Laser and light therapy

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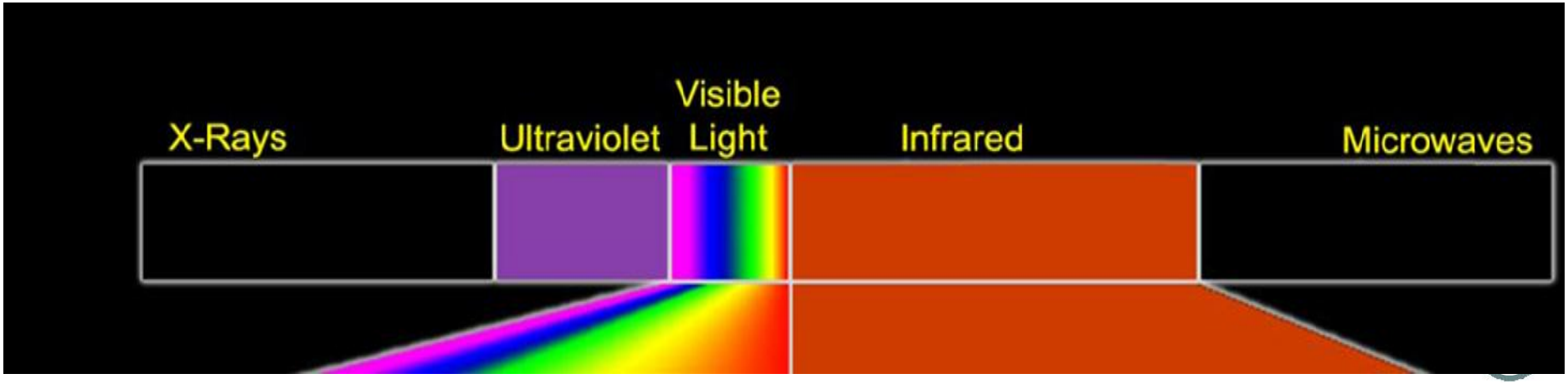
Objectives of lecture

- Define laser and explain its physical principle of laser.
- Explain the physical characteristics of laser.
- Describe the classifications of laser.
- Contrast the characteristics of helium neon and gallium arsenide low power laser.
- Analysis the therapeutic application of laser in different conditions.
- Demonstrate the application techniques of low power laser.
- Describe the precautions and contraindications for low power laser.

What Is Light Therapy?

***Light energy** is a form of **electromagnetic energy** that has wavelength between **100-10.000nm,** and contain tiny "**Energy packets**" called photons. Each photons cantinas definite amount of energy depending on its **wavelength** and may be one of the following

- **Laser**
- **Light emitting diodes (LED)**
- **Super-luminous diodes (SLD)**
- **Infrared**
- **Ultraviolet**



What Is Laser Therapy?

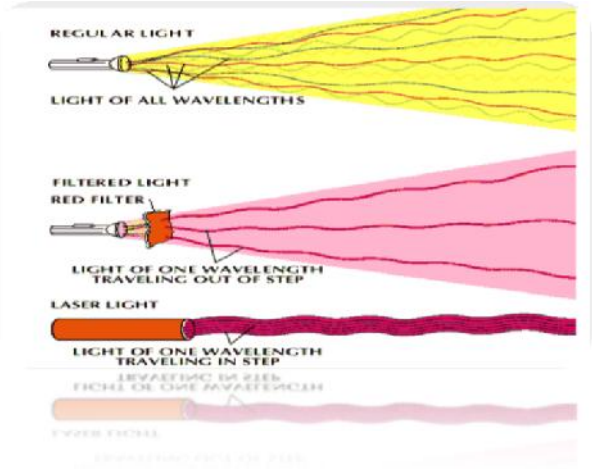
LASER is acronym of

- **L**ight : an electromagnetic radiation
- **A**mplification by
- **S**timulated
- **E**mission of
- **R**adiation

Characteristics of Laser Radiation

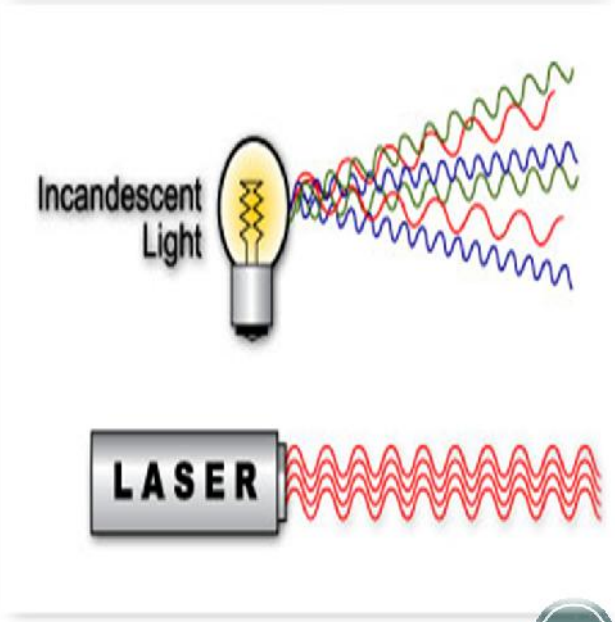
Monochromaticity:

Single wavelength, color, & frequency



Coherence:

Wavelengths are in-phase (synchronizing)

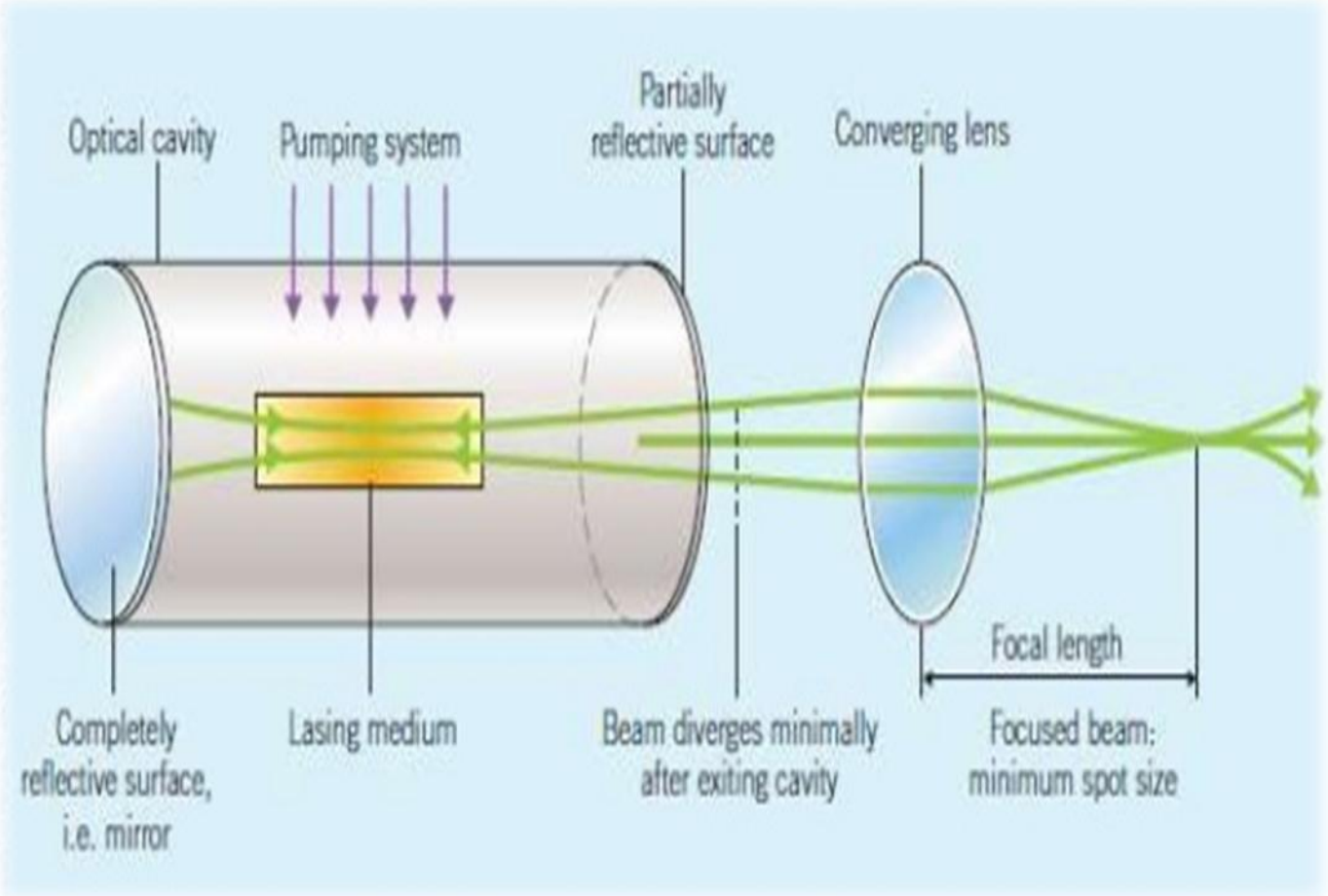


Collimation (directional):

All laser lights have minimal degree of divergence over distance. (38^0)

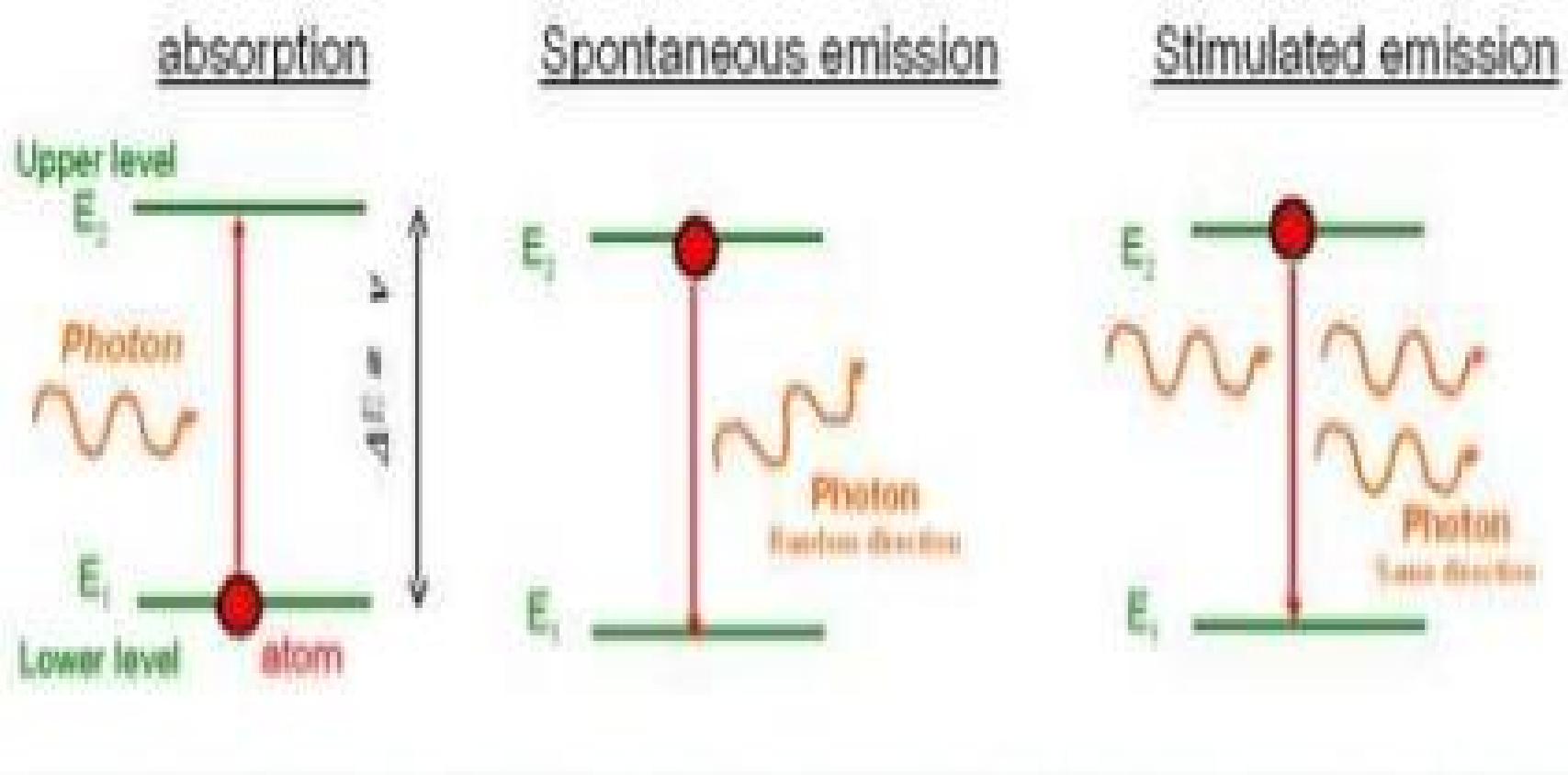
Production and components of Laser

There are 4 main components to a laser



Production and components of Laser

Principle of laser production



LASER Classification (Safety)

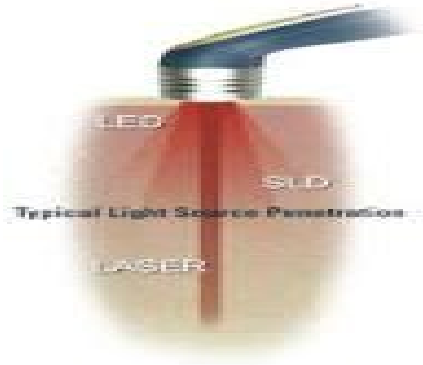
Class	Power level	Power (mW)	Example	Dangerous and safety
Class 1	Very low	<0.05mw	Laser printer, CD players Supermarket reader	No effect on eye & skin.
Class II	Low	<1mw	Laser pointer	Safe to skin
Class III-a	Low	<5mW	Laser pointer, low LLLT	Safe to skin Not to eyes
Class III-b	Medium	<5-500mW	LLLT	
Lass IV	Higher	>500mW	Hot Laser (surgical)	Unsafe to skin & eye

LASER Classification :(lasing media)

Laser type	Lasing Media	Wavelength (nm)	Safety
Gas	He-Ne	633	3a-3b
	CO_2	10.600	3b-IV
	Argon	488-514	IV
Diode/ semiconductors	AlGaAs GaAs GaAl	600-1000	3b
Excimer	Dimer	351	IV
Solid –state	Ruby Nd :YAG	694 1060	IV IV

Characteristics of LASER, LED, & SLDs

	LLLT	SLD	LED
Power	High	Medium	Low
Focus of light beam	Very focus (Small area)	Moderately focus	Scattered (wider area)
Penetration	deep Up to 5cm	intermediate	superficial
Characteristics	Monochromatic Coherence Collimated	Monochromatic Non-Coherence Less Divergent	Monochromatic Non-Coherence Divergent
Uses	Small area/deep area	Intermediate moderately deep	Larger area//superficial



High vs. Low Level Lasers

- **High (500-10000mW)**
  - Surgical Lasers
  - Hard Lasers
  - Thermal

  Used for

  -Ophthalmology

  -Dermatology

  -Oncology

  -Vascular specialties

- **Low (1-500mW)**
  - Medical Lasers
  - Soft/ cold Lasers
  - Sub-thermal

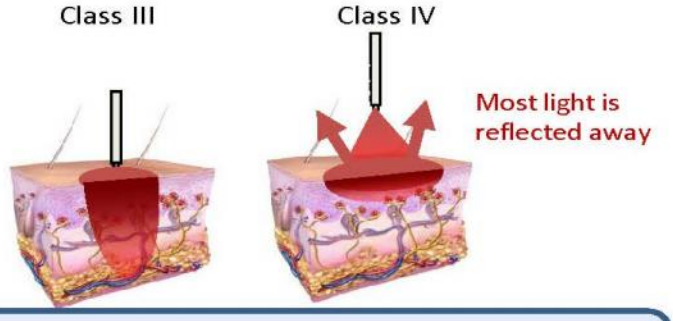
  Used for;

  - **-Pain relieve**
  - **-Wound healing**
  - **-Anti/ or pro-inflammatory**

Maximum output of (90mW or less)
Wavelength (600-1000nm)
Penetration of (3-4mm).

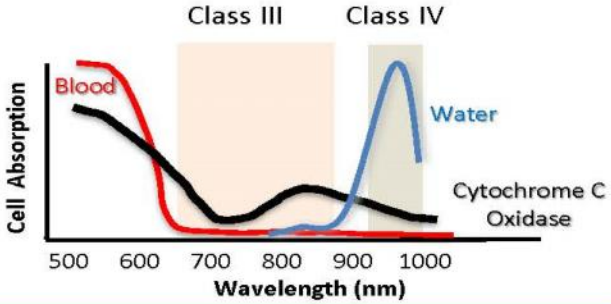
High vs. Low Level Lasers

Deeper Penetration of Photons



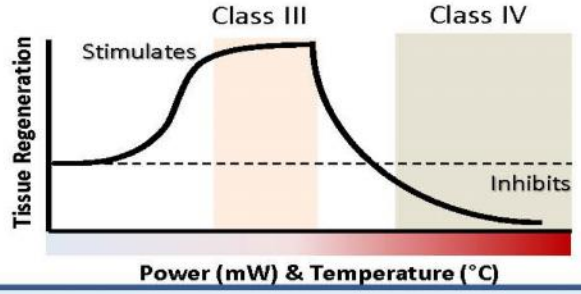
Contact with skin ensures that photons penetrate deep into the target tissue

Best Wavelengths for ATP Production



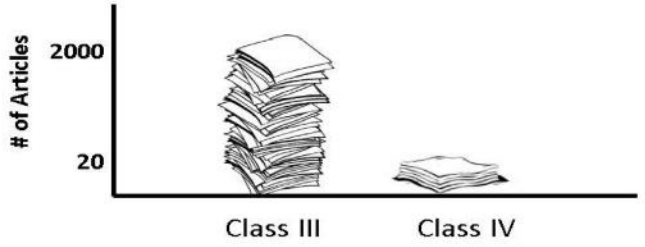
Avoiding photon absorption by blood and water ensures maximum ATP production through Cytochrome C Oxidase absorption

Optimal Power for Tissue Regeneration



Too little power has no effect and too much power can cause tissue damage through heating (Arndt-Schultz Law)

Published Research Articles



Over 50 years of evidence based peer-reviewed research supporting Class III lasers

What's in a Name?

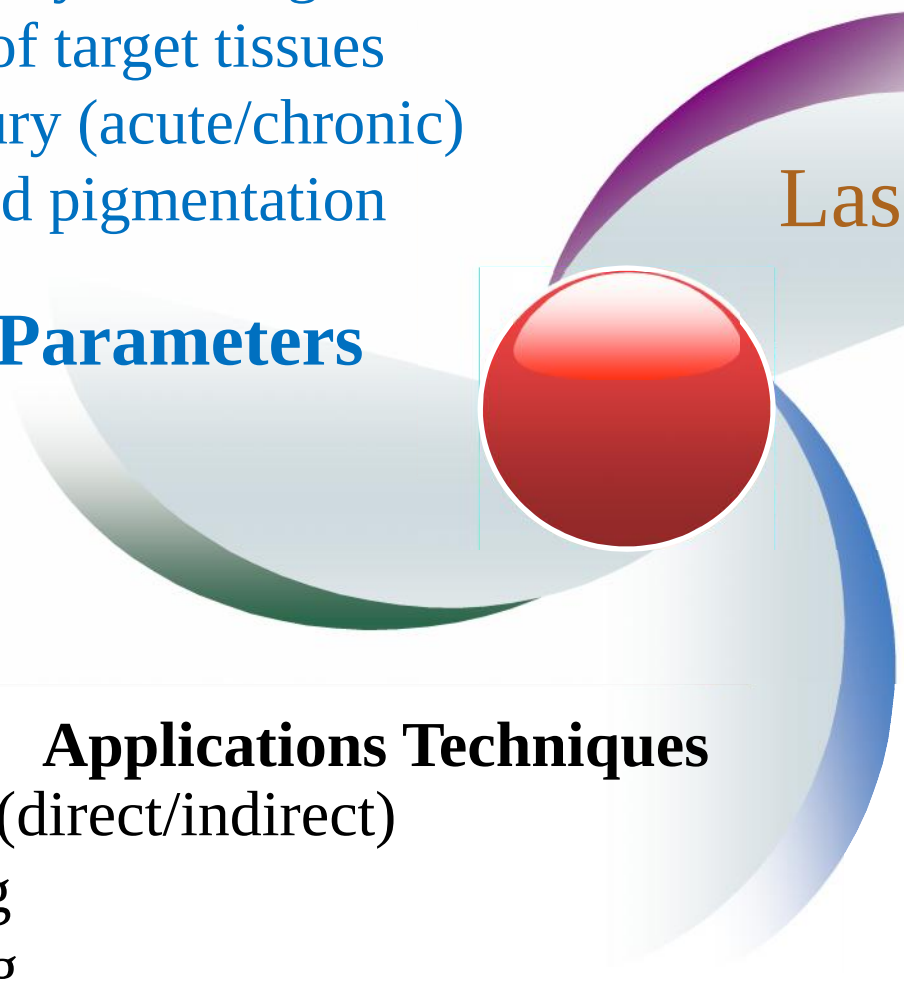
Historically referred to as:

- **LLLT (low level laser therapy)**
- LILT (low intensity laser therapy)
- Laser Biostimulation
- Low power laser therapy
- Cold laser therapy
- Note: LLLT best term for searching PubMed, the Nat'l Institutes of Health Public database
- Search: " PubMed "

LLLT Treatment Parameters

Medical history and diagnosis
Vascularity of target tissues
Stage of injury (acute/chronic)
Skin type and pigmentation
Medications

Patients Parameters



Laser Parameters

Wavelength (nm)
Power (mw)
Mode of laser
Energy
Treatment duration
Treatment frequency

Applications Techniques

Contact (direct/indirect)
Gridding
Scanning
Acuopoints

Laser Parameters: Wavelength

Longer wavelength penetrates deeper than shorter wavelength

Red visible laser Superficial conditions < 2cm

He-Ne (wavelength=632nm)
Used for Superficial wound, ulcer
Superficial trigger point

IR Laser "Deep conditions; (2-4cm)

Ga-As (wavelength=904nm)
(Ga-Al-As (wavelength =780-890nm)
Use for Deep wound, edema (acute &chronic),
Deep trigger point, & scar tissue

Laser Parameters: Power and Power density

Power is rate of energy production and measured in watts (mW) where (1watt=1J/second)

- Low-power lasers (1-5mW)
- Medium-power (5-500mW);commonly used PT clinic
- High-power lasers (> 500mW)

Power Density (PD) is the amount of power per unit area of the beam (spot size), and measured by W/cm^2 or mW/cm^2.

$$PD = \frac{Power\ output\ (mW)}{Spot\ size\ (cm^2)} = \text{mW/cm}^2$$

Laser Parameters: Energy& energy density

Energy (joules): Energy is the power multiplied by the treatment time, and is measured by Joule (J or mJ)

Energy (J) =Power output (W) X Treatment Time (s)

Energy Density (dosage) is the amount of energy per unit of area, and is measured in Joules/cm^2 .

Also known as "fluence"

$$ED = \frac{Energy\ (J)}{Spot\ size\ (cm^2)} = \text{J/cm}^2$$

Laser Parameters: Energy& energy density

Recommended Dosage Range

Therapeutic response = 0.01-20 J/cm^2 (average 6J/cm^2)

Too much – suppressive effect >20 J/cm^2

Conditions	Suggested Energy dosage 6J/cm^2
Soft tissue/ fracture healing	5-16
Arthritic acute	2-4
Arthritic chronic	4-8
Lymphedema	1.5
Acute soft tissue inflammation	2-8
Chronic soft tissue inflammation	10-20
Neuropathy	10-12

Exercises

Example: you are using a 50 mW LLLT device and you treat for 1 min (60 sec). What is the total energy (J) delivered)?

Answer:

Step 1. 50 mW needs to be converted to 0.05 W

Step 2. 0.05 W x 60 sec = 3 J of energy

Relationship of power (mW), time (sec), and energy (J)

mW	sec	Joules (energy delivered)
50	80	4
100	40	4
500	8	4

Exercises

Based on the information provided one can determine the power density and the energy density.

- *Power = 10 mW*
- *Beam Area = 0.125 cm^2*
- *50 sec treatment*

Calculations

- Power Density = Power ÷ beam area
- Power Density = 10 mW ÷ 0.125 cm2 = 80 mW/cm2

- Energy Density = (power x time) ÷ beam area
  **hint: remember to convert Milliwatts (mW) to Watts (W)*
- Energy Density = (0.01 W x 50 sec) ÷ 0.125 cm^2
- Energy Density = 4 J/cm^2

Laser Parameters: Mode

The power on most LLLT devices can be periodically interrupted for a very brief period on time. This is called "pulsing".

When pulsed mode is used the average power delivered will decrease proportional to the pulse frequency that is selected.

In continuous mode: Average power= Peak power
In pulsed mode the Average power calculated as:

Average power = Pulse rate X Peak power X Pulse width
=100Hz X 2WX ($2x10^{-7}$ seconds)=0.04mW

Laser Parameters: Treatment frequency

Evidence Recommended the followings;

- Treatment should be individualized
- 3-4 times/week with moderate dose are more effective than higher dose for fewer time per week
- Acute conditions should be treated more frequently than chronic
- Laser therapy has accumulative effect

Helium Neon Lasers versus Gallium Arsenide

Parameters	Helium Neon Lasers	Gallium Arsenide
Laser type	Gas	Semiconductor
Emitting radiation	Red (visible) light	IR (invisible) laser
Wavelength	632.8 nm	904–910 nm
Pulse rate (frequency)	continuous	1-1000Hz
Pulse width	continuous	200nsec
Peak power	1-2mW (25mW)	1-5mW
Average power	1.0mW	0.04-0.4mW
Beam area	0.01cm	0.07cm
Depth of penetration	0.5-1 cm	2cm up to 5 cm
Used	Superficial wound	Deeper tissue

Physiological effects of LASER

Low level laser-tissue interaction is essentially **ATHERMIC.**

The main type of reaction with tissue during laser therapy would appear to be **PHOTOCHEMICAL.**

So, Laser light absorbed by irradiated tissue produce chemical rather than thermal energy.

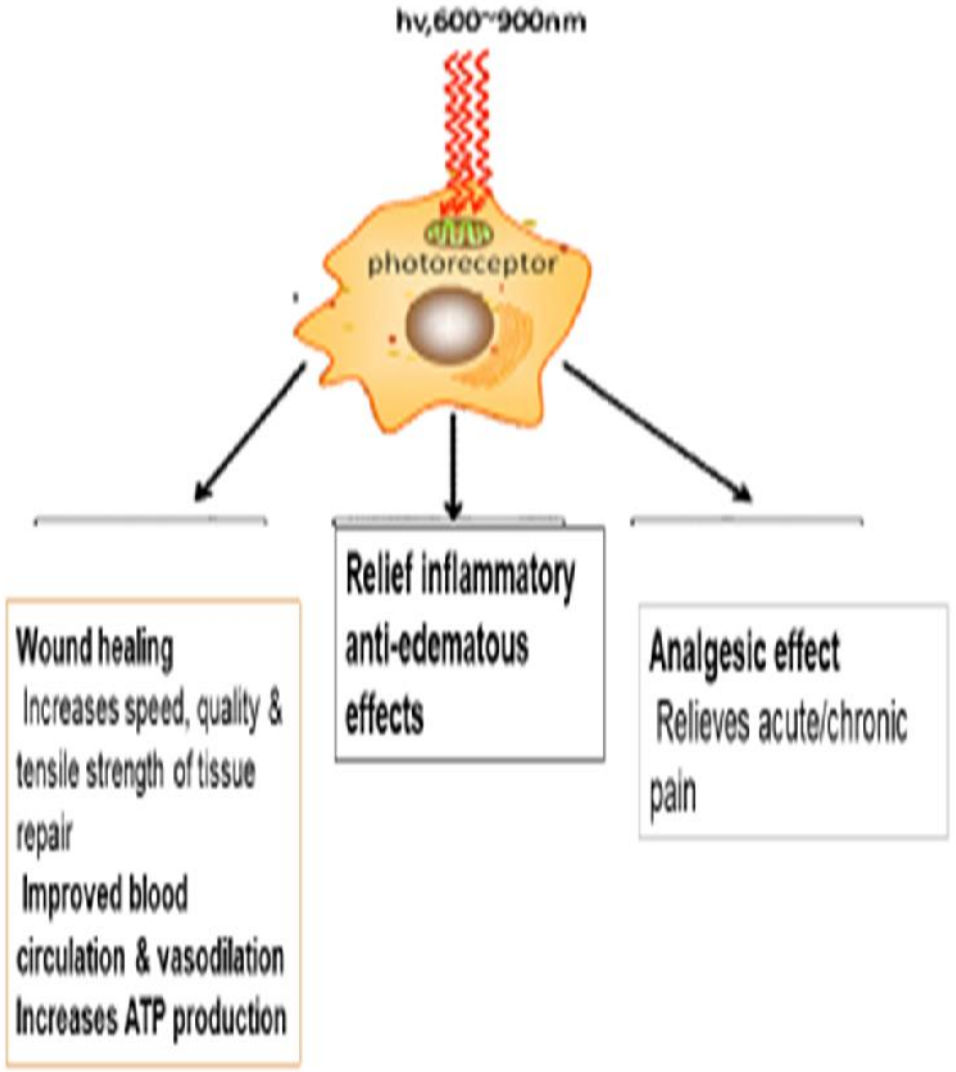
Physiological effects of LLLT

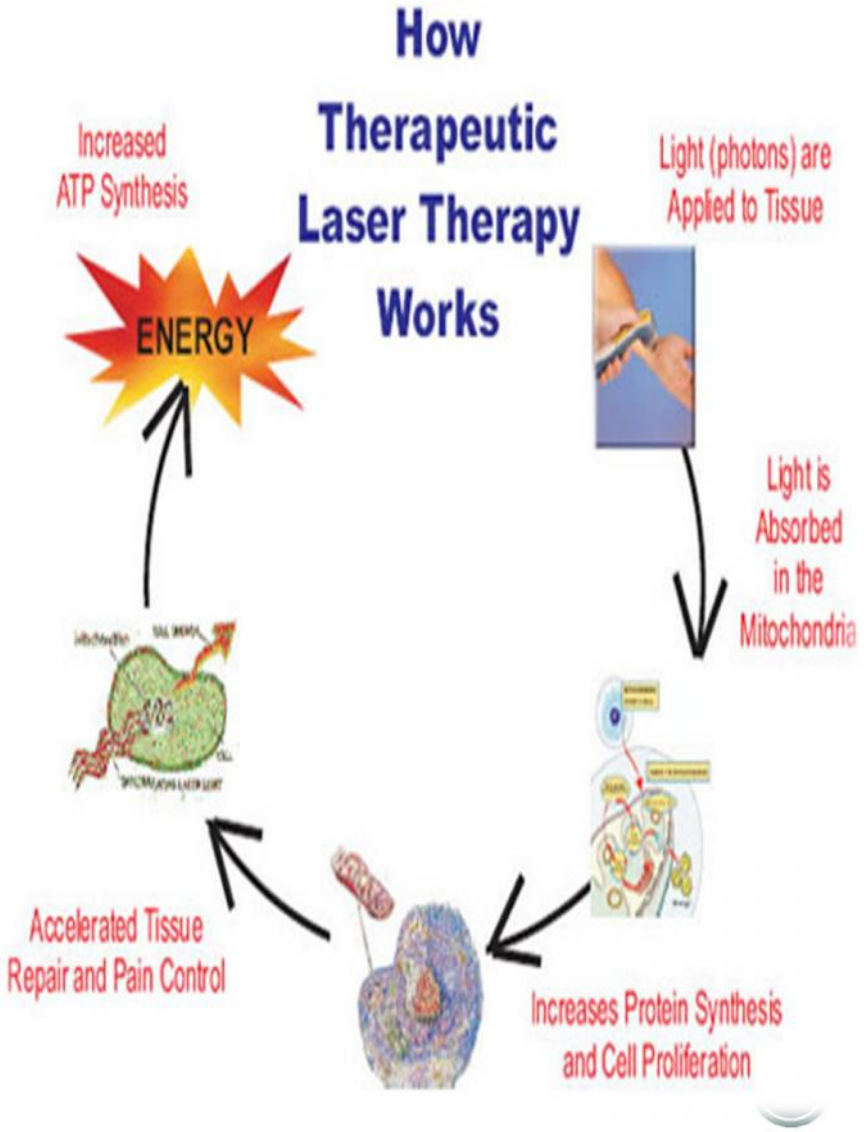
Chromophores is a light absorbing part of the molecules that gives it color and stimulated by light energy and produce chemical reaction

These chromophores may be:

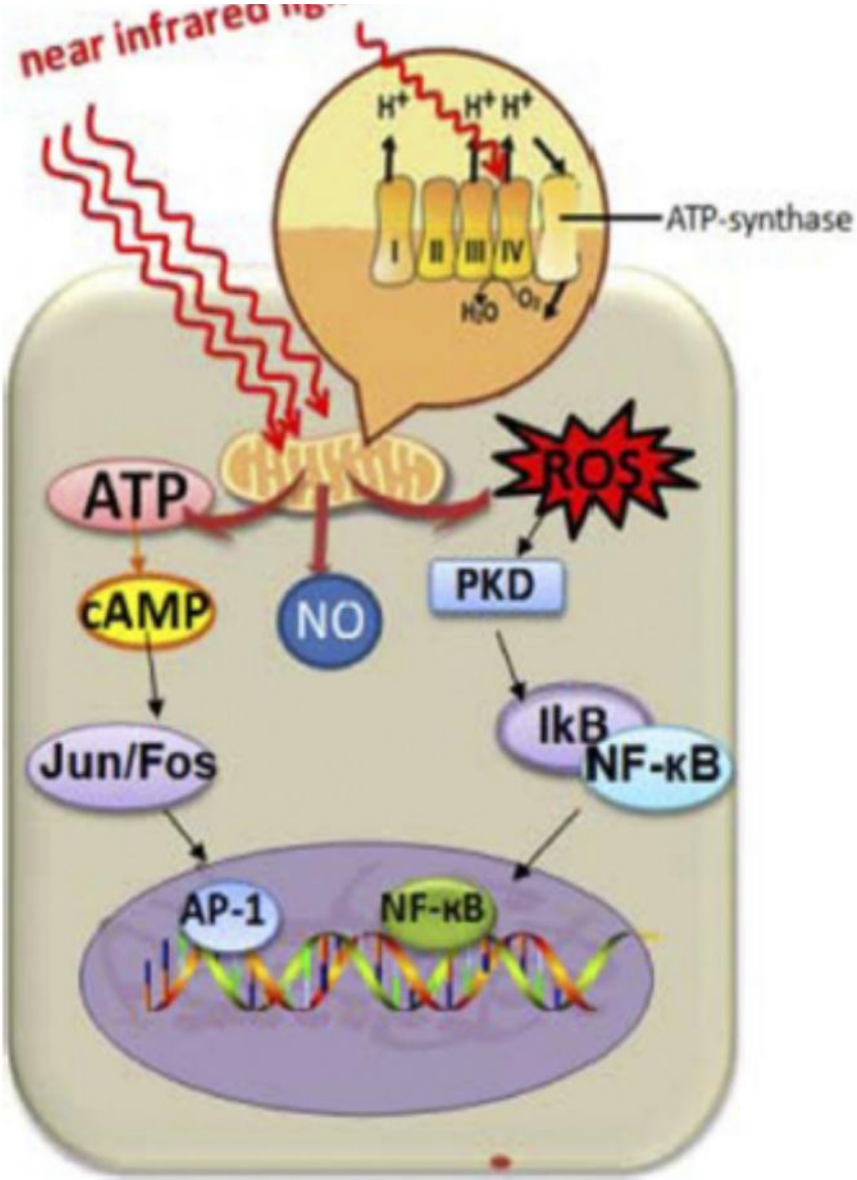
- Enzymes
- Membrane molecule
- Cellular or extracellular substances,

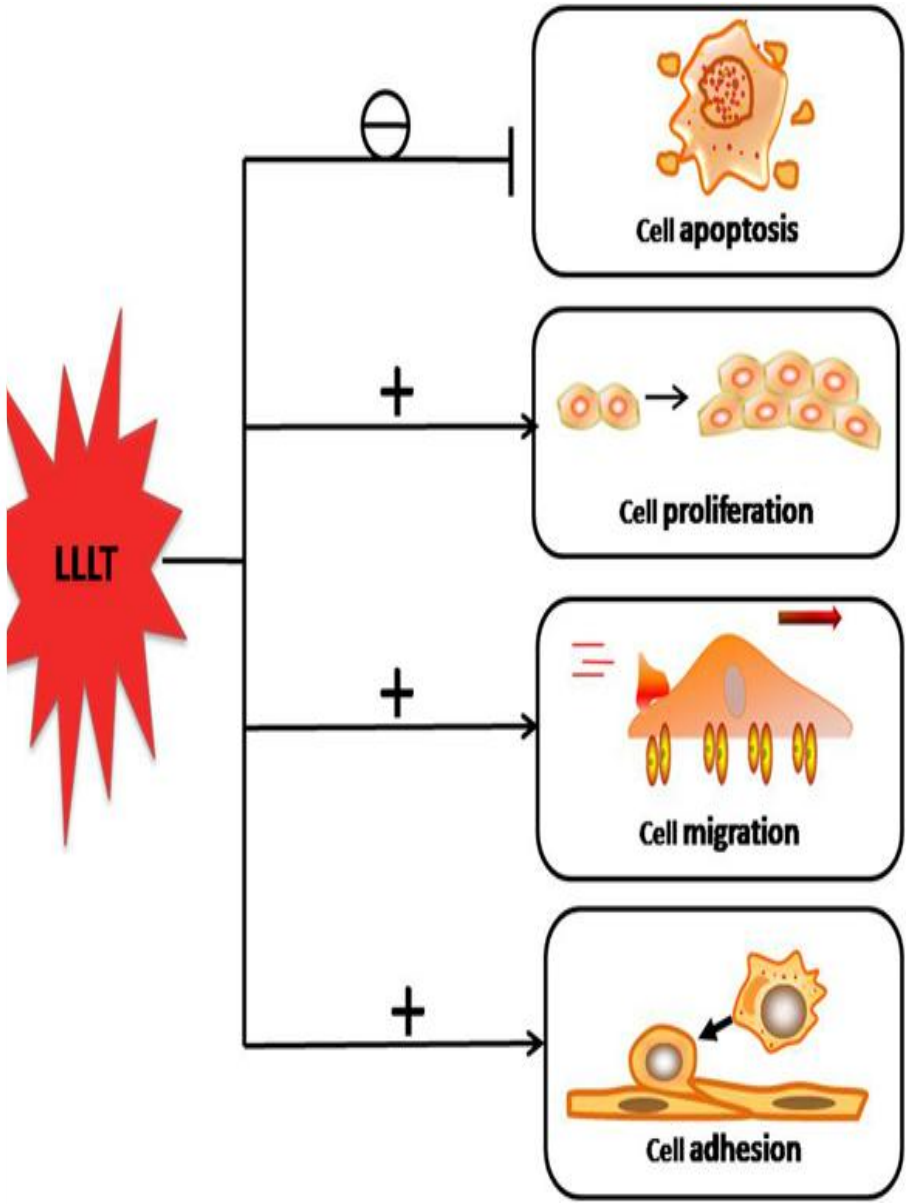
What LASER do?



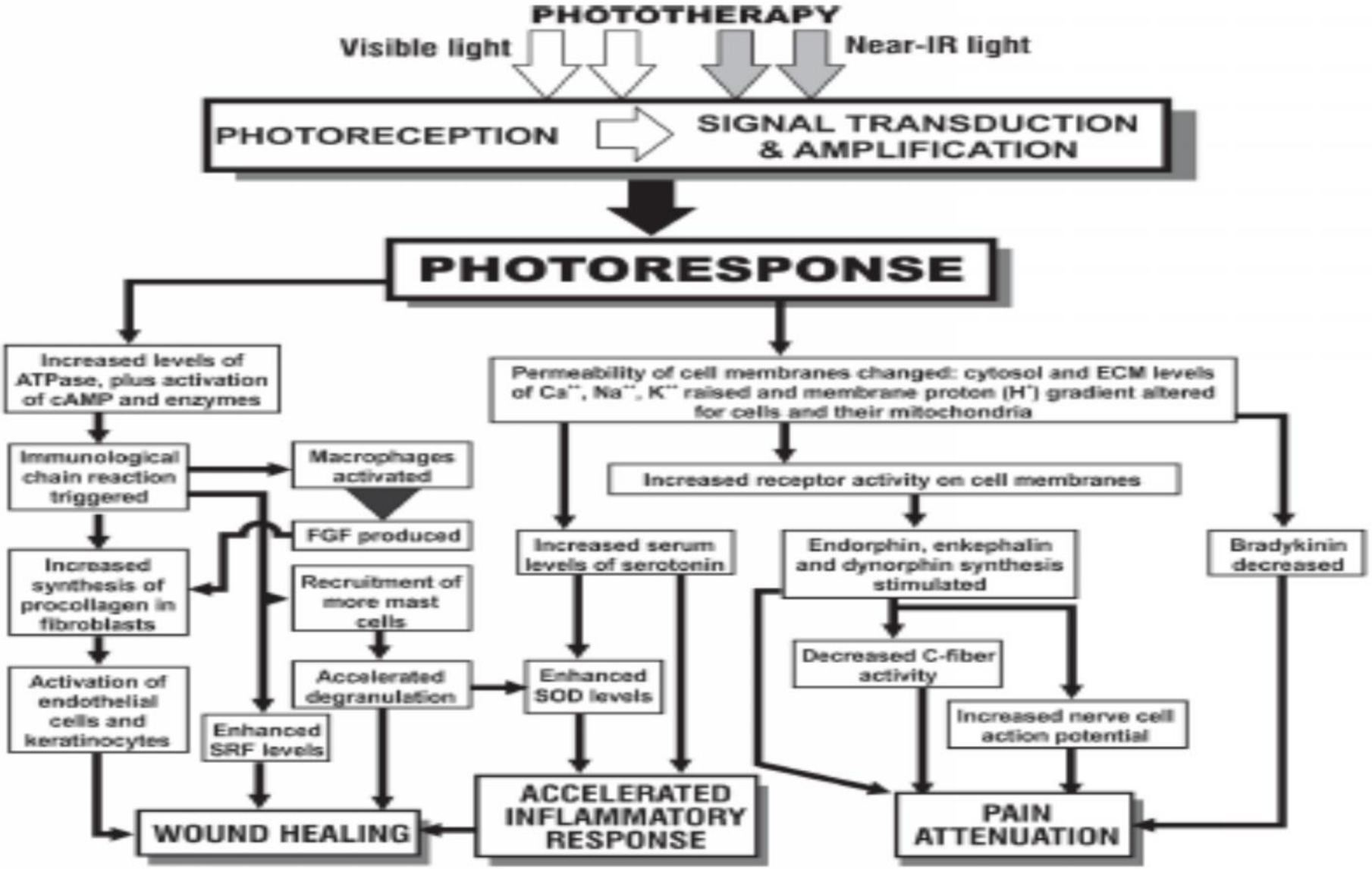


Tissue & Cellular Response





Physiological effects of Laser



LASER for Wound healing/ inflammation

- **Enhance ATP synthesis**
- **Enhance collagen/ procollagen production , so increase tensile strength**
- **Stimulate production of DNA and mRNA**
- **Increases in vascular endothelial growth factor (VEGF)**
- **Increase fibroblast growth factor (FGF-2)**
- **Stimulate release of Nos, so enhance angiogenesis**
- **Stimulate multiple cell proliferation (e.g. fibroblast, endothelial cells, and keratinocytes cells)**
- **Enhance Mast cell degranulation**
- **Inhabit bacterial growth**
- **Activates T and B lymphocytes cells**
- **Activate microphage cell**
- **Decrease level of PGE_2, and increase $PGF_2\alpha$**
- **Increased level of interleukin-Iα ($IL\text{-}1_\alpha$)/ interleukin-8 (IL-8)**
- **Decrease level of tumors necrosis factors-alpha (TNF-α)**

LASER for Pain Reduction

- **Increase nerve conduction velocity**
- **Decrease latency of sensory nerve**
- **Decrease activity of C-fibers , blocking pain gate**
- **Increase in b-Endorphins**
- **Increase frequency of nerve action potential/increase acetylcholine**
- **Axonal sprouting and nerve cell regeneration**
- **Increase level of serotine**
- **Decrease level of bradykinin**

Physiological Response

Magnitude of tissue's reaction are based on physical characteristics of:

Output wavelength/frequency
Energy density
Duration of treatment
Vascularity of target tissues

- **Direct effect - occurs from absorption of photons**
- **Indirect effect – produced by chemical events caused by interaction of photons emitted from laser & the tissues**

Indications

Pain reduction

- Pain secondary to soft tissue injuries (sprain. Strain, bursitis)
- Osteoarthritis, Rheumatoid Arthritis, & low back pain
- Neurogenic Pain (trigeminal , post-herpetic, neuralgia)
- Acupuncture & trigger point pain application.

Wound Healing

- Pressure Ulcers, Diabetic foot
- Burn wound Postoperative wound care.
- Fracture healing

Inflammation

- Post traumatic, peripheral nerve injury.
- Edema /lymphedema reduction

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Contraindications & Precautions

C

- Application over eyes
- Over or around Cancer
- Over pregnant uterus
- Over & around thyroid gland & endocrine glands
- Over area or radiotherapy

P

- Over cardiac region
- Vogues nerve
- Growth plates in children
- Confused/disoriented patients
- Photosensitive area
- Lower back/abdomen in pregnancy

Application Techniques: Indirect contact

This technique is used in treatment of open wounds.

The distance between the laser probe and wound bed should be 0.5-1 cm.

The probe also should be held perpendicular to the site of radiation

Application Techniques: Direct contact

Clean area prior to treatment

The tip of the probe is held perpendicular in contact with skin.

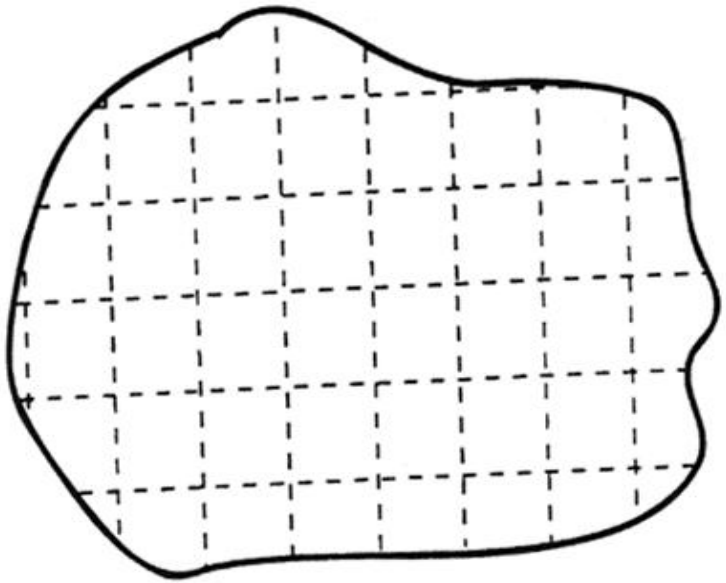
Allow deeper penetration and maximize the power density on the target tissues as reflection is minimized



Application Techniques: Gridding

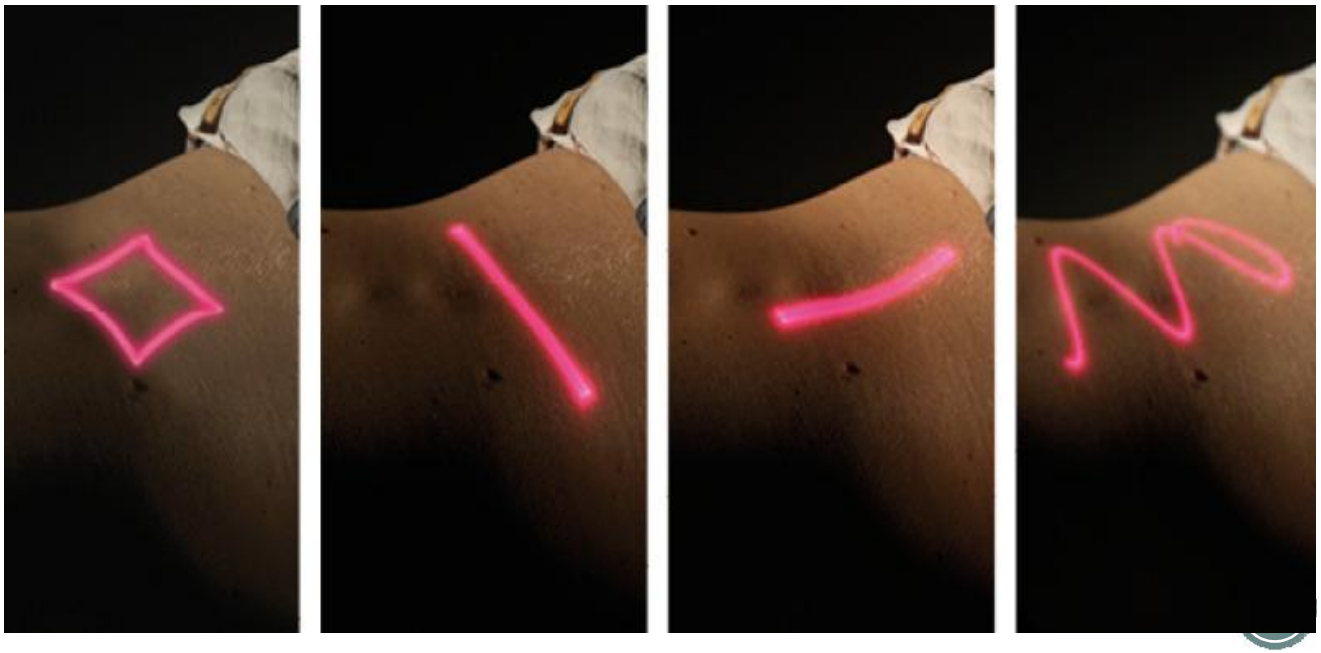
- Divide treatment areas into grids of square centimeters
- Hand held applicator in light contact with treatment area.
- Each square is stimulated for specific period of time

(60-90seconds)



Application Techniques: Scanning

- Scanning or back and forth movement for the duration of the treatment time
- No contact between laser tip and skin.
- Tip is held at variable distance 10-50 cm from treatment area
- As distance from target increases amount of energy decreases



Application Techniques: Acupoint

It is used to irradiate localized painful spot.

Using hand held probe, one can use contact and non-contact technique.

It is commonly used in treatment of localized painful site, trigger points, and acupuncture points.

Treatment consideration

- Better to underexpose than to overexpose
- Begin treatment with minimal and gradually increase
- Avoid direct exposure into eyes (If lasing for extended periods of time, safety glasses are recommended)

- If icing – use BEFORE phototherapy • Enhances light penetration
- If heating – use AFTER phototherapy • Decreases light penetration

- Not recommended to combined US and LASER in the same sessions

- Medication should be considered e.g. photosensitizers

Patients Parameters of laser therapy

- Need medical history & proper diagnosis
  - Diabetes – may alter clinical efficacy
- Medications
  - Photosensitivity (antibiotics)
- Pigmentation
  - Dark skin absorbs light energy better
- Clean skin surface
- Wearing goggles