with each patient?
a) Yes
b) No
c) Maybe
d) Only with males
e) Only with females

38. Water compromises what percentage of the human body?
a) 25 to 35%
b) 35 to 45%
c) 80 to 95%
d) 45 to 75%
e) 10 to 15%

39. What is the recommended fluid intake while undergoing laser therapy treatments?
a) 1/2 of a patient body weight in fluid ounces daily
b) 100% of a patient's body weight in fluid ounces daily
c) 30 ounces of fluid per day
d) 200 ounces of fluid per day
e) two cups of water per day

40. What is the most common type of stress?

a) Chronic stress
b) episodic stress
c) physical stress
d) acute stress
e) traumatic stress

41. What type of stress induces cell damage?

a) Physical - intense exertion
b) Chemical - drugs such as alcohol, caffeine, nicotine, and environmental pollutants
c) Mental - perfectionism, worry, anxiety, long work hours
d) Emotional - anger, guilt, loneliness, sadness, fear
e) Nutritional - food allergies, vitamin and mineral deficiency
f) Traumatic - injuries, surgery, illness, infections, extreme temperatures
g) Psychospiritual - troubled relationships, financial or career pressures, challenges with life goals, spiritual alignments or general state of happiness
h) All of the above

42. Is laser therapy more difficult with an older patient?

a) Yes
b) No

43. What makes laser therapy more difficult in older patients

a) Lipids (fatty substances) in cells increase
b) Many cells lose their ability to function, or begin to function abnormally
c) Waste products (lipofuscin) buildup in tissues
d) connective tissues become stiffer and less pliable
e) many tissues have more trouble getting oxygen and nutrients
f) All of the above

44. **in treating an older patient, is higher energy dosage typically required for most** treatments?

a) Yes
b) No

45. What are some of the other processes that occur as our tissues age?

a) Cells experience atrophy - cellular shrinkage
b) Cells experience hypertrophy - cellular enlargement
c) Cells experience hyperplasia - cellular increase
d) Cells experience dysplasia - the size of the shape of cells become abnormal
e) Cells experience neoplasia - enhanced reproduction of cells, forming tumors

f) all of the above

46. How does laser therapy reverse the aging process?

a) Laser therapy stimulates cellular function enhancement
b) Laser therapy enhances tissue regeneration
c) Laser therapy stimulates the production of collagen and elastin
d) Laser therapy stimulates the body's natural healing processes
e) Laser therapy speeds up metabolism
f) all the above

47. **Systemic applications of high volumes of quantum energy can assist in controlling and** redirecting the mechanisms of homeostasis in enhancement of tissue regeneration, added vigor, robustness, and more dynamic interactions throughout the full range of metabolic processes.

a) True
b) False
c) Maybe

48. **DNA contains molecules that absorb and transfer laser therapy energy via the FRET** process. Substances in the DNA (receptor chromophores) are excited by therapeutic laser energy to a higher energy state; they then transfer that higher energy to other substances in the DNA (acceptor chromophores). This process is called fluorescent resonance energy transfer, or FRET, and is used to direct stimulate energy to where it is most needed.

a) True
b) False
c) Maybe

49. RET (fluorescent resonance energy transfer) is a function of the ATP synthase process

a) True
b) False
c) Maybe

50. Therapeutic laser energy delivers additional sources of energy for the ATP synthase process to be stimulated, thereby boosting the process whereby FRET can occur most efficiently.

a) False
b) True
c) Maybe

51. **Mitochondria are a principal intracellular target of near infrared light energy.** Cytochrome C oxidase (unit IV of the mitochondrial respiratory chain) is a chromophore that

absorbs light as far into the infrared as 1000 nm. Numerous clinical studies report increased cytochrome c oxidase activity after laser therapy treatments, and increased ATP synthesis after light delivery to isolated mitochondria.

a) False
b) True
c) Maybe

52.Which of the following is a example of GOOD cytokine modulation?

a) When stimulating the immune system to fight at foreign pathogen
b) when reducing and overexcited immune system response
c) when causing inflammatory diseases
d) A and B
e) A, B, and C

53. How does photomedicine help enhance cytokine modulation?

a) When managing higher levels of cytokine production due to environmental stress, injury, or pathogenic infection
b) when stimulating the immune system to fight viruses and bacteria
c) when enhancing the immune system
d) when reducing the inflammatory processes that occur in overactive cytokine response
e) All the above

54. **What happens when photomedicine is absorbed by chromophores found in the body** (particularly mitochondrial cells and DNA)?

a) Accelerated tissue repair and healthy cell proliferation occurs
b) Increased reduction of fibrous tissue formation occurs
c) Increased anti-inflammatory response occurs
d) Increased analgesic response occurs
e) Improved vascular function occurs
f) Increased metabolic activity occurs
g) Improved nerve function occurs
h) Enhanced immunoregulatory response occurs
i) Trigger and acupuncture point stimulation occurs
j) All the above

END OF MODULE II

MODULE III – TYPES OF ENERGY MEDICINE, LASER THERAPY APPLICATION MODES, WAVELENGTH DIFFERENTIALS, STIMULATION vs. INHIBITION

INTRODUCTION & OUTLINE

- Review and Summary of previous modules
- The nature of energy medicine
- The benefits of phototherapy over other energy medicine types
- Physical laws governing the transference of electromagnetic energy to living tissues
- Laser Stimulation vs. Laser Inhibition (L.S. vs. L.I.)
- Energy - How much is too much?
- When does laser stimulation end and laser inhibition begin?
- How much infrared energy does the sun provide to living tissues in a one-hour interval?
- How to Calculate Energy Density, or Dosage
- How to determine laser output frequency
- Continuous Wave vs. Pulsed, Phased, Fractional, or Gated Wave
- Laser modes of operation
- How to determine which laser mode will determine optimal treatment outcomes
- Guidelines used to determine treatment parameters
- Primary Tissue Variability Factors (Review)
- The science of wavelength color
- Primary therapeutic wavelength properties
- Photomedicine guidelines by category

LEARNING OBJECTIVES:

Upon completion of this module, you should be able to:

1. Understand 'Energy' Medicine, the many types and the advantages of photomedicine over every other type including Pulsed Electromagnetic Field Therapy, Extracorporeal Shock Wave Therapy, E-Stim, TENS, and more…

2. Understand the following principle: As with any energy treatment, the ability to heal tissues with energy is equaled by its corresponding ability to harm tissues

3. Know the physical laws that govern energy transference from electromagnetic radiation to targeted living tissues

4. Understand how light is another form of electromagnetic radiation, it's place on the energy scale, how it relates to other forms of radiation, and its beneficial effects on the human body

5. Understand the nature of and principles behind LS (laser stimulation) vs. LI (laser inhibition)

6. Learn to question EVERYTHING in relation to photomedicine, including preset treatment protocols (WHY is it that way?)

7. Prove to yourself the laws and principles of phototherapy as presented in this training program

8. Understand the principle 'What Goes around Comes Around' as it relates to Photomedicine

9. Understand 'How Much is Too Much?' as it related to photomedicine

10. Know and understand how much solar radiation is absorbed by the skin withing a given period, and how it relates to photomedicine

11. Understand when stimulation ends and inhibition begins as it relates to photomedicine, and how it changes with each patient

12. Understand why LLLT studies with cells in a Petri dish do not translate to real-world situations and how it relates to photomedicine

13. Understand the principles and equations in order to calculate Energy Density in CW output

14. Understand the principles and equations in order to calculate Energy Density in pulse mode output

15. Understand the difference between true energy pulses and gated, or chopped pulses

16. Know the various terms for pulse (phased, fractional, gated, chopped, etc.) mode in photomedicine and be able to use them interchangeably

17. Understand the term 'super-pulsing' and its intended use in photomedicine, and why it is mostly ineffective in resolving tissue conditions (illness, injury, malfunction)

18. Be able to quickly calculate general and specific dosages (energy density)

19. Understand the many benefits of icing (cooling) overlying skin and subcutaneous tissues before treatment

20. Know and understand the most beneficial modes of treatment using the following variables (primary tissue variability factors):

- Contact vs. Non-Contact
- Multiple Wavelengths vs. single wavelength
- Which wavelength is best for targeted tissues?
- Permeable vs. dense tissue types
- Optimal power level
- Optimal treatment duration

21. Understand the science of wavelength color, and specific benefits of each wavelength

The human body is comprised of electro-magnetic transmission and communication. It emits waves of electromagnetic energy and responds to waves of electromagnetic energy. All biological functions correspond to vibrational resonant harmonic electromagnetic phenomena. The electromagnetic energies that exist in living tissue are extremely potent; when living cells are targeted with the precise resonant frequency required for enhanced function and healing, they will respond favorably.

ENERGY MEDICINE DEFINED
Energy Medicine is a word coined by researchers who gathered at Boulder, Colorado in the late 1980s, and is defined as any energetic or informational interaction with a biological system to bring back homeostasis in the organism.

Vibrational Energy medicine includes a wide-ranging group of energies – all in their own way therapeutic. Since light is the basic quanta of energy in the universe, and the human body is constructed of light, the body responds more readily to photomedicine than any other form of vibrational therapeutics.
In this document we will be discussing exclusively photomedicine, although other electromedicine types exist, namely:

Pulsed Electromagnetic Field Therapy (PEMF)
The original basis for this form of therapy is the interaction between biological systems with the natural magnetic fields. Optimization of the physical window comprising the electromagnetic field generator and signal properties (frequency, intensity, duration, waveform) with the biological window, inclusive of the experimental model, age and stimulus has helped in achieving consistent beneficial results. Low frequency pulsed electromagnetic field (PEMF) can provide noninvasive, safe and easy to apply method to treat pain, inflammation and dysfunctions associated with rheumatoid arthritis (RA) and osteoarthritis (OA) and PEMF has a long-term record of safety. This review focusses on the therapeutic application of PEMF in the treatment of these forms of arthritis. The analysis of various studies (animal models of arthritis, cell culture systems and clinical trials) reporting the use of PEMF for arthritis cure has conclusively shown that PEMF not only alleviates the pain in arthritis, but it also affords chondroprotection, exerts anti-inflammatory action and

helps in bone remodeling and this could be developed as a viable alternative for arthritis therapy. https://pubmed.ncbi.nlm.nih.gov/20329696/ https://pubmed.ncbi.nlm.nih.gov/20329696/

Extracorporeal Shockwave Therapy (ESWT)
Treatment of musculoskeletal conditions with extracorporeal shockwave therapy (ESWT) or ultrasound is gaining popularity as greater evidence supports its use. ESWT protocols (describing energy flux density, number of impulses, type of shockwave (focused or radial), number/frequency/duration of treatment session, area of application, and postprocedural therapy protocols) can be adjusted in the clinical setting. Protocols vary across studies, and optimal protocols for most indications are yet to be determined. ESWT can safely be used to treat various musculoskeletal conditions including rotator cuff tendinopathy, lateral elbow epicondlyopathy, greater trochanteric pain syndrome, hamstring tendinopathy, patellar tendinopathy, Achilles tendinopathy, other tendinopathies, plantar fasciopathy, bone stress injuries, and medial tibial stress syndrome. https://pubmed.ncbi.nlm.nih.gov/34099607/

Electrical Stimulation (E-Stim, or T.E.N.S.)
machines stimulate the nerves exclusively for the purpose of relieving pain, whereas Electrical Muscle Stimulation (EMS) machines are designed to stimulate the muscles for the purposes of strengthening and rehabilitating them. The theory is that applying an electrical current helps to strengthen muscles, block pain signals, and improve blood circulation.

Photomedicine (Laser Therapy, Photobiomodulation or PBM Therapy)
Light (Photonic Energy) is part of the electromagnetic spectrum, which ranges from radio waves to gamma rays. Electromagnetic radiation waves, as their names suggest, are fluctuations of electric and magnetic fields, which can transport energy from one medium to another across a barrier. Visible light is not inherently different from the other parts of the electromagnetic spectrum with the exception that the human eye can detect visible waves. Electromagnetic radiation can also be described in terms of a stream of photons which are massless particles each travelling with wavelike properties at the speed of light. A photon is the smallest quantity (quantum) of energy which can be transported, and it was the realization that light travelled in discrete quanta that was the origin of Quantum Theory.

What Goes Around Comes Around
As with any energy treatment, the ability to heal with this particular therapeutic regimen is only equaled by its ability to harm tissues. In other words, in order for any kind of energy healing therapy to stimulate a radical change to targeted tissues it must have a corresponding ability to damage the same tissues. A laser can be left too long on a given area, thereby causing thermal increase and a potential for burns. This is true of any laser no matter what the class. Cavitation, a potential negative side effect of ultrasound, can occur when tissue cells continue to enlarge in size to the point of rupture due to built-up acoustical vibrations over the treatment area. Ultrasound poses several risks to patients, such as overheating and burning tissue, damage to blood vessels

and tissue in the treatment area, and cavitation. Electrical stimulation can burn or cause pain when over-stimulation occurs. It should not be used on patients that do not have sensation in the treatment area. This theory is illustrated by several physical laws as discussed in Module I, including the following:

- Bunsen Roscoe Law of Reciprocity: (http://www.photobiology.com/reviews/bunsen/index.htm)
- The Grotthuss–Draper Law (http://www.newworldencyclopedia.org/entry/Photochemistry)
- The Stark-Einstein Law (http://ccb.rutgers.edu/sites/default/files/coursefiles/courses_sp10/512/Handout_I_Photochemistry_I.pdf)
- The Beer-Lambert Law http://www.pci.tu-bs.de/aggericke/PC4/Kap_I/beerslaw.htm.

The therapies discussed here and following, i.e., electro-magnetic radiation, frequency harmonics therapy, electrical current, oscillating and pulsed magnetic fields, radio waves, stimulated infrared light therapy (photomedicine) and sound therapy (shockwave therapy) are all energy mediums. Conventional physics does not regard sound as part of the electromagnetic spectrum per-se. However, every frequency in the electromagnetic spectrum has a corresponding sound, even if we cannot hear it. Thus, audible and inaudible sound has an intricate relationship to electro-magnetic frequencies and can be utilized for healing. In this sense, sound acts as slow light energy and light acts fast sound.

While we have many disparate forms of vibrational energy that are used therapeutically: Photomedicine, or Laser Therapy, Pulsed Electromagnetic Field Therapy, or PEMF, Extracorporeal Shockwave Therapy, or ESWT, Transcutaneous Electrical Nerve Stimulation (T.E.N.S.), Electrical Muscle Stimulation, or EMS, and several others, only one of these offers multiphasic dose responses that are therapeutic, while all the rest only damaged tissue with increasing dosages. Laser therapy alone offers benefits at the high end of the scale, which being tissue inhibition. While tissue healing is always a primary goal, it is sometimes overtaken by the need to mitigate pain. It is at these times that photomedicine really shines.

LASER STIMULATION vs. LASER INHIBITION (LS vs. LI)

It's important to realize that photobiomodulation is multiphasic in its dose response, meaning that stimulation can become inhibition simply by transferring additional energy to the targeted tissues until tissue inhibition occurs.

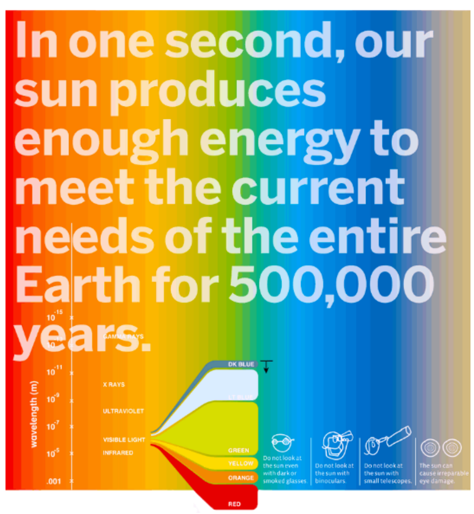
Most of the time we want to stimulate targeted tissues, such as when healing is our primary goal.

There are other times when we would rather choose to inhibit tissue function, which is we work to reduce or inhibit metabolism in targeted areas that are causing pain, especially in nerve tissues. Pain will be better controlled and mitigated through the inhibition of targeted tissues - this represents the upper end of the multiphasic dose response in photomedicine, and there are times when this will be our primary goal.

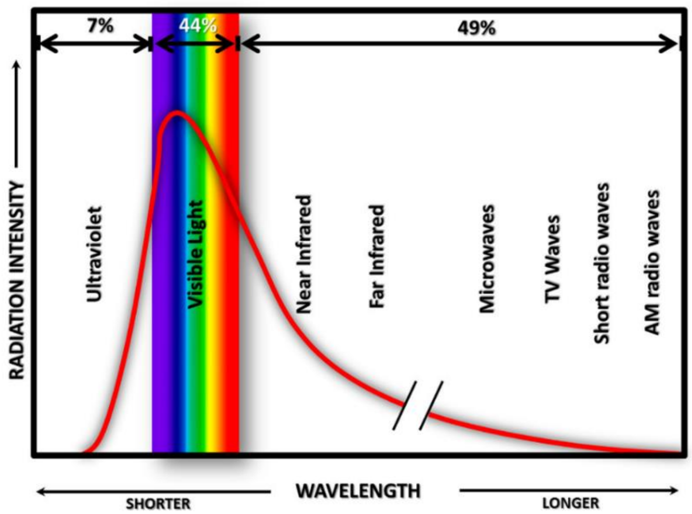
Experimental studies of non-ablative laser irradiation have been done on peripheral nerve morphology, physiology, and function to learn more about treatment parameters for pain relief. The findings were then evaluated with special reference to the neurophysiology of pain and implications for the analgesic effect of inhibitory laser therapy.

How much is too much?
Therapy lasers offer us many choices in the treatment of pain, amongst them has been treatments involving neurostimulatory effects and treatments involving neuroinhibitory effects.

Researchers at NASA use a measurement of luminosity to define the amount of energy the sun can emit. Luminosity is recorded in Joules per second internationally. The sun's luminosity is about 3.8 x 10^{26} Joules *continuously* (that's 10 with 26 zeros following). In other words, in one second the sun generates more energy than has been used in all of mankind's history!



Discounting solar energy absorbed by the atmosphere, it is correct to say that during one hour of sunbathing every exposed square centimeter of the body will receive many hundreds of Joules per centimeters squared of solar energy ($300Jcm^{2+}$) with 41% of the energy in the infrared range, 40% in the visible range, and the rest in UVA, UVB, and other more energetic waves:



Using solar radiation as an example, it is correct to assume that inhibitory dosages in laser therapy can reach 100Jcm^2 or more without causing permanent tissue damage.

WITH PHOTOMEDICINE, WHEN DOES STIMULATION END AND INHIBITION BEGIN?

So... When does laser stimulation end and laser inhibition begin? Again, we have to rely on tissue variability factors, all else being equal.

Almost all Initial laser therapy studies were based on muscle tissues in a Petri dish, with extremely low levels of energy being administered. In this setting it is easy to understand why any therapeutic laser dose higher than 2J to 4J/cm^2 will produce an inhibitory response and eventual tissue destruction, because the muscle tissues are completely vulnerable to any type of energy transmission no matter how low the dosage. The very same muscle tissues in a real-world situation will be highly protected by skin, subcutaneous, and other tissue layers. Figuring results based on primary tissue variability factors suggests that a much higher laser dosage will be required for stimulation and an even higher dosage required for inhibitory factors.

To what degree laser stimulation (LS) will occur and when it becomes laser inhibition (LI) is dependent again on tissue variability factors other treatment factors such as contact versus non-contact, continuous wave versus pulse mode, single wavelength versus multiple wavelengths, maximum laser output power, duration of treatment, and more.

It is the responsibility of each therapy laser practitioner to accurately diagnose each patient, and taking into account all variables, come up with optimal treatment protocols for individual patients. As stated before, the preset protocols found on all therapy laser programs are simply guidelines, or baseline figures determine for the most vulnerable of all patients.
We use the following formulas to calculate laser therapy treatment dosages:

HOW TO CALCULATE DOSAGE, OR ENERGY DENSITY

- *Continuous Wave (CW)*
  (P)Power X (D)Duration/(A)Area = J/CM²

For example, let's assume that the power is 10Watts, the duration of treatment is 600 seconds (10 minutes), and the treatment area is 100 cm², or about 5 ½" X 5½" which gives us the following equation: 10W(P) X 600 (D) = 6,000(J) / 100(A) = 60J/cm²

- *Pulsing*
  J/CM² X T-on T-off ratio - J/CM² = average peak power

For example, let's assume T-on is 25ms (microseconds) and T-off is 5ms - to determine the ratio (duty cycle) divide T-on by T-off, which gives us a ratio of 20% (5/25 - in other words, at a duty cycle of 20%), which is multiplied by energy density (60J/cm²) then subtracted from the same number (60J/cm² X 20% = 12), yielding the following equation: 60J/cm² (energy density) -12 (energy density minus duty cycle ratio) = Average Peak Power 48J/cm²

Another example for setting frequencies on the laser:
1/(T-on +T-off) = frequency; 1 sec. for T-on and T-off;
Example: T-on 300ms and T-off 20ms, frequency = 3Hz
300ms is 0.3s, 20ms is 0.02s, 1/(0.3+0.02)=3Hz

For treatment settings, use the following basic formulas:
• HIGHER dosage, increase Watts, Time, & DECREASE treatment AREA
Smaller treatment area means GREATER energy density

• LOWER dosage, decrease Watts, Time, increase treatment AREA
Larger treatment area means LOWER energy density

• DENSER tissues require HIGHER DOSAGE, PERMEABLE tissues allow for LOWER DOSAGE

• SHALLOW tissues are better treated with CW (continuous wave) output, tissues that are DEEPER in the body respond better to fractional, pulsed, or phased energy; the DEEPER and DENSER the tissues, the HIGHER the Hz rate (DUTY CYCLE) for deeper penetration and more optimal clinical outcomes.

Use the following to calculate treatment dosage: Treatment Time (T) = Total Energy Delivered (J)/Average Output Power (W)

- Treatment time at 30Watts (30 seconds = 1,000J)
- Treatment time at 10Watts (1 minute and 40 seconds = 1,000J)
- Treatment Time at 5Watts (3 minutes and 20 seconds = 1,000J)
- Treatment time at 500milliWatts (33 minutes and 20 seconds = 1,000J)

- Treatment time at 5milliWatts (55 hours, 33 minutes and 20 seconds) = 1,000J)
  How much time do you have?

The chart on the next page will aid in figuring dosages – all values in determining dosage should be included on a patient's medical records. When marking a patient's chart, it is always prudent to be as detailed as possible:

- Dosage (Joules) = Watts (power) X Time (duration of treatment in seconds) divided by treatment area (in centimeters)
- Energy Density = Joules/Area
- Typical treatment area $100cm^2$ (about the size of a playing card)
- To calculate energy density, simply divide the energy in joules by the area in square centimeters

- DOSE is affected by wavelength, power density, tissue type, tissue condition, chronic or acute, pigmentation

Continuous Wave vs. Pulsed, Phased, Fractional, or Gated Wave
In laser therapy, the terms pulsed, phased, fractional, or gated all mean the same thing. In this mode, the laser output is interrupted at regular or preset intervals do enhance the biological effects of the wave energy.
Pulsing is beneficial because it allows for more intense micro absorption of energy with less possibility of damage from excess heat or other effects

The following statements are true when pigmentation is not a primary factor:

1. Continuous wave energy is absorbed more rapidly in surface tissues, and therefore is considered to be most appropriate for more superficial conditions and more permeable tissues.

2. Pulsing is absorbed less rapidly with progression through surface tissues and can therefore be more effective at greater depth and denser tissues.

Icing/cooling surface tissues for a short time before treatment will inhibit absorption by surface tissues and allow the energy to penetrate more deeply to reach the targeted tissues in the muscles, nerves, connective tissues, collagenous tissues, bone tissues, etc., especially while providing a pulsed, or phased treatment modality.

Icing/cooling tissues for a short time before treatment offers two benefits: first, it desensitizes the skin and subcutaneous tissues to thermal increase, allowing for longer treatment times over a smaller treatment area; second, it reduces or inhibits metabolic function in surface and subcutaneous tissues, allowing energy to flow more freely to underlying targeted tissues as described above.

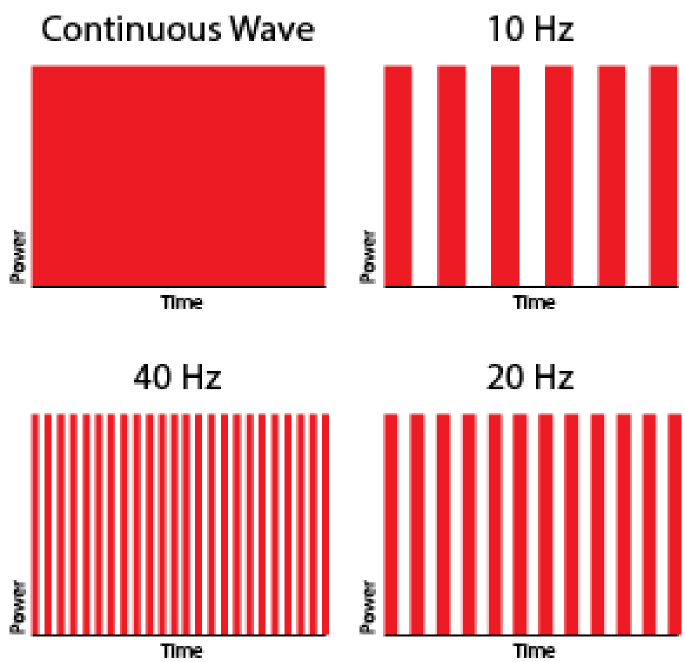
LASER MODES OF OPERATION

A laser can be classified as operating in either continuous or fractional mode, depending on whether the power output is continuous over time or whether its output takes the form of pulses of energy at regular intervals scale (see Figure 1):

Line 1: Continuous Wave

Line 2: Modulated Continuous Wave (Phased, Pulsed, Gated, Fractional)

Line 3: Modulated Continuous Wave (Phased, Pulsed, Gated, Fractional)



Line 4: Nanosecond Pulses

Continuous Wave Operation

Continuous wave emission has no interruption during the delivery of their energy

Some applications of lasers depend on a beam whose output power is constant over time; such an output is known as continuous wave mode.

Pulsed, or Phased Operation

Pulsed operation of lasers refers to any laser output not classified as continuous wave, so that the optical power appears in pulses of some duration at some repetition rate. This encompasses a wide range of technologies addressing a number of different motivations.

Some lasers are pulsed simply because they are unable to operate in continuous wave mode due to the weak output of their diodes. In other cases, laser therapy application requires the production of pulses having as large an energy as possible. Since the pulse energy is equal to the average power divided by the repetition rate, this goal can sometimes be satisfied by lowering the rate of pulses so that more energy can be built up in between pulses.

Other applications rely on the peak pulse power (rather than the energy in the pulse), especially in order to obtain nonlinear optical effects. For a given pulse energy, this requires creating pulses of the shortest possible duration utilizing techniques super pulsing. Typical peak power is in the order of many Watts; however, the necessary high current in this mode will quickly destroy a laser diode unless the time of current conduction is extremely short. Super-pulsed diode lasers cannot work continuously - the maximal pulse time for this laser is in nanoseconds and after each such pulse a long cooling time is needed, usually about a thousand times longer than the pulse time, therefore a so-called super-pulsed laser will transfer an exceedingly small volume of energy. As stimulatory as well as inhibitory therapy laser treatment outcomes depend on volume of energy transferred for optimal clinical outcomes - typically, this type of treatment alone (super-pulsing) usually does not yield desired results.

Application Mode - Contact vs. Non-Contact

Therapeutic laser beam energy is best directed toward the targeted tissues when the handpiece is held at a 90-degree angle to the skin with the handpiece emitter resting on the skin. The energy beam is delivered in such a way that it focuses at a distance away from the end of the emitter, according to where the lens is located in the handpiece.

When to Treat in Contact Mode

With the handpiece resting on the skin, the energy beam is usually focused at depth and closer to the vicinity of targeted tissues. When treating in this manner, less energy is left on the surface of the skin and more energy is delivered below the skin to the region of tissues being targeted. This can be observed by holding the hand piece two inches away from the skin and initiating treatment, then doing the same with the hand piece directly on the skin. With the hand piece two inches away from the skin, the sensation of heat is much higher than when it is resting directly on the skin. The majority of therapy laser treatments should be done in this manner. This mode of application is especially relevant when treating in pulse mode, which would typically comprise most treatments being administered.

When to Treat in Non-Contact Mode

when treating in non-contact mode, laser energy should be delivered in a continuous wave beam in the targeted tissue is generally very shallow or right on the skin. This is true when treating dermatological issues, or very shallow nerves such as cranial nerves. this mode of treatment is also done when there is minimal subcutaneous tissue over joints including the hands and fingers, wrists and elbows, knees and ankles, and feet.

Treating with a Single Wavelength

When utilizing the 810nm wavelength, the energy of the laser is best applied with the handpiece resting on the skin. The 810nm wavelength should be primarily used when treating large muscle groups or areas of the body that are suffused with hemoglobin or red adipose tissue.

When treating with the 980nm or 1064nm wavelengths as joints, nerves, or bone tissue is targeted, treatment can be on or off the skin depending on the depth of tissue being targeted. For example, when treating shallow nerves such as cranial nerves, treatment can be provided with the handpiece on or just off the skin.

Treating with Multiple Wavelengths
When treating with multiple wavelengths, it is best to treat with the hand piece gently gliding on the skin for optimal treatment outcomes.

The preset protocols in the laser are designed for a treatment area of one hundred centimeters squared (around the size of a playing card). When needing to treat a larger area, it is best to multiply the treatment duration by the number of areas to be treated. For example, if the treatment area is four hundred centimeters squared, then the whole treatment area can be treated at one time, but the duration of treatment needs to be four times longer. Another treatment option is to increase laser output power rather than extend treatment time to achieve the same dosage (joules per centimeter squared).

GUIDELINES USED TO DETERMINE TREATMENT PARAMETERS

- Contact
- Non-contact

For comparison, specific treatment guidelines will be determined according to the model of laser being used. In this module, we will use the lasers by Medray™ to base the settings on. on.

MODE

- CW-continuous wave
- Pulse, phased, or gated mode
- T-On/T-off
- Duty cycle

Medray T3 – 810nm, 915nm, 1064 at 15W/ea. (45W total)
Medray Quad – 650nm at 200mW + 810nm, 915nm, 980nm at 9W/ea. (27.2W total)
Medray Dual – 810nm, 980nm at 15W/ea. (30W total)
Medray D30 – 810nm OR 980nm at 30W/ea.

WAVELENGTH

- 650nm
- 810nm
- 915nm
- 980nm
- 1064nm

GENERAL TISSUE DEPTH (Tissue proximity)

- Shallow
- Deep

GENERAL TISSUE TYPE (Tissue density/permeability)

- Permeable
- Dense

Many treatment protocol guidelines are axiomatic, but need to be considered in a different light (no pun intended) when more modern and effective lasers like those by Medray are utilized. For example, setting the Hertz rate, which in-vitro studies at exceptionally low power levels have always indicated should always be lower than 100Hz, may be more effective when set higher when using more appropriate higher power settings. Although this was axiomatic in past years, modern in-vivo treatments at power levels higher than the previous standard "low-level' settings will prove that this necessarily isn't the case anymore.

The previously established *Primary Tissue Variability Factors* (P.T.V.F.) should always govern treatment protocols since each patient is so vastly different. As a review, they are listed again here:

1. Tissue Type: blood, fat, nerve, muscle, skin, tendon, cartilage, bone
2. Tissue Structure: Simple, stratified, pseudostratified, transitional
3. Tissue Density: adiposity index or BMI (Body Mass Index)
4. Tissue Permeability (ability of wave energy to pass through, or be absorbed by tissue structures)
5. Tissue Proximity: (depth of tissue (shallow vs. deep)
6. Tissue Pigmentation: six levels, from white to black (Fitzpatrick Scale)
7. Tissue Hydration: hydrated or dehydrated (typical = Min. 54.8% to Max. 78.1%)
8. Tissue Stress: bio-behavioral factors that can induce cell damage (cortisol levels, etc.)
9. Tissue Age: from atrophic to neoplastic
10. Tissue Function/malfunction: Equilibrium, Entropy, & Homeostasis

THE SCIENCE OF WAVELENGTH/COLOR - BENEFITS IN PHOTOMEDICINE; (810nm vs. 915nm vs. 980nm, vs. 1064nm)

Previously established was the fact that different tissue types absorb different wavelengths, which can be identified according to their color:

THE 650nm WAVELENGTH

The 650nm wavelength, besides being used as an aiming beam since it is in the visible range, serves a dual purpose by offering laser energy in the class 3B range, thereby stimulating the effects of photobiomodulation. 650nm is best absorbed by the skin, and acts to enhance the effects of the other wavelengths. In addition, this wavelength transfers a great deal of heat energy to targeted tissues, this being therapeutic in and of itself.

THE 810nm WAVELENGTH

The conversion of ATP through molecular oxygen has the highest saturation using the 810nm wavelength. This wavelength has been called the 'therapeutic' wavelength, or the 'Jack of all Trades' wavelength as it penetrates deeper and affects a wider range of metabolic activity than

other wavelength. In addition, the 810nm wavelength stimulates red blood cells to transport oxygen more effectively from the lungs to cells throughout the body, improving the delivery of oxygen molecules to where they are most needed. This wavelength will help regenerate damaged muscle, collagenous, connective, bone, and other tissue types. In the metabolic process, specific proteins including hemoglobin binds to oxygen; the 810nm wavelength enhances rapid activation of the binding process, stimulating more rapid
cellular recovery and tissue healing.

THE 915nm WAVELENGTH

The 915nm wavelength is ideally suited to absorption by fluid in the tissues; What this means is enhanced reduction of inflammatory conditions come on reduction of pain due to the reduction of the inflammatory process, enhanced wound healing, and enhanced oxygenation of tissues throughout the body. Oxygen is life; the 915nm allows faster oxygen discharge into the bloodstream, increasing cellular food loads and stimulating increased healing capabilities. hemoglobin assimilation is best accomplished by the 915nm wavelength; for any engine to properly function it needs fuel; the 915nm wavelength provides that fuel and the photomedicine processes ensures the fuel is released and delivered.

THE 980nm WAVELENGTH

Oxygen that is released by the function of the 915nm wavelength needs a transport system; that transport system is H2O. Along with oxygen transport, water helps in the elimination of waste which makes it a dual mode carrier. In the photomedicine process, photon absorption is converted to heat energy. This heat energy creates a controlled thermal environment at the cellular level, triggering microcirculation and the transport of oxygen do the cells that are demanding it. In addition, the 980nm wavelength stimulates the distribution of calcium by transferring it from the mitochondria to the fluid within the cell. Stimulating cells with the 980nm wavelength helps lead to pain reduction, the stimulation of circulation, and enhanced muscle relaxation. In addition, stimulating the brain and the enteric system in the body (epithelial tissues containing mitochondria and suffused with blood) helps to stimulate the production of serotonin, a primary mitigator in the pain reduction process.

THE 1064nm WAVELENGTH

Photomedicine at 1064nm penetrates more deeply into denser tissues than either the 810nm or 980nm wavelengths, meaning metabolic processes deeper in the body are stimulated more readily by this wavelength. Since skin cells contain most of the body's melanin, and the 1064nm wavelength is especially absorbed by melanin, tissue stimulation occurs more readily with this wavelength; mitochondria is more highly populated in epithelial cells than any other cell type; the 1064nm wavelength is an especially effective way to stimulate mitochondria.

MODULE III – TYPES OF ENERGY MEDICINE; LASER THERAPY APPLICATION MODES; WAVELENGTH DIFFERENTIALS; STIMULATION vs. INHIBITION – QUIZ

What are the four types of energy medicine?
a) Pulsed Electromagnetic Field Therapy (P.E.M.F.)
b) Extracorporeal Shockwave Therapy (E.S.W.T.)
c) Electrical Stimulation (E-Stim, or T.E.N.S.)
d) Photomedicine (Laser Therapy)
e) All of the Above

1. What is the Bunsen Roscoe Law of Reciprocity?
a) What goes around comes around
b) The ability to heal tissues with energy medicine is equaled by the ability of the same energy to harm tissues
c) Laser therapy is multiphasic in its dose response, meaning that stimulation can become inhibition simply by transferring additional energy to the targeted tissues until tissue inhibition occurs
d) A & B
e) A, B & C

2. In photomedicine, when does stimulation end and inhibition begin?
a) It depends on power output
b) It depends on tissue variability factors
c) It depends on contact mode vs. non-contact mode
d) It depends on duration of treatment (treatment time)
e) All of the Above

3. What calculation is used to determine continuous wave (CW) energy density?
a) (P)Power X (D)Duration/(A)Area = J/CM^2
b) J/CM^2 X T-on T-off ratio - J/CM^2 = average peak power
c) 1/(T-on +T-off) = frequency; 1 sec. for T-on and T-off
d) T-on 300ms and T-off 20ms, frequency = 3Hz
e) All of the Above

4. Which of the following is true?
a) For HIGHER dosage, increase Watts, Time, & DECREASE treatment AREA
b) For HIGHER dosage, increase Watts, Time, & INCREASE treatment AREA
c) For LOWER dosage, decrease Watts, Time, DECREASE treatment AREA
d) For LOWER dosage, decrease Watts, increase Time, INCREASE treatment AREA
e) All of the Above

5. Which of the following is true?
a) SHALLOW tissues are better treated with CW (continuous wave) output
b) Tissues that are DEEPER in the body respond better to fractional, pulsed, or phased energy
c) DENSER tissues require HIGHER DOSAGE, PERMEABLE tissues allow for LOWER DOSAGE
d) The DEEPER and DENSER the tissues, the HIGHER the Hz rate (DUTY CYCLE) for deeper penetration
e) All of the Above

6. Which of the following is true?
a) Dosage (Joules) = Watts (power) X Time (duration of treatment in seconds) divided by treatment area (in centimeters)
b) Energy Density = Watts/Area
c) DOSE is determined by wavelength, power density, blood pressure, oxygen saturation, skin pigmentation
d) The DEEPER and DENSER the tissues, the HIGHER the Hz rate (DUTY CYCLE) for deeper penetration
e) All of the Above

7. The following statements are true when pigmentation is not a primary factor:
a) Continuous wave energy is absorbed more rapidly in surface tissues, and therefore is considered to be most appropriate for more superficial conditions and more permeable tissues
b) Pulsing is absorbed less rapidly with progression through surface tissues and can therefore be more effective at greater depth and denser tissues.
c) Icing/cooling surface tissues for a short time before treatment will inhibit absorption by surface tissues and allow the energy to penetrate more deeply to reach the targeted tissues
d) A & C
e) A, B, & C

8. Which of the following is true?
a) A laser can be classified as operating in either continuous or fractional mode
b) Energy Density = Watts/Area
c) DOSE is determined by wavelength, power density, blood pressure, oxygen saturation, skin pigmentation
d) The more permeable the tissues, the HIGHER the Hz rate (DUTY CYCLE) for deeper penetration
e) All of the Above

9. What is meant by the term 'What goes around comes around' as it relates to Photomedicine?

a) If you burn someone while treating them with the laser, they're going to file a lawsuit against you
b) In photomedicine, a biological effect is directly proportional to the total energy dose received irrespective of the administered regime
c) The sun delivers 50milliWatts of energy per square inch to exposed skin on a sunny day at sea level
d) Shallow tissues are best treated with a dosage of at least 200J/cm^2
e) Deep tissues should be treated with a dosage of 4-5 J/cm^2

10. Which of the following is true?
 a) In photomedicine, the terms pulsed, phased, fractional, or gated all mean the same thing
 b) Continuous wave energy is absorbed more rapidly in surface tissues
 c) Pulsing is absorbed less rapidly with progression through surface tissues and can therefore be more effective at greater depth and denser tissues
 d) Icing/cooling surface tissues for a short time before treatment will inhibit absorption by surface tissues and allow the energy to penetrate more deeply to reach the targeted tissues
 e) All of the above

11. Learn to question EVERYTHING in relation to photomedicine, including preset treatment protocols (WHY is it that way – figure it out!)
 a) True
 b) False

12. Why do LLLT studies with cells in a Petri dish not translate to real-world situations where targeted tissues are buried deep in the body?
 a) Cells in a Petri dish are much more vulnerable to electromagnetic radiation than cells deep inside the body
 b) The Bunsen Roscoe Law of Reciprocity is true
 c) The Grotthuss–Draper Law is true
 d) The Stark-Einstein Law is true
 e) The Beer-Lambert Law
 f) All of the above

13. In super-pulsing, how much time is needed for diode cooling before another pulse can be generated?
 a) One and one-half times the width of the pulse
 b) 10 times the width of the pulse
 c) 100 times the width of the pulse
 d) 1,000 times the width of the pulse
 e) None of the above

14. Which of the following statements is false?

a) Super-pulsing alone is ineffective as a therapeutic regimen because of the extremely low energy volume delivered in the nano-second pulse
b) Due to the plethora of expensive super-pulse lasers available, super-pulsing is a viable therapeutic regimen

15. Which of the following statements is true?
a) Photomedicine at 1064nm penetrates more deeply into denser tissues than either the 810nm or 980nm wavelengths
b) The 915nm wavelength is ideally suited to absorption by fluid in the tissues
c) The conversion of ATP through molecular oxygen has the highest saturation using the 810nm wavelength
d) The 980nm wavelength stimulates the distribution of calcium by transferring it from the mitochondria to the fluid within the cell
e) All of the above

16. In the treatment of CRPS (Chronic Regional Pain Syndrome), which therapeutic regimen will best relieve chronic, long-term pain?
a) Tissue Stimulation
b) Tissue Inhibition

17. Which wavelength is best absorbed by endothelial cells that are found in melanin?
a) 650nm
b) 810nm
c) 980nm
d) 1064nm

18. The endothelium is a monolayer of endothelial cells cladding the lumen of the vascular beds of the entire cardiovascular system, from the heart to the smallest capillaries. Scientific evidence exists that the progression of endothelial dysfunction can be counteracted and reversed, preventing the progression of many diseases, and that endothelial function can be regulated through appropriate dosage of photomedicine.
a) True
b) False

19. What treatment mode should be used to treat an arthritic shoulder?
a) Contact
b) Non-contact

20. What treatment mode should be used to treat degenerative disc disease?
a) Contact
b) Non-contact

21. What treatment mode should be used to treat degenerative disc disease?
a) Contact
b) Non-contact

22. What treatment mode should be used to treat cervical spondylosis?
a) Continuous Wave
b) Pulse Mode

23. What treatment mode should be used to treat knee degenerative joint disease?
a) Contact
b) Non-contact

24. What treatment mode should be used to treat peripheral neuropathy?
a) Contact, pulse mode
b) Contact, continuous wave mode
c) Non-contact pulse mode
d) Non-contact continuous wave mode
e) All of the above

25. Epithelial cells contain most of an individual's melanin
a) True
b) False

26. Epithelial cells have many mitochondria because these cells have high levels of energy output and require the ATP (adenosine triphosphate) produced by the mitochondria
a) True
b) False

27. Your heart muscle cells contain about 5,000 mitochondria per cell. These cells need more energy, so they contain more mitochondria than any other organ in the body, making it beneficial to target the heart with photomedicine (laser therapy)
a) True
b) False
c) Very, very true!

MODULE IV - LASER SAFETY

INTRODUCTION & OUTLINE

Laser Safety Checklist (Abbreviated)

- Differences between ionizing and non-ionizing radiation
- Three mechanisms by which tissues are impacted by photomedicine
- Protection for the skin and the eyes
- Laser Safety checklists, facility, traffic, fire safety, electrical power, equipment, documentation
- CDRH, ANSI performance standards and protocols
- Maximum permissible exposure
- Descriptions, Class 1, Class 2, Class 3, and Class 4 laser systems
- the Laser Safety Officer, duties and responsibilities of…
- Warning signs and safety notices
- Review of Contraindications (see Module I)
- Laser Safety Checklist (Complete)

LEARNING OBJECTIVES:

Upon completion of this module, you should be able to:

1. Be aware of the FDA's Center for Devices and Radiological Health and their Mandatory Performance Standards
2. Know who is the ANSI (American National Standards Institute) and how their standards influence the manufacture and use of medical lasers
3. Medical laser safety general requirements
4. Identify safety risks for laser practitioners and patients
5. Describe procedures for safely working with lasers
6. Know and understand the three mechanisms or effects by which body tissue is affected by stimulated light energy
7. Know and understand the various damage mechanisms by which stimulated light energy can cause injury to biological tissues
8. Understand how each tissue type possesses unique spectral properties for light absorption by varying wavelengths
9. Understand how accidental eye exposure can cause serious retinal damage, understand how to protect the eyes from inadvertent exposure to laser energy
10. Know and understand the difference between ionizing and non-ionizing radiation
11. Contraindications (Review from Module I)

LASER SAFETY

The principles and concepts contained in the Basic Training Curriculum satisfy the ANSI (American National Standards Institute) guidelines and requirements for the Laser Safety Officer;

- Every Trained and Certified Practitioner and Technician will jointly achieve Certification as an LSO with completion of the Basic Training Course Materials).
- Laser Safety Officer (LSO) requirements
- Working within the parameters of FDA Approval
- Contraindications: (Including Absolute, Relative, and Anecdotal)

Since laser safety regulations and protocols vary according to each state, the ANSI standards are the closest thing we have to national laser safety guidelines.

Laser Safety Checklist (Abbreviated)

- Appropriate warning signs must be posted
- Access to laser and treatment area is secure and controlled
- Visually inspect and clean all optical connectors for dirt, debris, etc.
- Visually inspect laser for proper function
- Visually inspect and clean all safety goggles
- Goggles must be available for all persons within the Nominal Hazard Zone
- Extra goggles must be placed outside treatment room if necessary
- Sources of potential laser beam reflection and scatter must be controlled
- Treatment protocol must be established for each patient
- Laser injury management protocol must be in place for accidental injury
- Record laser treatment and post-treatment outcomes, and document any incidents or accidents

BODY TISSUES ABSORB LIGHT ENERGY ACCORDING TO UNIQUE SPECTRAL PROPERTIES

Body tissues are diverse in composition with each tissue type possessing unique spectral properties for light absorption. For example, blood containing large amounts of reduced (deoxygenated) hemoglobin effectively absorbs visible red light, while blood containing large amounts of oxygenated hemoglobin effectively absorbs infrared light. This specific spectral property of blood tissue is the basis for pulse oximetry technology. The therapeutic value of laser light is dependent upon the spectral absorption property of the target tissue. The wavelength of laser radiation must be compatible with the tissue being treated.

Accidental exposure to a high-power or low power laser beam can possibly produce serious eye damage caused by laser-tissue interaction. Laser radiation is nonionizing and produces physiological effects that are different from those produced by ionizing radiation, such as X-rays and gamma-rays where damaged at the molecular level occurs when electrons are stripped from atoms.

Eye damage from a laser energy beam is primarily caused when retinal tissue, which is uniquely made to absorb light, absorbs stimulated light energy which in turn causes scarring of the retina. This is similar to taking a picture of the sun with a single lens reflex camera, where the camera's mirror and lens combine to intensify and magnify the sun's image, thereby intensifying the corresponding light energy and causing retinal damage.

It is important to note that exposure to a very low-level laser beam can just as easily damage the eye because of its luminescence. The corresponding energy of the beam may be low, but even if the beam is in the non-visible range, it's luminescence may still be quite high, and possibly cause retinal damage. Luminous and superluminous LEDs are sometimes used in therapeutic modalities. The luminosity of these devices is quite high and are therefore capable of damaging the retina as well.

Prolonged skin exposure to a high-power therapy laser beam produces skin damage by causing thermal build up. as laser energy is nonionizing, tissue isn't damaged or destroyed at the molecular level; rather, overexposure to light energy produces thermal burns, much like when a magnifying glass is held over the skin and the light from the sun is intensified. In almost all cases, the damage is usually confined to first degree burns; as the heat increases a person will pull away from the laser beam as thermal increase occurs and it begins to hurt. For longer exposures, second, or even third-degree burns are possible.

If the handpiece emitter is held directly on the skin damage may occur from prolonged exposure to the underlying dermal layers rather than the epidermis. This can sometimes result in pain and blistering that may take a day or two to fade away. It is better to avoid prolonged skin exposure to radiant beam energy output at more than 3Watts for longer than 10-second durations. If such a prolonged exposure occurs, it is best to ice the area for up to five minutes to negate the thermal effects of the prolonged exposure to the laser beam.

The Difference Between Ionizing and Non-ionizing Radiation

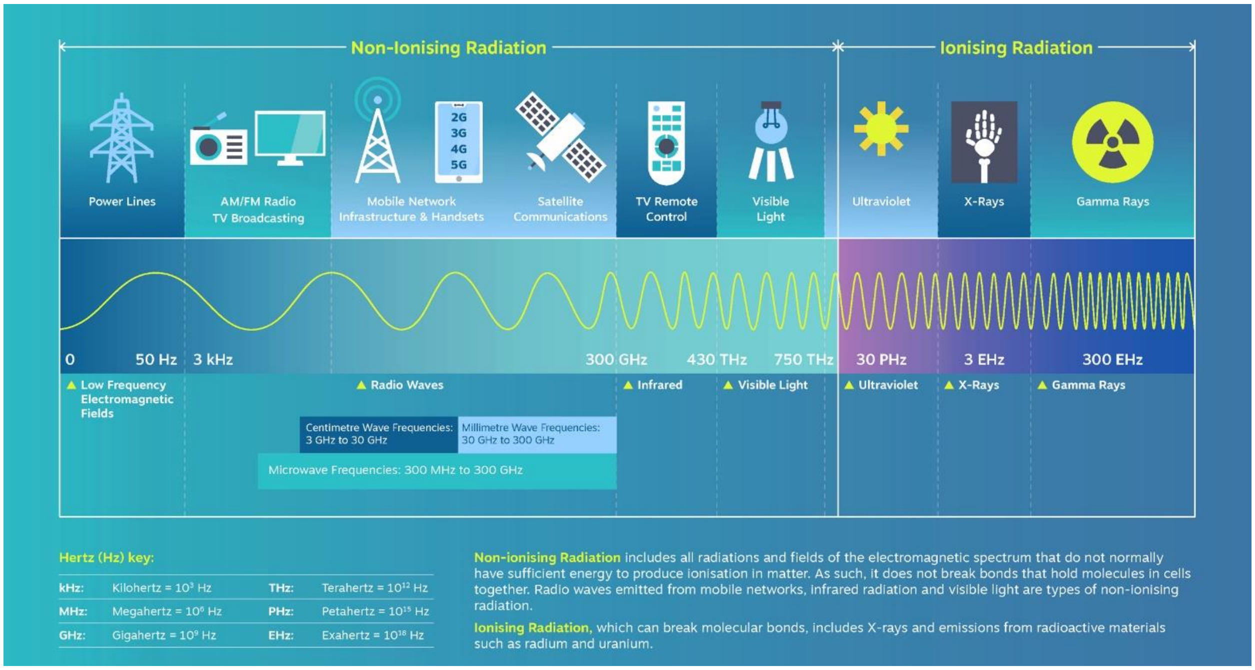
Radiation exists all around us, from both natural and manmade sources, and is in two forms: ionizing and non-ionizing radiation.

Ionizing radiation is a form of energy that acts by removing electrons from atoms and molecules of materials that include air, water, and living tissue. Ionizing radiation can travel unseen and pass through these materials, sometimes causing cellular damage as they pass through living tissue.

Laser energy consists of stimulated light energy in the visible, near infrared (NIR), and infrared (IR) range, and as such is non-ionizing and beneficial to the human body in appropriate doses (except for the eyes.

Accidental exposure to the eyes can often occur through reflected light. Reflected light is often more energetic than direct light (have you ever walked in front of a window that reflected the sun, and noticed how much hotter it was?

Non-ionizing radiation exists all around us from many sources; see below:



Three Mechanisms

In general, there are three mechanisms by which body tissue is changed or damaged by laser light:

- Photo-thermal effect
- Photochemical effect
- Photomechanical or photo-acoustic effect

The photo-thermal effect (the greatest safety hazard) causes tissue to be heated by conversion of laser radiant energy into thermal energy when the light is absorbed by the tissue. The elevation in temperature denatures tissue proteins. The resulting degree of tissue change is proportional to the absorbed energy.

When sufficient light energy is transformed into heat, it vaporizes tissue and a plume of steam and particulate matter is expelled from a surgical field.

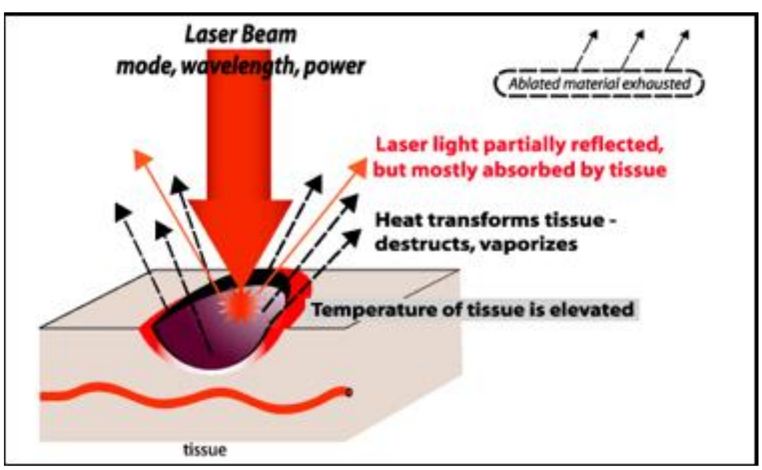
The thermal effect produced by a laser beam is a function of:
- The laser power emitted from delivery system
- The size of the tissue area upon which this energy is focused
(optical spot size)
- The resulting power density (irradiance) in Watts/cm2

• The wavelength-dependent coefficient of absorption for the specific body tissue
• Duration of irradiation

Damage mechanisms

Lasers can cause damage in biological tissues, both to the eye and to the skin, due to several mechanisms. Thermal damage, or burns occur when tissues are heated to the point where denaturation of proteins occurs. Another mechanism is photochemical damage, where light triggers chemical reactions in tissue. Photochemical damage occurs mostly with short-wavelength (blue) and ultra-violet light and can be accumulated over the course of minutes or hours depending on the intensity of the beam. Laser pulses shorter than about 1µs can cause a rapid rise in temperature, resulting in explosive boiling of water. The shock wave from the explosion can subsequently cause damage relatively far away from the point of impact. Ultra-short pulses can also exhibit self-focusing on the transparent parts of the eye, leading to an increase of the damage potential compared to longer pulses with the same energy.

The eye focuses visible and near-infrared light onto the retina. A laser beam can be focused to a point on the retina which may be up to 200,000 times higher than at the point where the laser beam enters the eye. Most of the light is absorbed by melanin pigments in the epithelium just behind the photoreceptors, and causes burns in the retina. Ultraviolet light with wavelengths shorter than 400 nm tends to be absorbed in the cornea and lens, where it can produce injuries at relatively low powers due to photochemical damage. Infrared light mainly causes thermal damage to the retina at near-infrared wavelengths and to more frontal parts of the eye at longer wavelengths. The table below summarizes the various medical conditions caused by lasers at different wavelengths, not including injuries due to pulsed lasers.



Energy is the product of power and duration of exposure. The physician has the ability to select the power and duration of the laser beam. The beam spot size is a function of both the selected type of delivery system and the skill and experience of the physician necessary to hold it constant with respect to the target tissue.

Eye Protection - Beam Hazards

- The greatest single risk for personnel using lasers is eye injury to the cornea or retina from direct or reflected laser beams. Eye protection should be worn by all persons in the treatment area, including physician, staff, and patient
- OSHA and state regulations concerning eye protection during procedures should be strictly observed due to the potential risk of injury to the retina
- Protective eyewear with the proper optical density for the particular wavelength in use must be clearly labeled. Side shields should be used to protect the eyes from tangential beams and scattered reflections
- Reflection hazards should be minimized with the use of anodized, blackened or matte retractors and other instruments, especially when using lasers in the visible and near infrared zones of the spectrum

Tissue Protection - Beam Hazards

- Aim the beam only at target tissue according to recommended treatment protocols
- Always use the least amount of energy necessary to reach the treatment objective
- Utilize good eye-foot-hand coordination
- Protect non-target tissue as recommended
- Do not use the laser on biological structures for which it was not intended, and for which the laser has not received FDA marketing clearance
- Ensure that there is good visualization of the treatment area before commencing
- Place the laser in the stand-by mode, disable, or turn the laser off when procedure is completed

In the U.S., guidance for the use of protective eyewear, and other elements of safe laser use is given in the ANSI Z136 series of standards. A full copy of these standards can be obtained via ANSI or the secretariat and publisher of these standards, i.e., the Laser Institute of America.

Thyroid Tissue - See MODULE I Contraindications

Wavelength Range - Pathological Effect

- 180-315 nm (UV-B, UV-C) photokeratitis (inflammation of the cornea, equivalent to sunburn)
- 315-400 nm (UV-A) photochemical cataract (clouding of the eye lens)
- 400-780 nm (visible) photochemical damage to the retina, retinal burn
- 780-1400 nm (near-IR) cataract, retinal burn
- 1.4-3.0ffm (IR) aqueous flare (protein in the aqueous humour), cataract, corneal burn
- 3.0 ffm-1 mm corneal burn

Laser Safety Checklist, Facility

- Post a laser warning sign outside the treatment area when the laser is in use
- The sign should include the "danger" logo
- The sign should indicate whether visible or invisible laser radiation is being employed
- The sign should include a warning to avoid eye or skin exposure to direct or scattered laser radiation
- The sign should include the class type for the laser in use. Most therapeutic lasers are Class 4 lasers
- Ensure that the treatment area is accessible only to authorized personnel
- Ensure that all treatment area personnel wear the appropriate eye protection when the laser Is in use
- Never look directly into the laser aperture or fiber-optic tip when power is applied, even when laser safety eyewear is being used
- Minimize or shield reflective surfaces during laser beam operation
- If mirrors are to be used intentionally for laser beam redirection, use rhodium or stainless steel (not glass) mirrors, as glass can absorb the energy and shatter

Traffic

- Keep laser components (especially the handpiece emitter) out of the mainstream of traffic in the treatment area
- Protect the fiber-optic cable from kinking, twisting, or otherwise becoming tangled
- Keep the optical fiber off the floor to minimize the possibility of damage
- Test fire the laser before using to ensure the integrity of the delivery system

Fire Safety

- Do not use combustible gases in the treatment area
- Do not use sponges or gauze pads that have been moistened with alcohol, to remove smudges or dirt from the handpiece emitter
- Do not use alcohol-based topical anesthetics

Electrical Power

- Inspect all external power cords and footswitch cables
- Plug the power source into the wall socket last during set-up, and unplug the power source from the wall socket first during the dismantle process
- Foot pedal covering should be in place to prevent the accidental depression of the pedal that may lead to accidental laser exposure (where applicable)

Equipment

- Password switch can only be activated with the proper password. This password cannot be shared with anyone who is not qualified and certified to operate the laser. The laser can be operated only when this has been entered and the laser is in the ON position
- The laser emission indicator is located on the control screen
- In order for the laser to function, the remote interlock jack must be in place so that electrical continuity is made across the contacts
- The protective housing of the laser prevents unintended access to laser radiation
- The controls are located on the control screen for economically functional access during system operation
- The power display is prominently located on the control screen
- The safety switch is *fail-safe* so that full attenuation of the laser beam is accomplished
- If laser emission is interrupted for any reason, a manual re-set will turn off the laser so that it goes into a *standby* mode
- The foot pedal has a protective housing to prevent unintentional laser discharge (where applicable)
- The software diagnostics include error detection if specifications fall outside a pre-determined range
- The emergency stop switch is located for easy access
- There is a separate and distinct enable switch
- All accessories must be plugged in, in order for the laser to operate (delivery system, handpiece emitter, remote interlock)
- There is a separate and distinct stand-by or disable button
- System time-out puts the system in the standby mode if the laser has been in the enable mode but has not been used for a period of 10 minutes

Documentation

- The Laser Safety Officer must keep documents and have them available onsite
- Appointment of Laser Safety Officer and qualifications
- Standard Operating Procedures (SOP) for laser use
- Record of any and all previous safety Inspections
- Written Laser injury management protocol in place for accidental injury
- Documentation of all incidents or accidents

CENTER FOR DEVICES AND RADIOLOGICAL HEALTH

About the CDRH

The FDA's Center for Devices and Radiological Health (CDRH) is responsible for regulating firms who manufacture, repackage, re-label, and/or import medical devices sold in the United States. In addition, CDRH regulates radiation-emitting electronic products (medical and non-medical) such as lasers, x-ray systems, ultrasound equipment, microwave ovens and color televisions.

Mandatory Performance Standards

All laser devices distributed for both human and animal treatment in the U.S. are subject to Mandatory Performance Standards and must meet the Federal laser product performance standard and must submit an "initial report" to CDRH's Office of Compliance prior to distributing the product (see 21 CFR 1000-1040.11). This performance standard specifies the safety features and labeling that all laser products must have in order to provide adequate safety to users and patients.

Laser product manufacturers must certify that each model complies with standards before introducing the laser into U.S. commerce. This includes distribution for use during clinical investigations prior to device approval. Certification of a laser product means that each unit has passed a quality assurance test and that it complies with the performance standard. The firm that certifies a laser product assumes responsibility for product reporting, recordkeeping, and notification of defects, noncompliance, and accidental radiation occurrences, as specified in sections 21 CFR 1000-1010. A certifier of a laser product is required to report the product via a Laser Product Report submitted to CDRH.

Contact the CDRH

Reporting guides and related regulatory information are available directly from the CDRH.
Center for Devices and Radiological Health
U.S. Food and Drug Administration - CDRH/FDA
Consumer Assistance Center
10903 New Hampshire Avenue
W066-4521
Silver Spring, MD 20993-0002
800-638-2041 (Voice - Toll-free)
301-796-7100 (Voice)
Email: dsmica@fda.hhs.gov
Website: www.fda.gov/AboutFDA/CentersOffices/CDRH/default.htm

LASER CLASSIFICATIONS

ANSI Standards

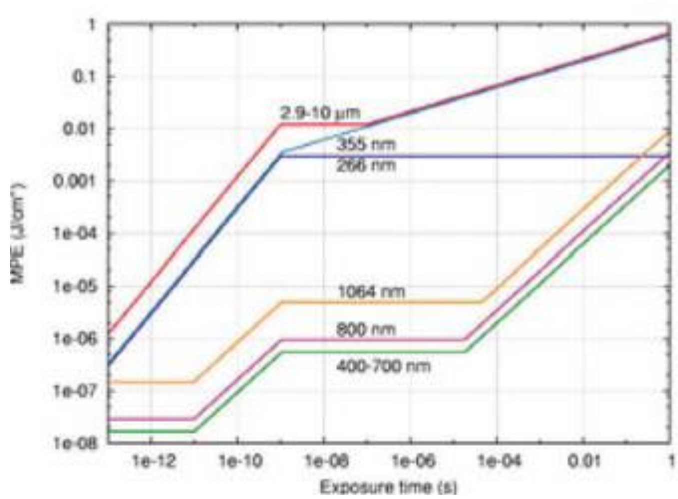
Every medical laser facility is required by ANSI (American National Standards Institute) guidelines to have an "Appointed" Laser Safety Officer (if you have several offices in one geographical area, each location must have their own LSO). Note – Laser "Operators" are the practitioners & techs who operate the laser under the guidance from the facility's Medical Director, and they work under the authority and license of the attending physician. Non-Physician Laser "Operators" can perform patient treatments. They also operate under the authority of the LSO for laser safety or may be authorized LSOs themselves, but function clinically under the Medical Director for patient safety & effectiveness.

The ANSI Standard Laser Hazard Classifications are used to signify the level of hazard inherent in a laser system and the extent of safety controls required. These range from Class 1 lasers (which are inherently safe for direct beam viewing under most circumstances) to Class 4 laser (which require the strictest controls).

The applicable parameters are:
- Laser output energy or power
- Radiation wavelengths
- Exposure duration
- Cross-sectional area of the laser beam at the target tissue

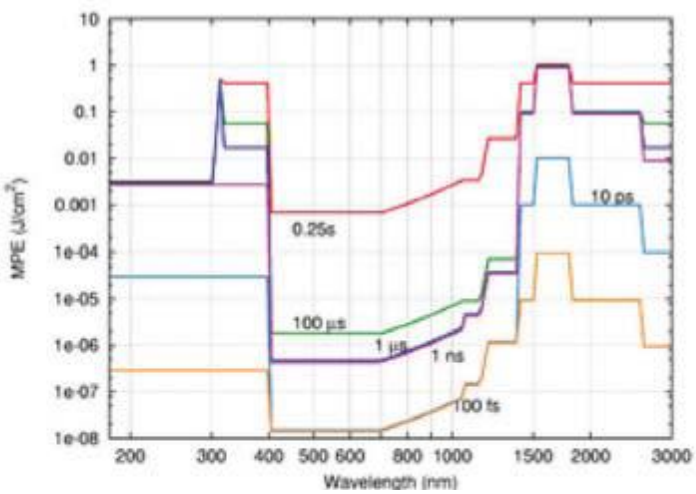
The standards are written as follows:
ANSI Z136.1 – Safe Use of Lasers
ANSI Z136.3 – Safe Use of Lasers in Health Care Facilities
ANSI Z136.4 – Recommended Practice for Laser Safety Measurements for Hazard Evaluation
ANSI Z136.5 – Safe Use of Lasers in Educational Institutions
ANSI Z136.6 – Safe Use of Lasers Outdoors
ANSI Z136.7 – Testing and Labeling of Laser Protective Equipment

Maximum Permissible Exposure (MPE)
MPE is the maximum level of laser radiation to which a person may be exposed without hazardous effects or biological changes in the eye or skin. The MPE is determined by the wavelength of a laser, the energy involved, and the duration of the exposure. MPE is a necessary parameter in determining the appropriate optical density and the nominal hazard zone (the area around a laser that can represent a hazard if proper protection gear is not worn, typically 10′-12′).



Maximum permissible exposure (MPE) at the cornea for a collimated laser beam according to IEC 60825, as energy density versus exposure time for various wavelengths

MPE as power density versus exposure time for various wavelengths



MPE as energy density versus wavelength for various exposure times (pulse durations

The maximum permissible exposure (MPE) is the highest power or energy density (in W/cm2 or J/cm2) of a light source that is considered safe, or that has a negligible probability for creating damage. It is usually about 10% of the dose that has a 50% chance of creating damage under worst-case conditions. The MPE is measured at the cornea of the human eye or at the skin, for a given wavelength and exposure time.

A calculation of the MPE for ocular exposure considers the various ways light can act upon the eye. For example, deep-ultraviolet light causes accumulating damage, even at very low powers. Infrared light with a wavelength longer than about 1400 nm is absorbed by the transparent parts of the eye before it reaches the retina, which means that the MPE for these wavelengths is higher than for visible light. In addition to the wavelength and exposure time, the MPE considers the spatial distribution of the light (from a laser or otherwise). Collimated laser beams of visible and near-infrared light are especially dangerous at relatively low powers because the lens focuses the light onto a tiny spot on the retina.

Light sources with a smaller degree of spatial coherence than a well-collimated laser beam, such as high-power LEDs, lead to a distribution of the light over a larger area on the retina. For such sources, the MPE is higher than for collimated laser beams. In the MPE calculation, the worst-case scenario is assumed, in which the eye lens focuses the light into the smallest possible spot size on the retina for the particular wavelength and the pupil is fully open. Although the MPE is specified as power or energy per unit surface, it is based on the power or energy that can pass through a fully open pupil (0.39 cm2) for visible and near-infrared wavelengths. This is relevant for laser beams that have a cross-section smaller than 0.39 cm2. The IEC-60825-1 and ANSI Z136.1 standards include methods of calculating MPEs.

LASER CLASSIFICATIONS

Class 1-Exempt Lasers and Laser Systems

- All Class 1 lasers must be labeled.
- Class 1 laser cannot, under normal operating conditions, produce damaging radiation levels. These lasers are exempt from the requirements of most corporate Laser Safety Programs.
- Example: A laser printer is an example of a Class 1 laser.

Class 2 Low Power Visible Lasers and Laser Systems

- Class 2 lasers must be labeled.
- Class 2 lasers are low power lasers or laser system in the visible range (400 - 700 nm wavelengths) that may be viewed directly under carefully controlled exposure conditions.
- The laser beam should not be purposefully directed toward the eye of any person. Alignment of the laser optical systems (mirrors, lenses, beam deflectors, etc.) should be performed in such a manner that the primary beam, or specular reflection of the primary beam, does not expose the eye to a level above the MPE for direct irradiation of the eye. The work area should be posted with a warning label or sign cautioning users to avoid staring into the beam or directing the beam toward the eye of individuals. If the MPE is exceeded, design viewing portals and/or display screens to reduce exposure to acceptable levels.

  Example: A bar code scanner is an example of a Class II laser.

Class 3-Medium Power Lasers and Laser Systems

Class 3 lasers are medium power lasers or laser systems that require control measures to prevent viewing of the direct beam. Control measures emphasize preventing exposure of the eye to the primary or specularly reflected beam.

Class 3a denotes lasers or laser systems that normally would not produce a hazard if viewed for only momentary periods with the unaided eye. They may present a hazard if viewed using collecting optics.
Class 3a lasers must be labeled accordingly. The work area should be posted with a warning label or sign cautioning users to avoid staring into the beam or directing the beam toward the eye of individuals. Removable parts of the housing and service access panels should have interlocks to prevent accidental exposure. A permanent beam stop or attenuator may also be used.

If the MPE is exceeded, design viewing portals and/or display screens to reduce exposure to acceptable levels. Alignment procedures should be designed to ensure the MPE is not exceeded.

Visible above 1 mW, but not exceeding 5 mW radiant power
Example: A laser pointer is an example of a Class 3a laser

Class 3b denotes lasers or laser systems that can produce a hazard if viewed directly. This includes intrabeam viewing or specular reflections. Except for the higher power Class 3b lasers, this class laser will not produce diffuse reflections. Class 3b lasers and laser systems must be labeled accordingly. These lasers are used in areas where entry by unauthorized individuals can be controlled. If an individual who has not been trained in laser safety must enter the area, the laser operator or supervisor should first instruct the individual as to safety requirements and must provide protective eyewear, if required.
If the entire beam is not enclosed or if a limited open beam exists, the laser operator, supervisor or laser safety officer should determine a Nominal Hazard Zone (NHZ). An alarm, warning light or verbal countdown should be used during use or startup of the laser. The controlled area should:

- have limited access to spectators
- have beam stops to terminate potentially dangerous laser beams
- be designed to reduce diffuse and specular reflections
- have eye protection for all personnel
- not have a laser beam at eye level,
- have restrictions on windows and doorways to reduce exposure to levels below MPE, and require storage or disabling of the laser when it is not being used
- Visible above 5 mW, but not exceeding 500 mW radiant power.

Class 4-High Power Lasers and Laser Systems
Class 4 Lasers are high power lasers or laser systems that can produce a hazard not only from direct or specular reflections, but also from a diffuse reflection. In addition, such lasers may produce fire and skin hazards. Class 4 lasers include all lasers in excess of Class 3 limitations. In addition to the control measures described for Class 3b, Class 4 lasers should be operated by trained individuals in areas dedicated to their use. Failsafe interlocks should be used to prevent unexpected entry into the controlled area, and access should be limited by the laser operator to persons who have been instructed as to the safety procedures and who are wearing proper laser protection eyewear when the laser is capable of emission.

- Laser operators are responsible for providing information and safety protection to untrained personnel who may enter the laser-controlled areas as visitors.
- The laser area should be:
- restricted to authorized personnel only
- designed to allow for rapid emergency egress

- equipped with a device that allows for deactivation of the laser or reduction of the output to below the MPE
- designed to fulfill Class 3b controlled area requirements
- designed with entry safe controls
- Designed such that the laser has interlocks designed to turn off the power supply or interrupt the beam by means of shutters. The beam path must be free of specularly reflective surfaces and combustible objects, and the beam terminated in a non-combustible, non-reflective barrier or beam stop
- Visible above 500 mW radiant power

THE LASER SAFETY OFFICER:

- Directs and is responsible for laser safety practices
- Authorized to shut down laser operation if safety protocols are violated
- Be familiar with the operator manual and with safety procedures including the adverse effects reporting mechanism
- Maintain the instrument and accessories in accordance with the manufacturer's recommendations
- Be familiar with the safety recommendations and requirements of standards organizations, (e.g., CDRH, and OSHA)
- Ensures that the laser is operated only by trained and authorized personnel
- Secures the key to the laser in a safe place
- Ensures that personnel wear safety eyewear of the appropriate optical density
- Sees that laser safety signs are posted during operation of the laser
- Sees that laser maintenance is current
- Documents procedures (in the patient chart)
- Checks inventories and maintains laser supplies and accessories
- Makes sure that staff is current on laser education
- Assists with the evaluation when a new laser system is needed
- Makes suggestions to the laser surgical team
- Cross-trains other personnel in the office
- May be the physician or other designated person

Laser operators are responsible for providing information and safety protection to untrained personnel who may enter the laser-controlled areas as visitors.

THE LASER AREA SHOULD BE:

- Restricted to authorized personnel only
- Designed to allow for rapid emergency egress
- Equipped with a device that allows for deactivation of the laser or reduction of the output to below the MPE
- Designed to fulfill Class 3b controlled area requirements

- Designed with entry safe controls
- Designed such that the laser has interlocks designed to turn off the power supply or interrupt the beam by means of shutters. The beam path must be free of specularly reflective surfaces and combustible objects, and the beam terminated in a non-combustible, non-reflective barrier or beam stop
- Visible above 500 mW radiant power

A laser safety Officer (LSO) must be appointed before using the Class IV laser in a clinical environment. The safe use of a laser is the responsibility of the Laser Safety Officer (LSO). It is his/her responsibility to train staff, maintain training and laser mechanical performance records, perform safety checks, and prepare the laser for use on a daily basis. Once the LSO has sufficient introductory training, the next step is to create customized written safety procedures for use of the laser. The LSO must also keep records of any incident that relates to the failure of the laser, or any adverse effects related to laser use, and report any such incidents as prescribed by law. The LSO assures a medical follow-up has been sought or has occurred following any adverse incident during treatment. The LSO is also responsible for the training of all office personnel who are involved with the laser preparation and use. Daily checks of the facility and equipment are also the LSO's responsibility. The LSO should test fire the laser each day prior to beginning each treatment procedure.

The U.S. Food and Drug Administration (FDA) requires all Class IIIB and Class IV lasers offered in commerce in the US to have five standard safety features: a key switch, a safety interlock dongle, a power indicator, an aperture shutter, and an emission delay (normally two to three seconds). OEM lasers, designed to be parts of other components (such as DVD burners) are exempt from this requirement. Some non-portable lasers may not have a safety dongle or an emission delay, but have an emergency stop button and/or a remote switch.

The skin is usually much less sensitive to laser light than the eye, but excessive exposure to ultraviolet light from any source (laser or non-laser) can cause short-and long-term effects similar to sunburn, while visible and infrared wavelengths are mainly harmful due to thermal damage:

WARNINGS AND SAFETY NOTICES

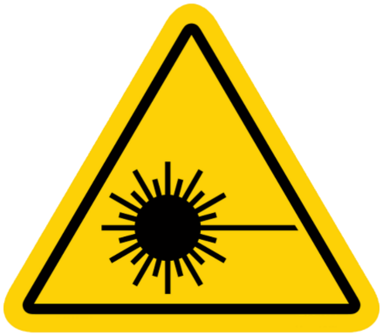
Each treatment area should have a "laser in use" warning sign posted at the entrance to the treatment area. This signage serves to warn people to not enter the treatment area without proper safety eyewear and protective clothing when the laser is in use.

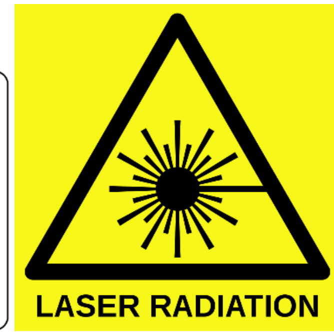
Environmental Protection Disposal of The Equipment:
This is a medical laser device; dispose of this device and all accessory items in accordance with state, local and federal rules on the disposal of laser equipment.

WARNING:

- Medical electrical equipment needs special precautions regarding EMC and needs to be installed and put into service according to the EMC information provided in this manual
- Portable and mobile RF communications equipment can affect the performance of the Laser
- The use of accessories, transducers and cables other than those specified by the Laser Manufacturer may result in increased emissions or decreased immunity of the Laser
- The Laser should not be used adjacent to or stacked with other equipment and that if adjacent or stacked use is necessary, the Laser should be observed to verify normal operation in the configuration in which it will be used

LABELS, SIGNS, WARNINGS AND MANUFACTURER'S INFORMATION





Important for All Laser Safety Programs

One of the important aspects of implementing a successful laser safety program is displaying proper signage. According to ANSI Z136.1 Safe Use of Lasers, laser area warning signs should be posted around Class 2M and 3R laser areas, and are required to be posted around all Class 3B and 4 laser areas. Additionally, when Class 3B and Class 4 lasers are being serviced or receiving maintenance of any kind, laser 'notice' signs are required to be posted. All laser clinicians are required to provide laser warning and laser notice signs that meet ANSI Z136.1 requirements for laser safety.

Laser Safety Checklist (Complete)

Check When Completed

________ Minimize or shield reflective surfaces during laser beam operation
________ NEVER look directly into the laser aperture or fiber-optic tip when power is applied, even when laser safety eyewear is being used
________ Ensure that all treatment area personnel wear the appropriate eye protection when the laser is in use
________ Ensure that the treatment area is accessible only to authorized personnel
________ The sign should include the class type for the laser in use
________ The sign should include a warning to avoid eye or skin exposure to direct or scattered laser radiation
________ The sign should indicate whether visible or invisible laser radiation is being employed
________ The sign should include the DANGER logo
________ Post a laser warning sign outside the treatment area when the laser is in use

Traffic Areas

________ Test fire the laser before using, to ensure the integrity of the delivery system
________ Keep the optical fiber off the floor to minimize the possibility of damage
________ Protect the fiber-optic cable from kinking, twisting, or otherwise becoming tangled
________ Keep laser components (especially the fiber optic cable) out of the mainstream of traffic in the treatment area

Fire Safety

________ Do not use sponges or gauze pads that have been moistened with alcohol to remove debris from handpiece emitter

________ Do not use combustible gases in the treatment area

Eye Safety – Beam Hazards

________ Reflection hazards should be minimized with the use of anodized, blackened or matte retractors and other instruments, especially when using lasers in the visible and near infrared zones of the spectrum.

________ Protective eyewear with the proper optical density for the particular wavelength in use must be clearly labeled.

________ Side shields should be used to protect the eyes from tangential beams and scattered reflections

________ Eye protection should be worn by all persons in the treatment area, including surgeon, staff, and patients.

________ The greatest single risk for personnel using lasers is eye injury to the cornea or retina from direct or reflected laser beams.

Tissue Protection – Beam Hazards

________ Place the laser in the stand-by mode, disable, or turn the laser off when procedures are completed

________ Ensure there is good visualization of the targeted tissues before commencing a procedure

________ Do not use the laser on biological structures for which it was not intended, and for which the laser has not received FDA clearance

________ Protect non-target tissue as recommended

________ Always use the least amount of energy necessary to achieve treatment objectives

________ Aim the beam only at target tissue according to recommended treatment protocols

Device Awareness – Know the laser

________ Identify the Emergency Stop Switch and know how and when to operate it

MODULE IV, LASER SAFETY – QUIZ

1. Who can be a Laser Safety Officer (LSO)?
   f) Only a licensed physician
   g) Only the clinic's Medical Director
   h) Any clinic employee who is trained and certified
   i) Only clinical technicians
   j) Only the laser distributor

2. What items are part of a comprehensive Laser Safety Checklist?
   a) Access to laser and treatment area must be secure and controlled
   b) Goggles must be available for all persons within the Nominal Hazard Zone
   c) Treatment protocol must be established for each patient
   d) Laser injury management protocol must be in place for accidental injury
   e) Record laser treatment and post-treatment outcomes, and document any incidents or accidents
   f) All of the Above

3. The therapeutic value of laser light is dependent upon the spectral absorption property of the target tissue.
   a) True
   b) False

4. What is meant by spectral absorption properties?
   a) Laser energy has special properties according to specters
   b) Laser energy absorbency into tissues is highly dependent on the color of the wavelength and tissues being the same color
   c) Body tissues absorb light energy only when laser output is very low
   d) Targeted tissues only absorb light energy in the visible range
   e) All of the Above

5. Which of the following is true?
   a) Accidental exposure to a high-power energy beam can cause serious eye damage
   b) Accidental exposure to a low-power energy beam can cause serious eye damage
   c) All of the Above

6. Laser energy is:
   a) Ionizing
   b) Non-ionizing
7. What is meant by the phrase 'The therapeutic value of laser light is dependent upon the spectral absorption property of the target tissue'?
   a) Laser energy permeability is heightened by compatible skin color

b) Lightly pigmented skin is more absorbent that darkly pigmented skin

8. What are some of the mechanisms whereby laser energy can cause damage to human tissues?
   a) Thermal damage or burns occur when tissues are heated to the point where denaturation of protein occurs
   b) Photochemical damage can occur when certain wavelengths of light triggers chemical reactions in tissues
   c) Laser pulses shorter than about 1µs can cause a rapid rise in temperature
   d) Ultra-short laser pulses can exhibit super luminosity on the transparent parts of the eye, leading to an increase of the damage potential compared to longer pulses with the same energy
   e) All of the above

9. Which of the following is true?
   a) The eye focuses visible and non-visible light onto the retina
   b) A laser beam can be focused to a point on the retina which may be up to 200,000 times higher than at the point where the laser beam enters the eye
   c) Ultraviolet light with wavelengths shorter than 400 nanometers is absorbed in the cornea and lens, where it can produce injuries at relatively low powers due to photochemical damage
   d) A and C are true
   e) A, B, and C are true

10. Which of the following is true?
    a) Aim the beam only at target tissue according to recommended treatment protocols
    b) Always use the least amount of energy necessary to reach the treatment objective
    c) Protect non-target tissue as recommended
    d) Do not use the laser on biological structures for which it was not intended, and for which the laser has not received FDA clearance
    e) Place the laser in the stand-by mode, disable, or turn the laser off when not in use
    f) All of the above

11. Confirm the following are required when using the laser:
    Minimize or shield reflective surfaces during laser beam operation
    a) True
    b) False

12. NEVER look directly into the laser aperture or fiber-optic tip when power is applied, even when laser safety eyewear is being used
    a) True

b) False

13. Ensure that all treatment area personnel wear the appropriate eye protection when the laser is in use
    a) True
    b) False

14. Ensure that the treatment area is accessible only to those wearing laser goggles
    a) True
    b) False

LASER WARNING SIGN

15. The Required Laser Warning sign should include the class type for the laser in use
    a) True
    b) False

16. The sign should include a warning to avoid eye or skin exposure to direct or scattered laser radiation
    a) True
    b) False

17. The sign should indicate whether visible or invisible laser radiation is being employed
    a) True
    b) False

18. The sign does not need to include the DANGER logo
    a) True
    b) False

19. Post a laser warning sign outside the treatment area when the laser is in use
    a) True
    b) False

20. There is no need to test fire the laser before using, to ensure the integrity of the delivery system
    a) True
    b) False

21. You can allow the optical fiber cable to be on the floor; there is no need to minimize the possibility of damage
    a) True

b) False

22. Protect the fiber-optic cable from kinking, twisting, or otherwise becoming tangled
    a) True
    b) False

23. You can allow laser components (like the fiber optic cable) to be in the mainstream of traffic in the treatment area
    a) True
    b) False

24. It is OK to use sponges or gauze pads that have been moistened with alcohol to remove debris from the handpiece emitter
    a) True
    b) False

25. It is OK to use combustible gases in the treatment area
    a) True
    b) False

26. Reflection hazards should be minimized with the use of anodized, blackened or matte retractors and other instruments, especially when using lasers in the visible and near infrared zones of the spectrum
    a) True
    b) False

27. Protective eyewear with the proper optical density for the particular wavelength use must be clearly labeled
    a) True
    b) False

28. Side shields should be used to protect the eyes from tangential beams and scattered reflections
    a) True
    b) False

29. Eye protection should be worn by all persons in the treatment area except for the physician, staff, and patients
    a) True
    b) False

30. The greatest single risk for personnel using lasers is eye injury to the cornea or retina from direct or reflected laser beams
    a) True
    b) False

31. Place the laser in the stand-by mode, disable, or turn the laser off when procedures are completed
    a) True
    b) False

32. Good visualization of the targeted tissues before commencing a procedure is not necessary
    a) True
    b) False

33. Do not use the laser on biological structures for which it was not intended, and for which the laser has not received FDA clearance
    a) True
    b) False

34. It doesn't matter if you protect non-targeted tissue or not
    a) True
    b) False

35. Always use the least amount of energy necessary to achieve treatment objectives
    a) True
    b) False

36. Aim the beam only at target tissue according to recommended treatment protocols
    a) True
    b) False

37. Identify the Emergency Stop Switch and know how and when to operate it

38. Which of the following is true?
    a) The Laser Safety Officer (LSO) must keep laser documentation on site and have them available when required
    b) Standard operating procedures for the laser must be well established and documented
    c) There should be a record of all previous safety inspections; safety inspections should be made on regular basis
    d) A written laser injury management protocol should be in place for accidental injury

e) All of the above

39. According to the ANSI (American National Standards Institute), several clinics can share one (LSO) Laser Safety Officer
    a) True
    b) False

40. All laser therapy technicians function under the license of the clinic's medical director, who is a physician
    a) True
    b) False

41. The ANSI Standard Laser Hazard Classifications are used to signify the level of hazard inherent in a laser system and the extent of safety controls required
    a) True
    b) False

42. The ANSI standard parameters used in determining laser hazards are:
    a) Laser output energy or power
    b) Radiation wavelengths
    c) Exposure duration
    d) Cross-sectional area of the laser beam at the target tissue
    e) All of the above

43. What does the term (MPE) maximum permissible exposure mean?
    a) MPE is a necessary parameter in determining the appropriate optical density and the nominal hazard zone
    b) Maximum level of laser light irradiation to which a person may be exposed without hazardous effects
    c) The area around which protective eyewear must be worn
    d) A & C
    e) A, B, & C

44. What class of lasers are exempt from the requirements of corporate laser safety programs?
    a) CLASS I
    b) CLASS II
    c) CLASS LLL
    d) CLASS IV
    e) All of the above

45. A bar code scanner is an example of what CLASS laser?

a) CLASS I
b) CLASS II
c) CLASS LLL
d) CLASS IV
e) All of the above

46. CLASS III and CLASS IIIa denotes lasers or laser systems that normally would not produce a hazard if viewed for only momentary periods with the unaided eye
    a) True
    b) False
46. CLASS III and CLASS IIIa lasers or laser systems produce enough energy to be useful as therapy devices
    a) True
    b) False

47. CLASS IIIb lasers or laser systems can produce a hazard if viewed for only momentary periods with the unaided eye
    a) True
    b) False

48. A CLASS IIIb laser or laser system can produce an amount of energy powerful enough to burn a patient
    a) True
    b) False

49. CLASS IIIb lasers or laser systems include devices that are only 7.5milliWatts
    a) True
    b) False
49. CLASS IIIb lasers or laser systems include some brands of laser pointers
    a) True
    b) False

50. Some therapy laser systems such as those made by Erchonia™ output no more energy than a laser pointer in the 7.5milliWatt range
    a) True
    b) False

51. CLASS IIIb lasers or laser systems can produce up to 500mW (1/2Watt) of energy
    a) True
    b) False

52. CLASS IV lasers or laser systems include ALL lasers that produce in excess of CLASS IIIb limitations
    a) True
    b) False

53. CLASS IV lasers or laser systems make up the vast majority of those used in medical practice
    a) True
    b) False

54. Access to a CLASS IV laser or laser system should be limited to those who are fully trained and certified to use them
    a) True
    b) False

55. The LSO (Laser Safety Officer) responsibilities include all safety aspects of the laser
    a) True
    b) False

56. The LSO directs and is responsible for laser safety practices
    a) True
    b) False

57. The LSO is authorized to shut down laser operation if safety protocols are violated
    a) True
    b) False

58. The LSO should be familiar with the operator manual and with safety procedures including the adverse effects reporting mechanism
    a) True
    b) False

59. The LSO should maintain the instrument and accessories in accordance with the manufacturer's recommendations
    a) True
    b) False

60. The LSO should be familiar with the safety recommendations and requirements of standards organizations, (e.g., CDRH, and OSHA)
    a) True
    b) False

61. The LSO Ensures that the laser is operated only by trained and authorized personnel
    a) True
    b) False

62. The LSO secures the key to the laser in a safe place
    a) True
    b) False

63. The LSO ensures that personnel wear safety eyewear of the appropriate optical density
    a) True
    b) False

64. The LSO ensures laser safety signs are posted during operation of the laser
    b) a) True
    c) b) False

65. The LSO ensures laser maintenance is current
    a) True
    b) False

66. The LSO documents procedures (in the patient chart)
    a) True
    b) False

67. The LSO checks inventories and maintains office supplies and accessories
    a) True
    b) False

68. The LSO makes sure that staff is current on laser education
    a) True
    b) False

69. The LSO assists with the evaluation when a new laser system is needed
    a) True
    b) False

70. The LSO makes sure the bathroom is clean before the laser is turned off
    a) True
    b) False

71. The LSO cross-trains other personnel in the office to keep medical records

a) True
b) False

72. The LSO may be the physician or other designated person
    a) True
    b) False

END OF MODULE IV

Congratulations on finishing the Photomedicine Training Guide – please scan and email the completed document to pauls@advanmed.com for grading and certification document. If you have any questions or comments, please call Paul Schwen at 1.801.473.7885

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