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L A S E R

With Or Without Laser?

Be careful

DR. HOOMAN EBRAHIMI

- *Welcome to the laser world*

Dr. Hooman Ebrahimi

Laser

light

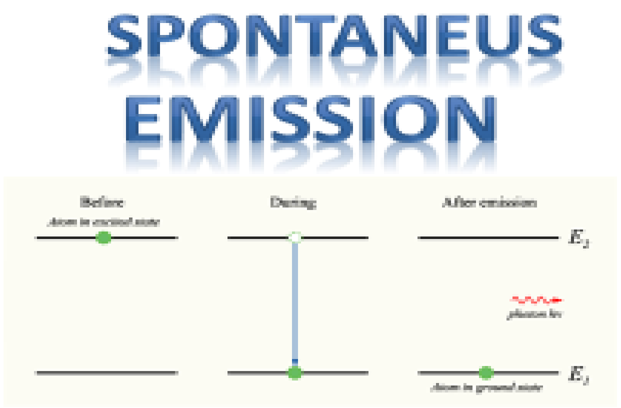
amplification by

stimulated

emission of

radiation

Spontaneous Emission



- برخورد فوتون به جسم
  - انعکاس یا پراکندگی
  - جذب

کاهش سطح انرژی فوتون

پرش الکترون داخل اتم به سطح بالاتر

برانگیختگی ناپایدار

بازگشت اتم به وضع پایدار

آزاد سازی انرژی به شکل فوتون ثانویه

پدیده گسیل خود به خودی spontaneus emission

Stimulated Emission

پدیده وارونگی
INVERSION

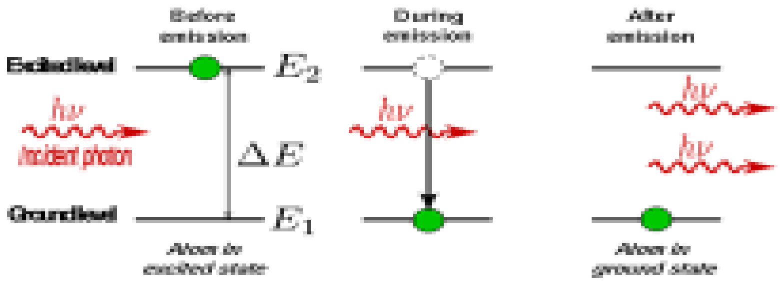
ورود فوتون اولیه به محدوده یک اتم برانگیخته

فوتون ثانویه　　phase

با طول موج معادل فوتون اولیه ، در همان جهت و ارتعاشات هماهنگ

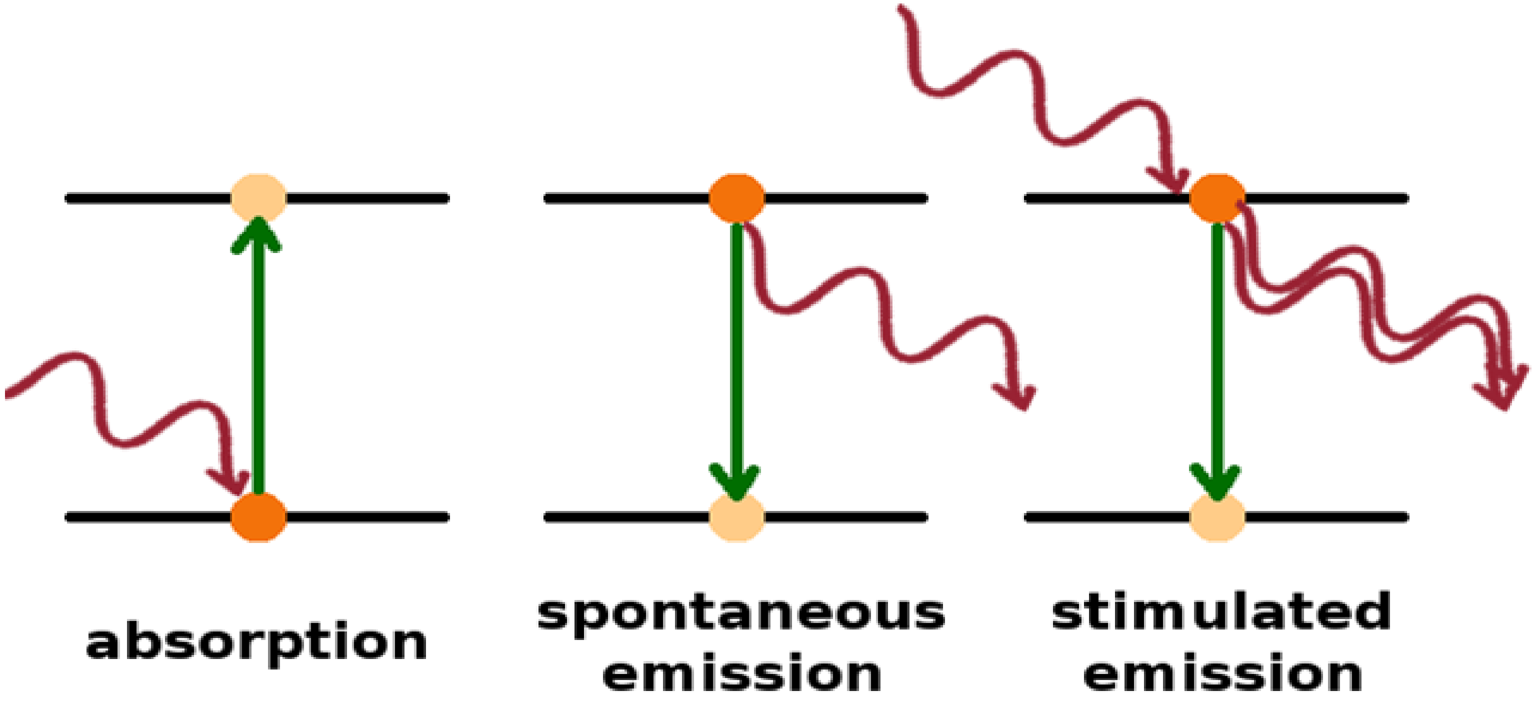
طول موج

تولید نور بسیار قوی و تک رنگ و یکپارچه ← لیزر

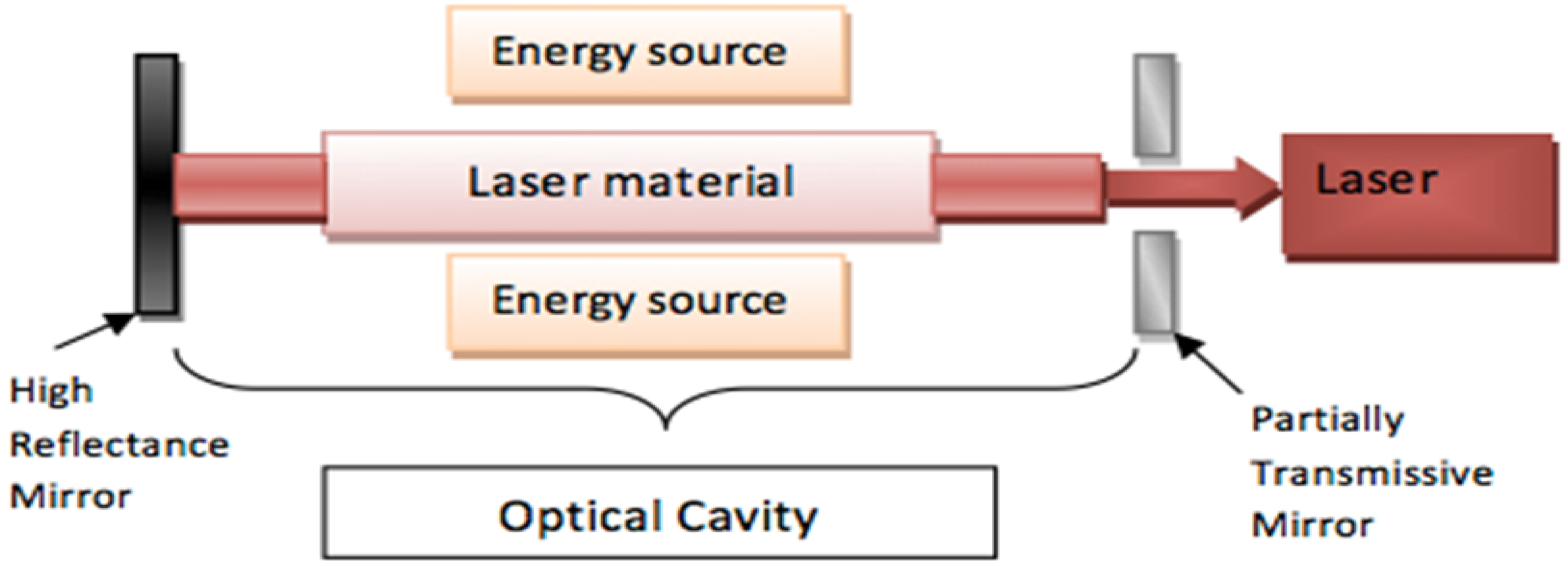


$$E_2 - E_1 = \Delta E = h\nu$$

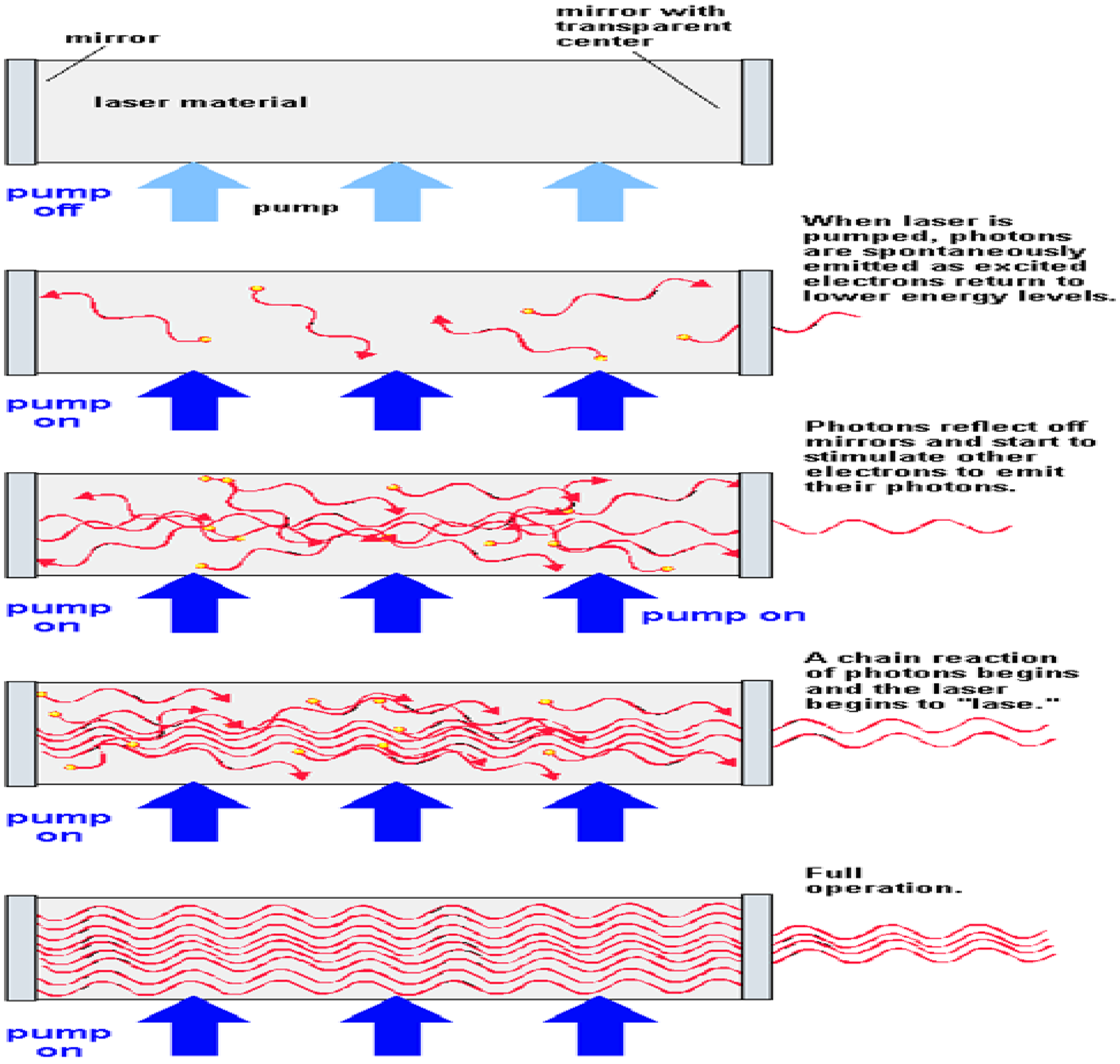
Stimulated Emission



LASER COMPONENTS

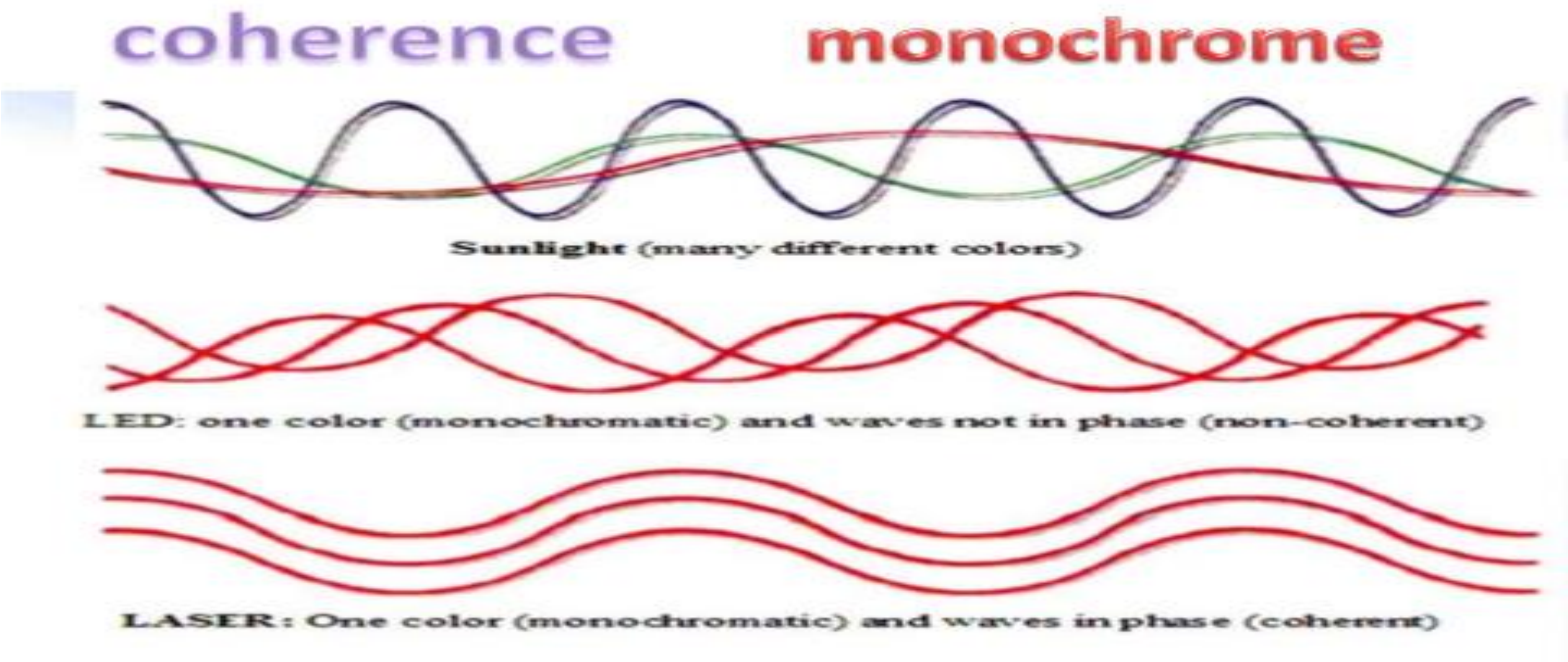


Schematic diagram showing different laser components


mirror
mirror with transparent center
laser material
pump off
pump
When laser is pumped, photons are spontaneously emitted as excited electrons return to lower energy levels.
pump on
Photons reflect off mirrors and start to stimulate other electrons to emit their photons.
pump on
pump on
A chain reaction of photons begins and the laser begins to "lase."
pump on
Full operation.
pump on

LAMP LED

LASER



CLASSIFICATION OF LASERS BASED ON SOURCE MATERIAL

- **Gas lasers :such as CO2,Ne and He**
- **Liquid lasers: such as Dye lasers**
- **Solid lasers :such as Ruby lasers**
- **Semi-conductor lasers: such as GaAlInP, GaALAs and GaA**

KIND OF LASER IN DENTISTRY

1. Diod laser: semi conductor 400-1000nm
2. Nd-YAG: 1064 nm
3. Erbium Family: Erbium –YAG 2940 nm , Erbium-CR-YSGG 2780 nm
4. CO_2:10600 nm

CLASSIFICATION OF LASERS BASED ON POWER

A-High power, warm or hard lasers:

Power of these lasers is usually more than 0/5W. These types of lasers have applications in surgery.

B-Lasers with Moderate Powers:

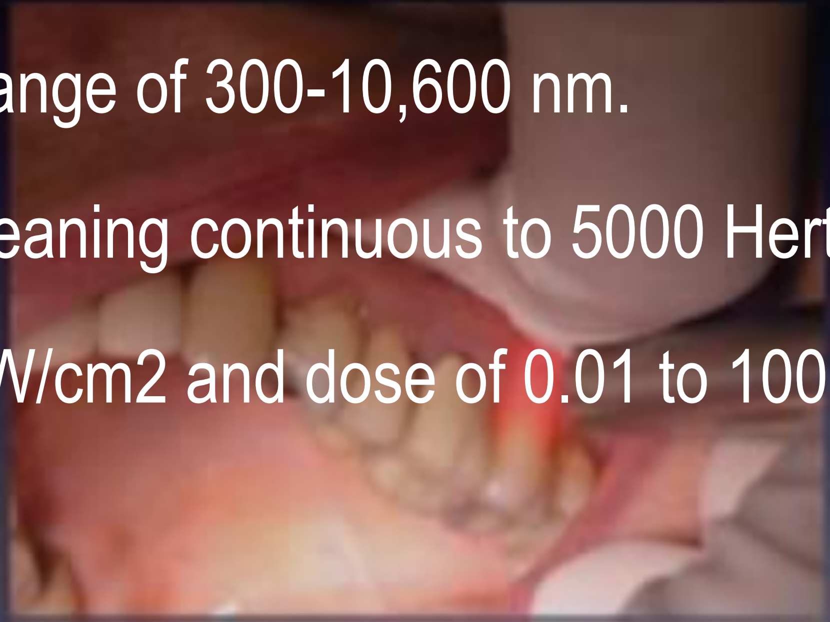
These lasers have their therapeutic effect without inducing a lot of heat. Their light has a stimulating effect in tissues. Powers of these lasers are between 250 to 500mW.

C-Low Level or Cold Lasers:

These lasers have no thermal effect on tissues. Inducing a light stimulation, they result in light and gradual reactions in tissues which are called Photobiostimulation. Power of these lasers is usually less than 250mW.

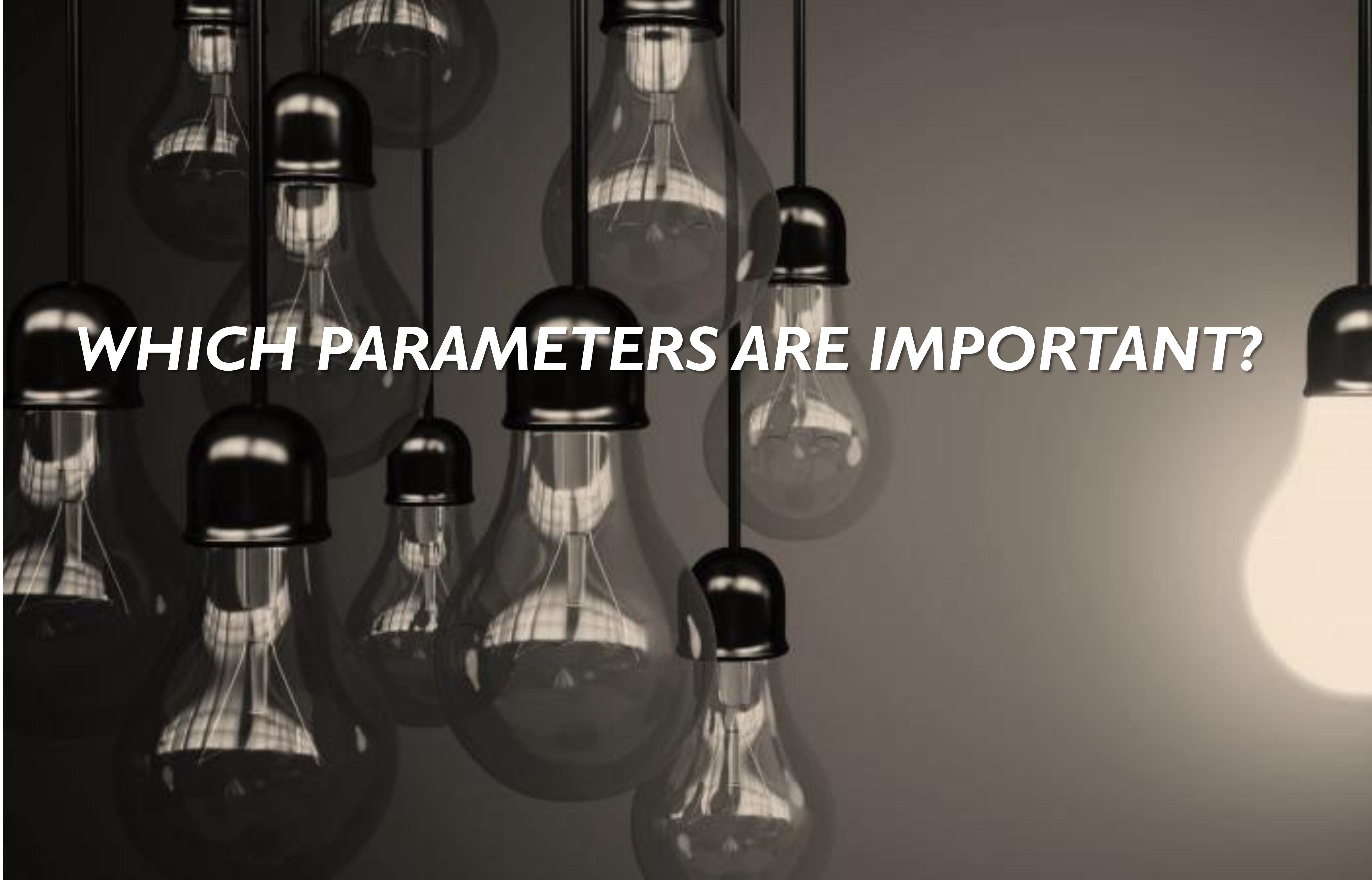
POSTEN ET AL

- a) Power output of lasers being 0.001- 0.1 Watts.
- b) Wave length in the range of 300-10,600 nm.
- c) Pulse rate from 0, meaning continuous to 5000 Hertz (cycles per second).
- d) Intensity of 0.01-10 W/cm2 and dose of 0.01 to 100 J/ cm2



Low Level Laser Therapy

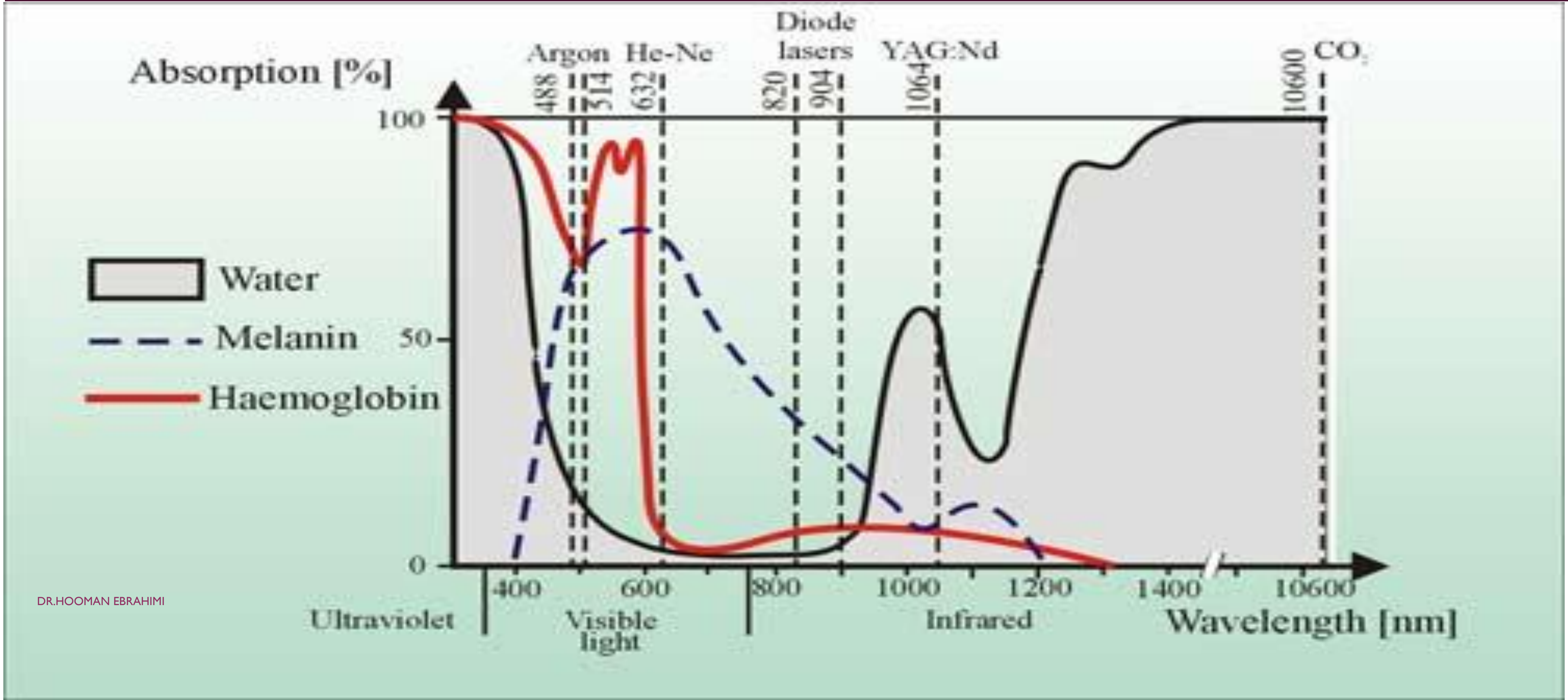
WHICH PARAMETERS ARE IMPORTANT?



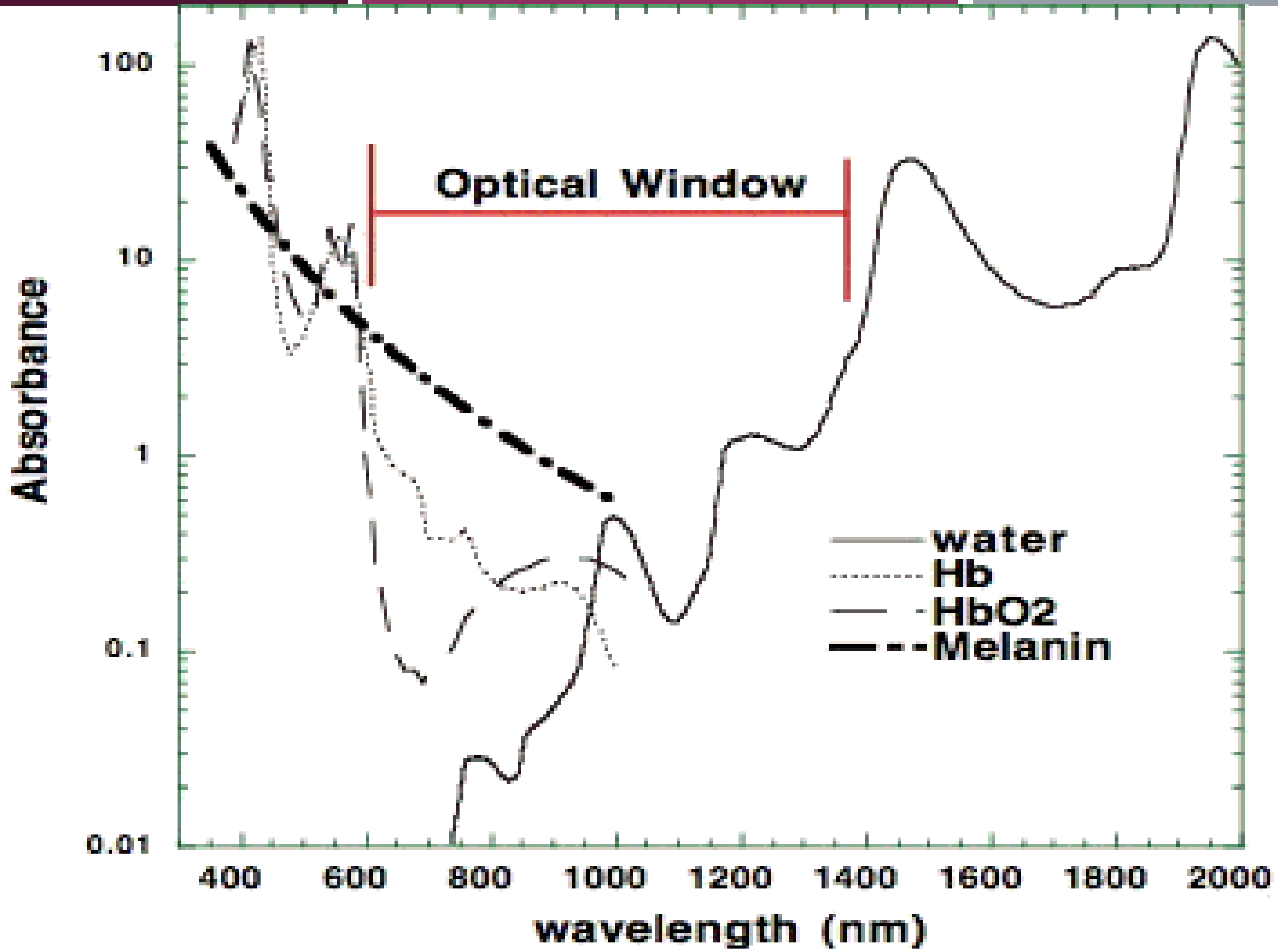
Which Parameters?

- Wave Length?
- Power?
- Energy?
- Energy Density?
- Time?
- Spot Area?

wavelength



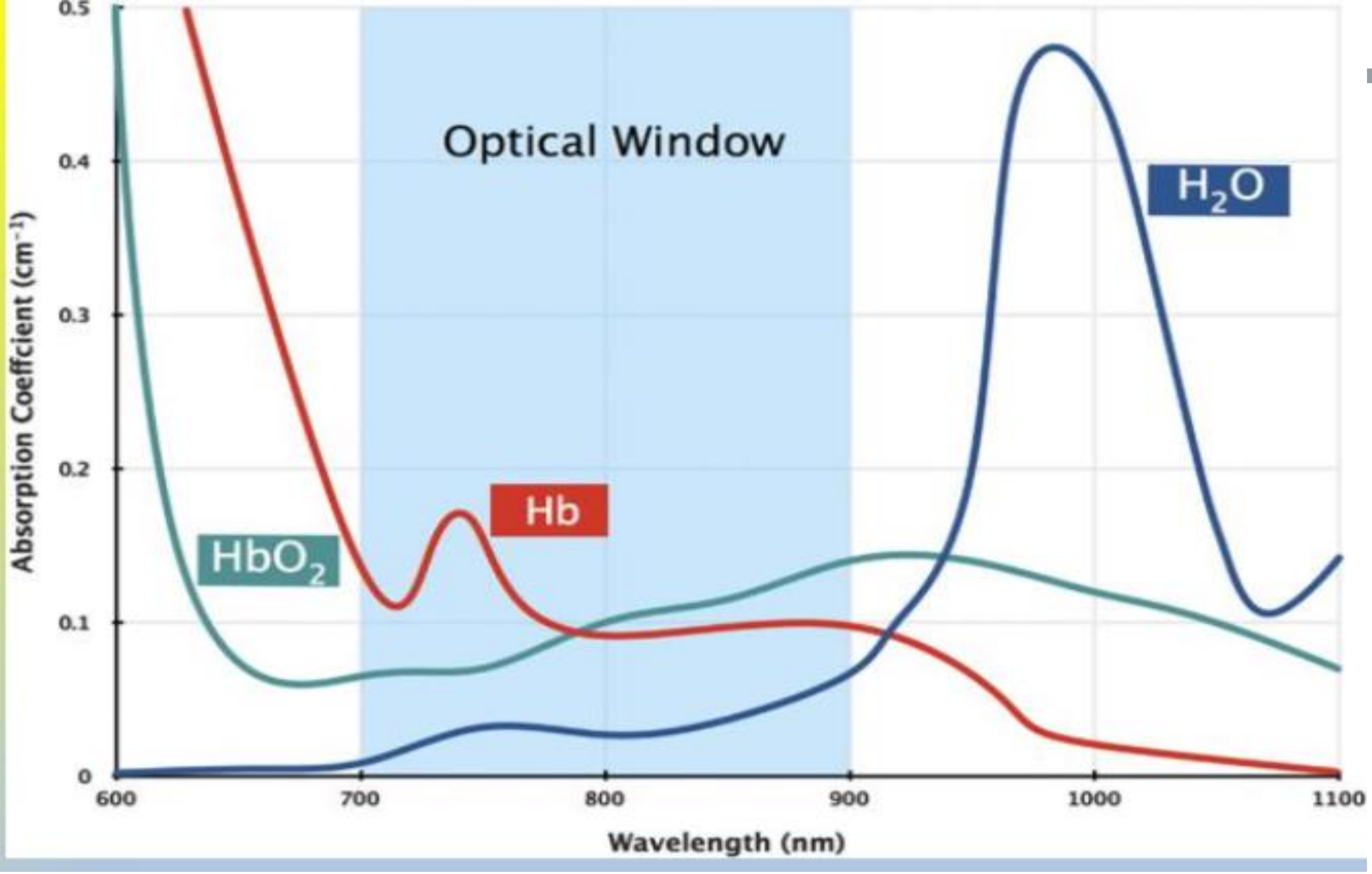
Absorption [%]
Argon
He-Ne
Diode lasers
YAG:Nd
CO2
488
514
632
820
904
1064
10600
100
50
0
Water
Melanin
Haemoglobin
400
600
800
1000
1200
1400
10600
Ultraviolet
Visible light
Infrared
Wavelength [nm]


Optical Window
Absorbance
100
10
1
0.1
0.01
400
600
800
1000
1200
1400
1600
1800
2000
wavelength (nm)
water
Hb
HbO2
Melanin

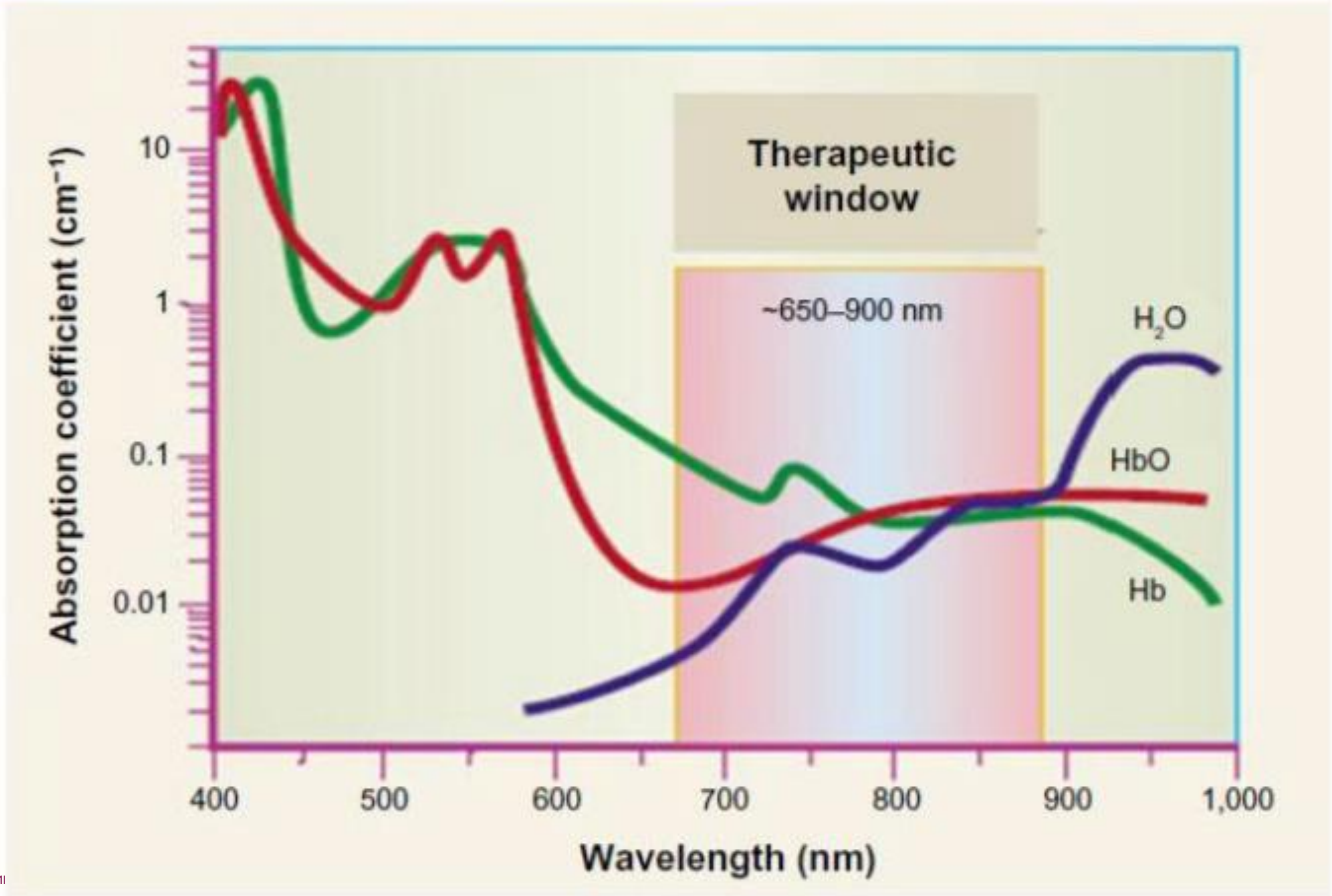
THERAPEUTIC (OPTICAL) WINDOW

- **therapeutic window that consists of red and infrared light (600–1200 nm)**
- **light penetrates deeper in biological tissue.**

- **hemoglobin and melanin have absorption peaks at wavelength shorter than 600 nm**
- **water is a major absorber at wavelengths greater than 1150 nm.**



Optical Window
H_2O
Hb
HbO_2
Absorption Coeffcient (cm⁻¹)
0.5
0.4
0.3
0.2
0.1
0
600
700
800
900
1000
1100
Wavelength (nm)


Therapeutic window
~650–900 nm
H_2O
HbO
Hb
Absorption coefficient (cm^{-1})
10
1
0.1
0.01
400
500
600
700
800
900
1,000
Wavelength (nm)

WHICH LASERS ARE IN OPTICAL WINDOW?

wavelength :optical window : 600–1200nm

Which Parameters?

- Wave Length?
- Power?
- Energy?
- Energy Density?
- Time?
- Spot Area?

WHICH POWER IS USEFUL FOR LLLT?

power :: 1–500mw **recently:** 1000mw????

WHAT IS THE ENERGY?

Energy : Power(W) * Time(S) : J

20 j=20j

5w* 4s =0.5w*40s

WHAT IS THE ENERGY DENSITY (DOSE)?

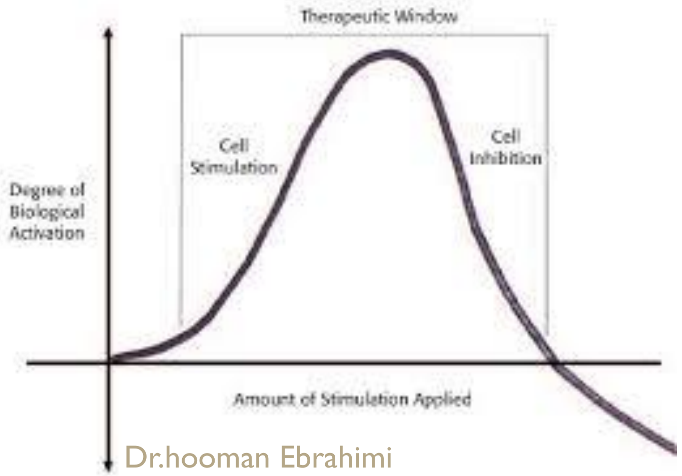
Energydensity : energy j /area cm2 : j/cm2

The premier index in efficacy

Arndt-Schultz law

- Arndt-Schultz law : (for an open ulcer)
  - Doses between 0.01-10 J/cm2 stimulate wound healing
  - Higher doses inhibit
  - It may be different for different applications

Start efficacy: 0.01 j/cm2
Best efficacy : 1 j/cm2



Which Parameters?

- Wave Length?
- Power?
- Energy?
- Energy Density?
- Time?
- Spot Area?

PENETRATION DEPTH

محدوده طیف	طول موج(nm)	عمق نفوذ(mm)
ماوراء بنفش	150-380	>0/1
بنفش تا آبی تیره	390-475	تقریبا 0/3
آبی تا سبز	475-545	تقریبا0/3-0/5
زرد تا نارنجی	545-600	تقریبا0/5-1
قرمز	600-650	تقریبا8-10
قرمزتیره تا مادون قرمز نزدیک	650-1000	20-40
مادون قرمز نزدیک تا مادون قرمز میانه	1000-1350	3-5
مادون قرمز دور	1350-12000	>0/1

LASER-TISSUE INTERACTION

- Transmission: in this way, the beam enters the medium, but there is no interaction between the incident beam and the medium. The beam will emerge distally, unchanged or partially refracted.
- Scatter: there is some interaction, but this is insuffi cient to cause complete attenuation of the beam. Scatter will cause some diminution of light energy with distance, together with a distortion in the beam, whereby rays proceed in an uncontrolled direction through the medium. Back-scatter of the laser beam can occur as it hits the tissue; this is seen most in short wavelengths, eg diode, Nd:YAG (≥50% back-scatter).
- Reflection: the density of the medium, or angle of incidence being less than the refractive angle, results in a total reflection of the beam. In true reflection, the incident and emergence angles will be the same or, if the medium interface is rough or non-homogenous, some scatter may occur.
- Absorption: the incident energy of the beam is attenuated by the medium and transferred into another form

TISSUE OPTICS

- Light crossing the interior of biological in two ways
  - absorption
  - scattering
- absorption and scattering depend on
  - Wavelength
  - tissue biochemistry
  - anatomy

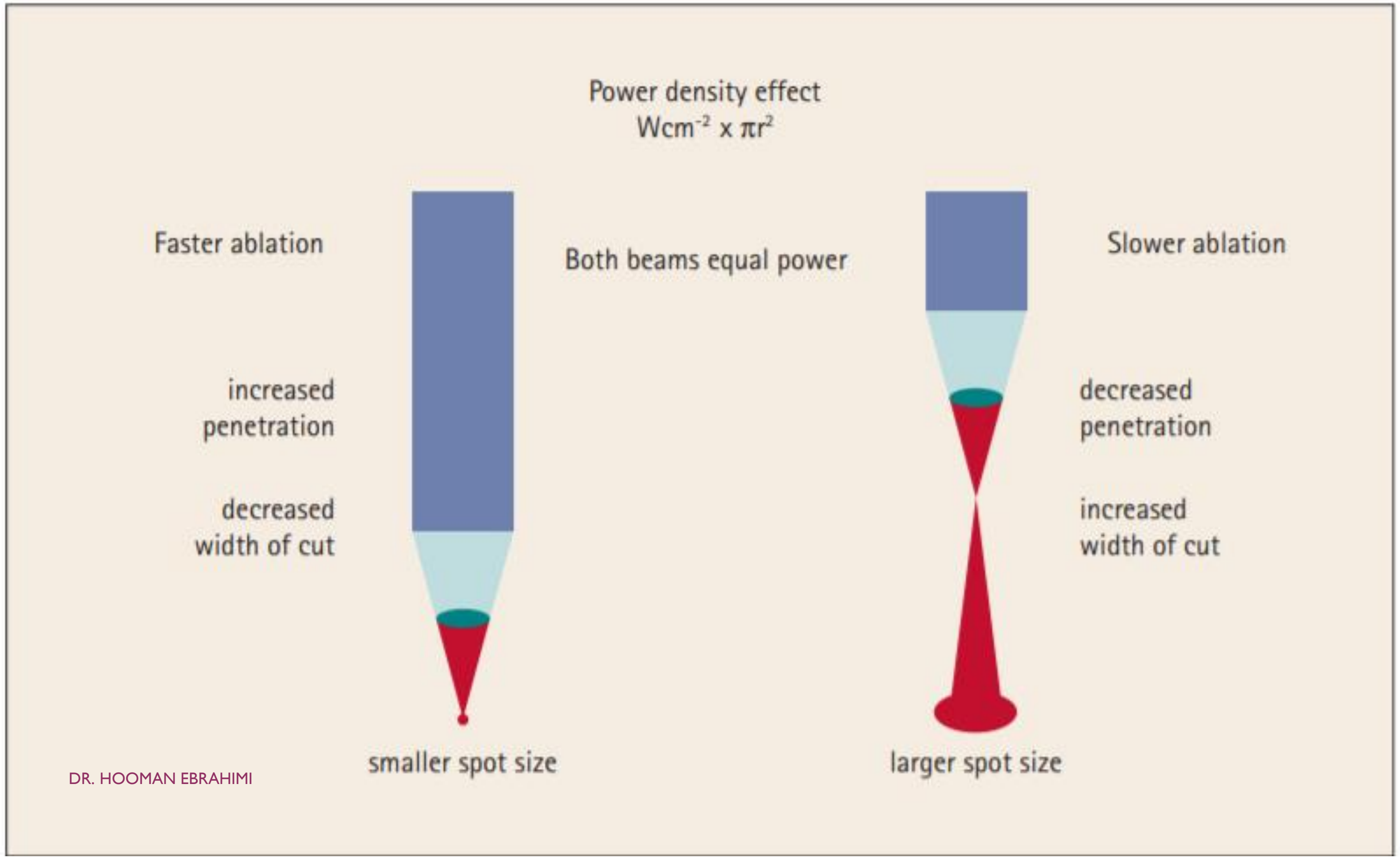
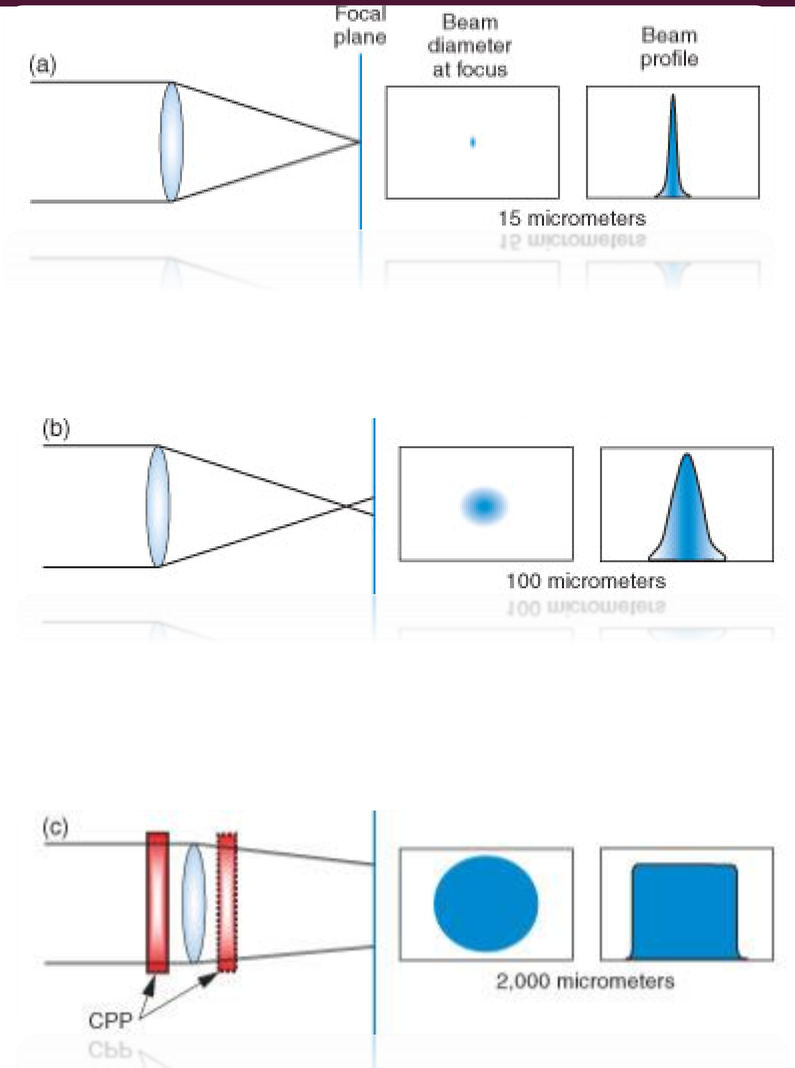


Fig. 4 Power density effects due to the change in spot size of a focused laser beam. This effect relates to the contact (or non-contact) of the laser hand-piece with the target tissue

- Focused
- Defocused
- Prefocused



- DOSIMETRY

Pulsed laser or CW laser, does it make a difference?

Bursts of light cause different effects than constant streams of light.

- Pulsed lasers emit bursts of light spaced in time.
  - Between pulses, the laser emits no light.
  - The ***period*** is the time from the start of one pulse to the next.
  - The ***pulse duration*** (***pulse width***) is the time measured across a pulse, often at its full width half maximum (FWHM).
- Continuous wave (CW) lasers provide steady emission.
  - Peak, minimum, and average powers are approximately identical.
  - Period and pulse width do not apply unless the light is modulated.
- Help, harm, or underperform: it depends on the pulse width, peak power, ***and*** period.
  - Short pulses and long periods may protect illuminated samples from overheating, by allowing them to cool down between bursts of light.
  - Short pulses with high peak powers and long periods may destructively ablate surface material, but heat the surrounding area minimally.
  - Long pulses and/or short periods may deliver damaging total emission, even if the peak power is moderate.

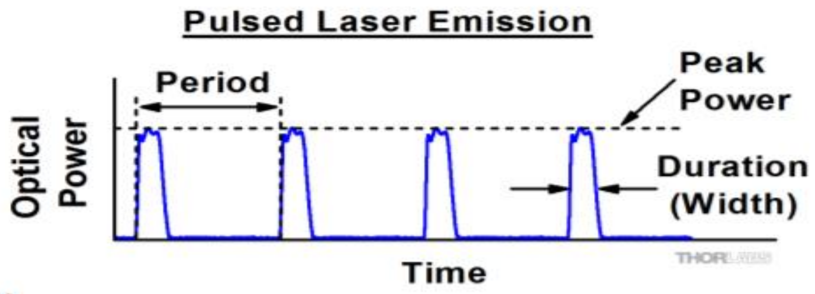


Figure 1. Pulsed lasers emit bursts of light, spaced in time. There is no emission between pulses.

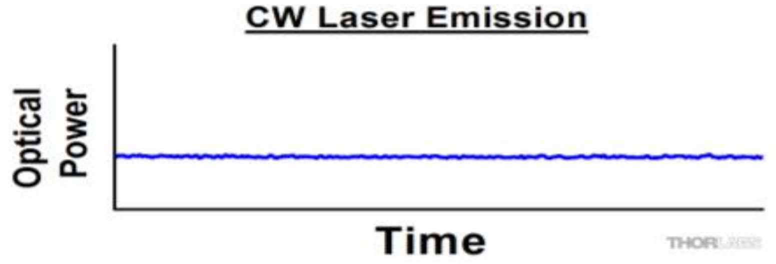


Figure 2. CW lasers emit light whose optical power is approximately constant with time.

What do power and pulse energy describe?

Energy and power describe different, but related, aspects of the emission.

- Pulse energy is a measure of emission over one period.
  - Each period contains a single pulse, and all energy emitted during one full period is delivered by the pulse.
  - Pulse energy, shown as the shaded regions in Figures 3 and 4, is the area under one full period of the power measurement curve.
- Optical Power Parameters:
  - ***Instantaneous power:*** the optical power at a specific point in time.
  - ***Peak power:*** the highest instantaneous optical power emitted.
  - ***Average power:*** the constant power, if the laser emission were CW.
    - The pulsed laser delivers bursts of emission. A CW version would spread that emission uniformly across the period.
    - Both the pulsed laser and the CW version provide the same energy (shaded areas in Figure 4) during one pulse period.
    - The height of the shaded area in the lower plot of Figure 4 is:
      - The constant optical power of the CW version.
      - The average power output by the pulsed laser.
- **Note**: average power provides no information about peak power, period, or pulse width.

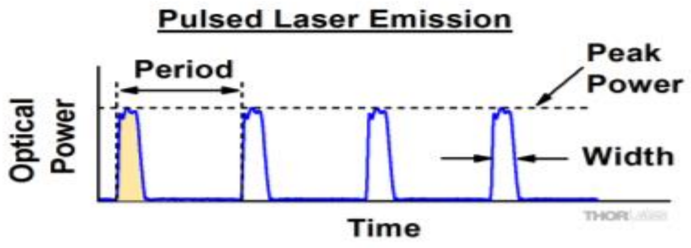


Figure 3. Period, peak power, and pulse width are used to characterize laser pulses

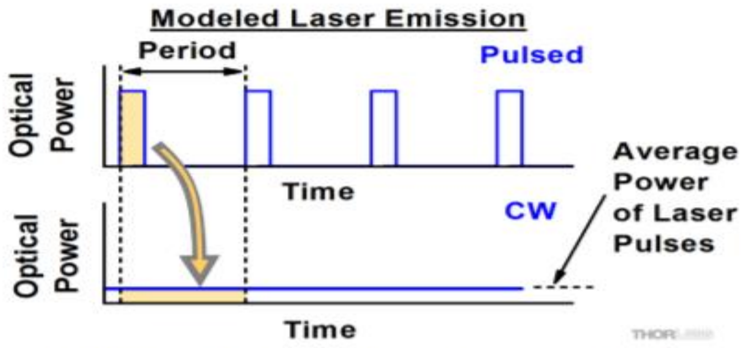


Figure 4. The modeled laser pulses (top) and CW laser output (bottom) provide the same energy per period, illustrated by the shaded areas. The CW laser's output power equals the pulsed laser's average power.

What is the effect of changing pulse width or period?

Pulse width and period control the average power emitted by the laser.

- Pulse width:
  - Both pulse energy (shaded area) and average energy (dotted green line) depend on pulse width.
  - Increase (or reduce) pulse width to increase (or reduce) both pulse energy and average power.

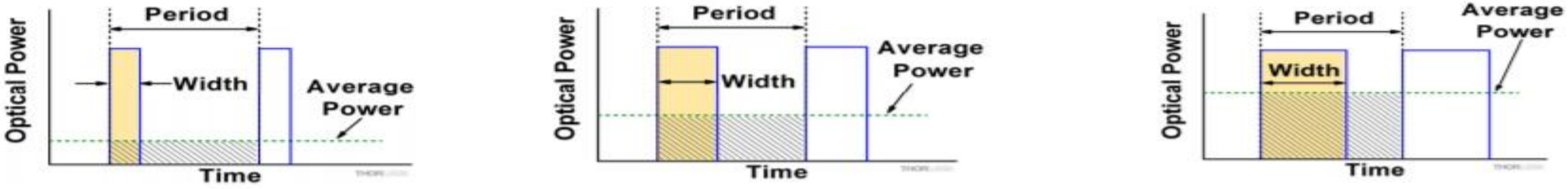


Figure 5. Changing the pulse width changes the pulse energy by changing the length of the pulses. The average power changes, since the total time light is emitted by the laser changes.

- Period:
  - Pulse energy (shaded area) does not depend on period, but average energy (dotted green line) does.
  - Reduce the period to increase the average power (or increase the period to reduce the average power).

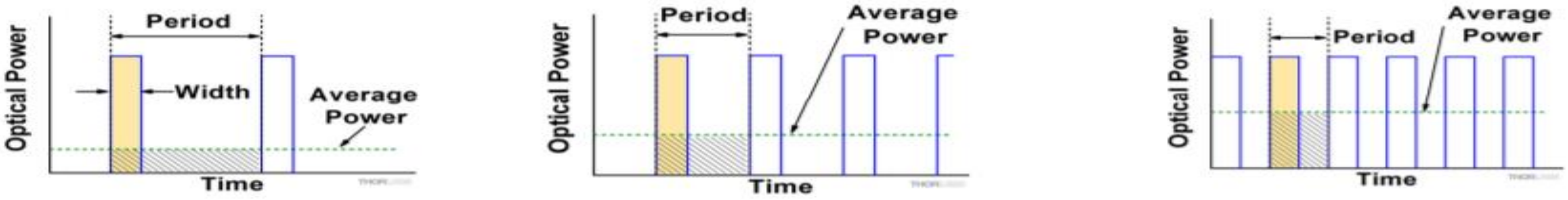


Figure 6. Changing just the period does not change the pulse energy, since the pulse width and peak power do not change. The average power changes due to pulses being delivered more (or less) frequently.

What are the symbols and units of pulse parameters?

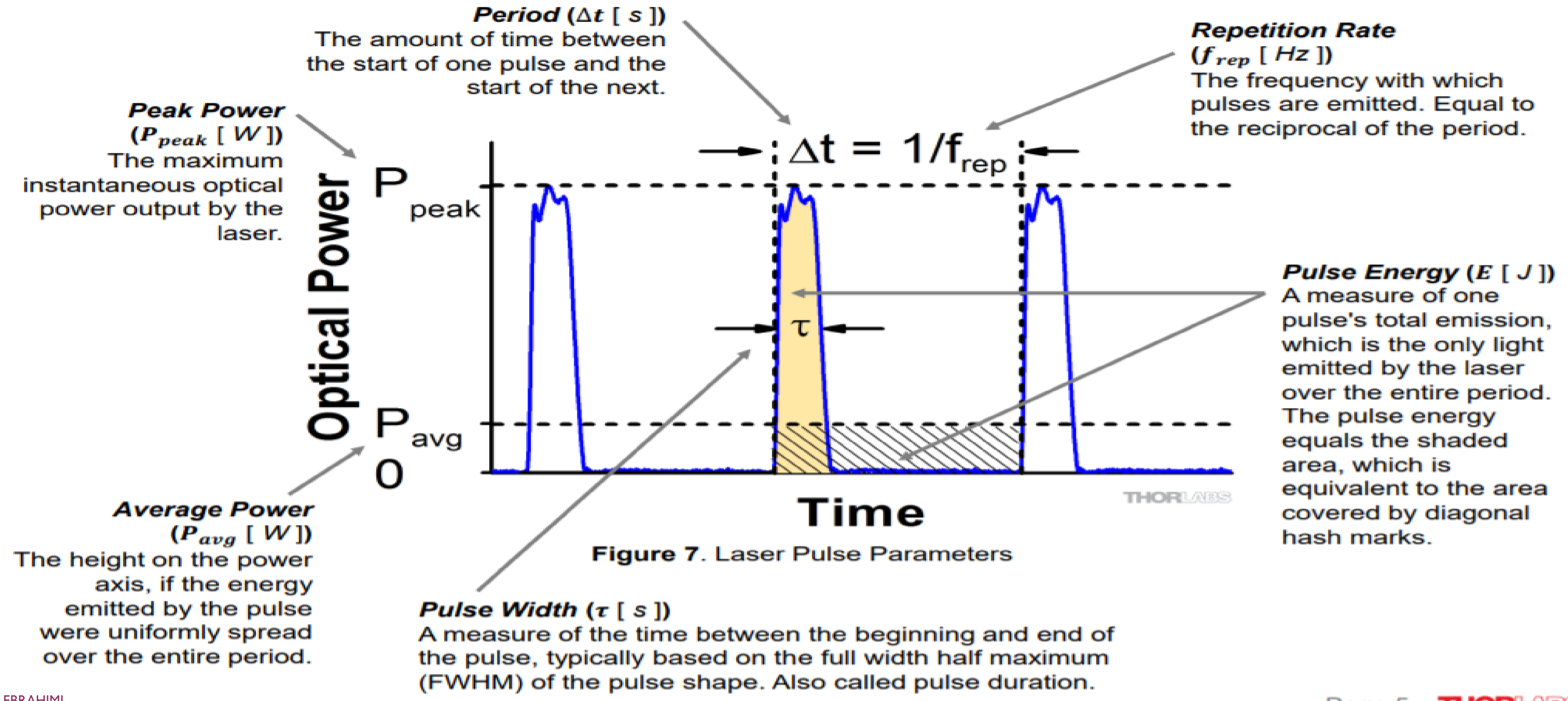


Figure 7. Laser Pulse Parameters

How are pulse energy and peak power calculated?

Pulses are often modeled with a rectangular shape as shown in Figure 8.

- Period and repetition rate are reciprocal:

$$\Delta t = \frac{1}{f_{rep}} \quad \text{and} \quad f_{rep} = \frac{1}{\Delta t}$$

- Pulse energy calculated from average power:

$$E = \frac{P_{avg}}{f_{rep}} = P_{avg} \cdot \Delta t$$

- Average power calculated from pulse energy:

$$P_{avg} = \frac{E}{\Delta t} = E \cdot f_{rep}$$

- Peak pulse power estimated from pulse energy:

$$P_{peak} \approx \frac{E}{\tau}$$

- Peak power and average power calculated from each other:

$$P_{peak} = \frac{P_{avg}}{f_{rep} \cdot \tau} = \frac{P_{avg} \cdot \Delta t}{\tau} \qquad P_{avg} = P_{peak} \cdot f_{rep} \cdot \tau = \frac{P_{peak} \cdot \tau}{\Delta t}$$

- Peak power calculated from average power and duty cycle*.

$$P_{peak} = \frac{P_{avg}}{\tau/\Delta t} = \frac{P_{avg}}{duty\ cycle}$$

*Duty cycle is the fraction time during which there is laser pulse emission.
duty cycle = $\tau / \Delta t$

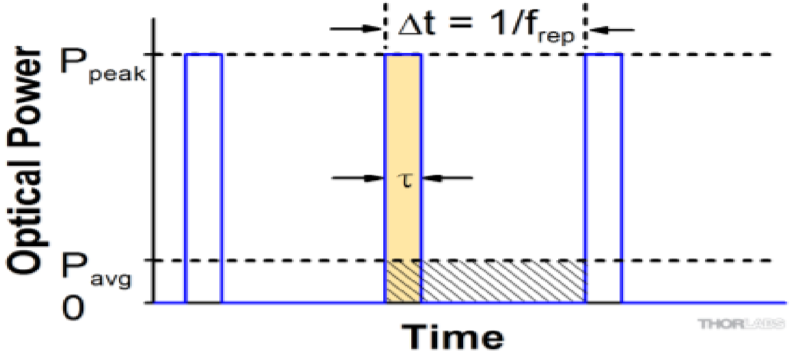
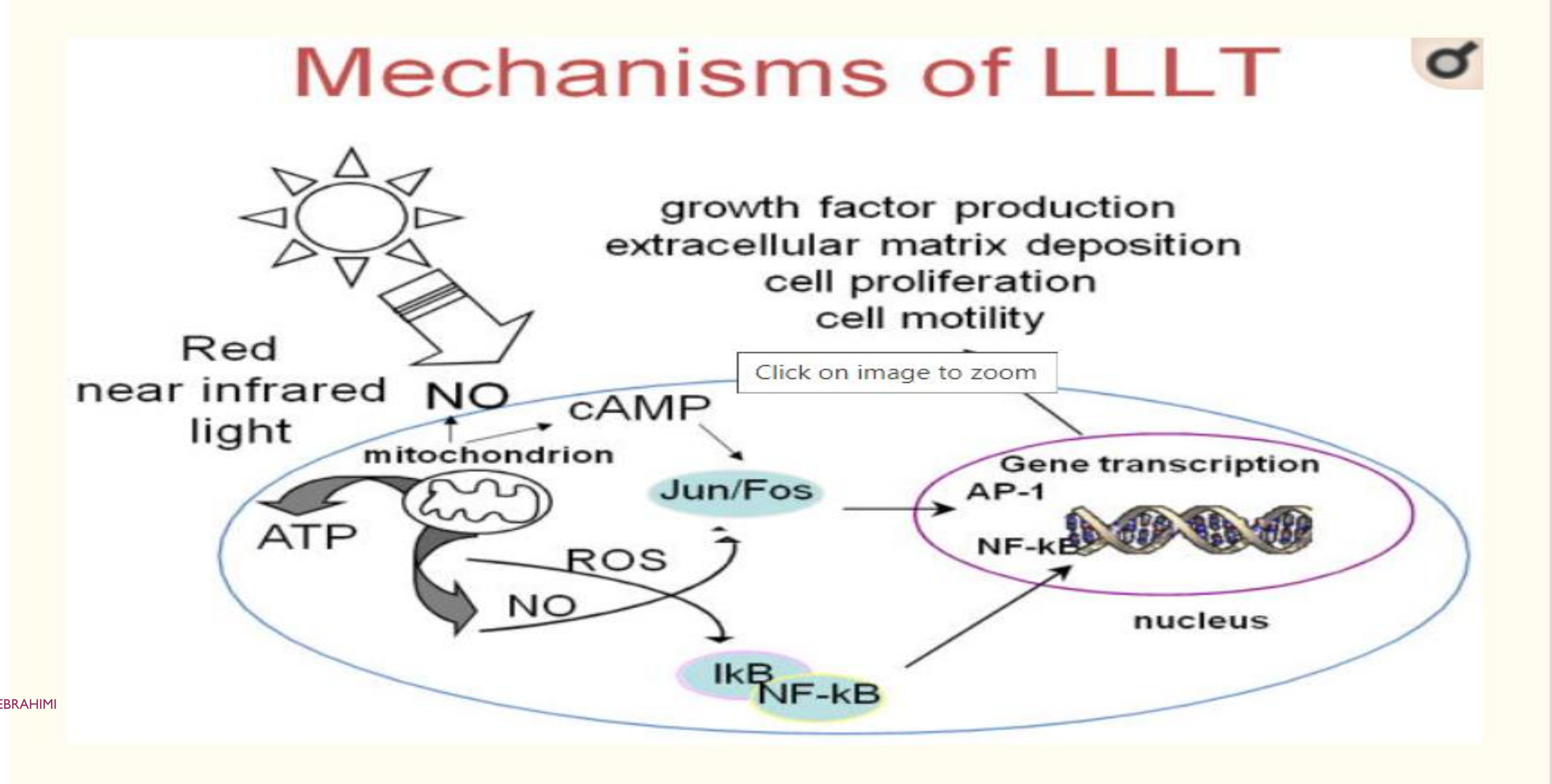


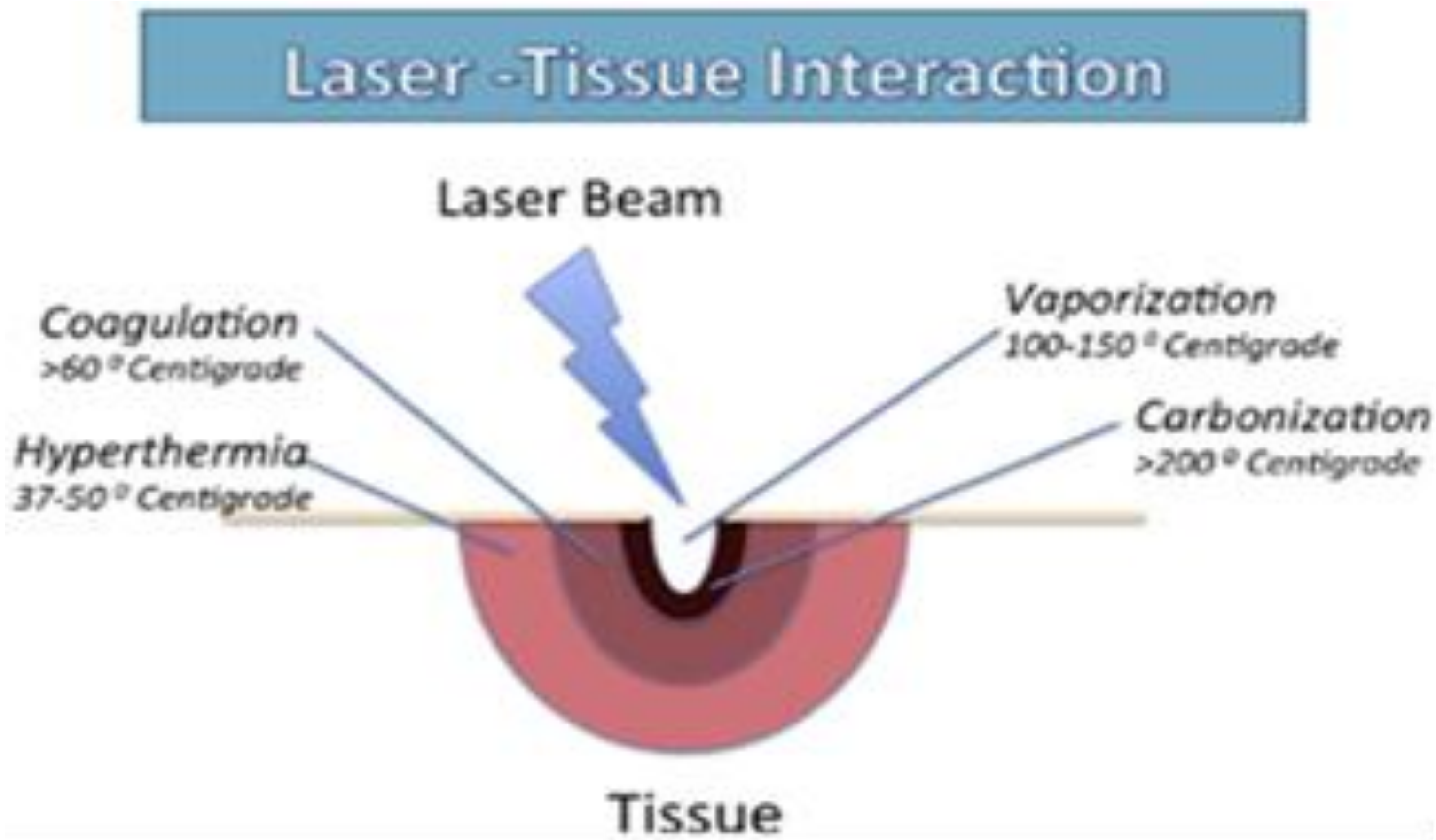
Figure 8. Laser Pulse Parameters

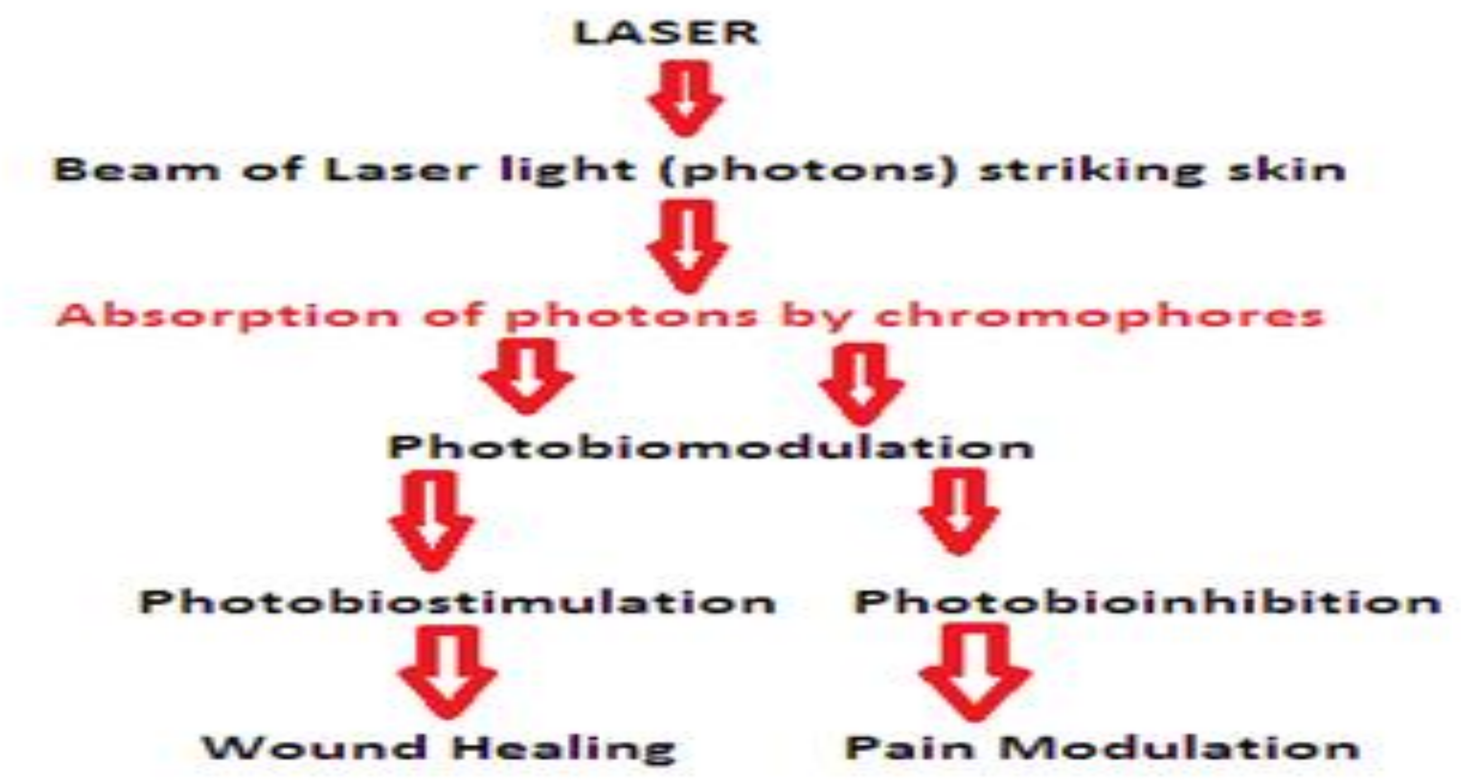
Δt	Pulse Period
E	Energy per Pulse
f_{rep}	Repetition Rate
P_{avg}	Average Power
P_{peak}	Peak Power
τ	Pulse Width


Mechanisms of LLLT
growth factor production
extracellular matrix deposition
cell proliferation
cell motility
Click on image to zoom
Red
near infrared
light
NO
cAMP
mitochondrion
Jun/Fos
Gene transcription
AP-1
NF-kB
ATP
ROS
NO
nucleus
IkB
NF-kB

- For low-power visible or near-infrared light to have an effect on a biologic system,
- the photon must be absorbed by electronic absorption bands belonging to a photon acceptor or chromophore (first law of photobiology) .
- A chromophore is a molecule (or portion of a molecule) which imparts a color to a compound (e.g. chlorophyll, hemoglobin, myoglobin, cytochrome c oxidase, other cytochromes, flavin, flavoproteins or porphyrins) .
- The “optical window” in a tissue describes a range of wavelengths where the penetration of light into tissue is maximized by employing red and near-infrared wavelengths .
- The optimum wavelength has been estimated to be around 810 nm.

- Mitochondria are “the cellular power plants” in our cells and as such they convert food molecules and oxygen into energy (ATP) by oxidative phosphorylation.
- It has been proposed that cytochrome c oxidase (COX) is the primary photo-acceptor for the red-NIR wavelength range in mammalian cells [19].
- Nitric oxide (NO) produced in mitochondria can inhibit respiration by binding to COX and displace oxygen especially in injured or hypoxic cells [20].
- It is proposed that LLLT can photo-dissociate NO from COX and reverse the mitochondrial inhibition of respiration due to excessive NO binding [21].
- The process of light mediated vasodilation was first described by RF Furchgott [22] in 1968, and his research on the biological properties of nitric oxide eventually led to the award of a Nobel Prize in 1998 [23].
- LLLT is able to produce a shift in the overall cell redox potential in the direction of greater oxidation by increasing reactive oxygen species (ROS) and decreasing reactive nitrogen species (RNS) [24–30].
- The long-term effects of LLLT are thought to be due to the activation of various transcription factors by the immediate chemical signaling molecules produce from mitochondrial stimulation by LLLT.
- The most important of these signaling molecules are thought to be ATP, cyclic-AMP, NO and ROS

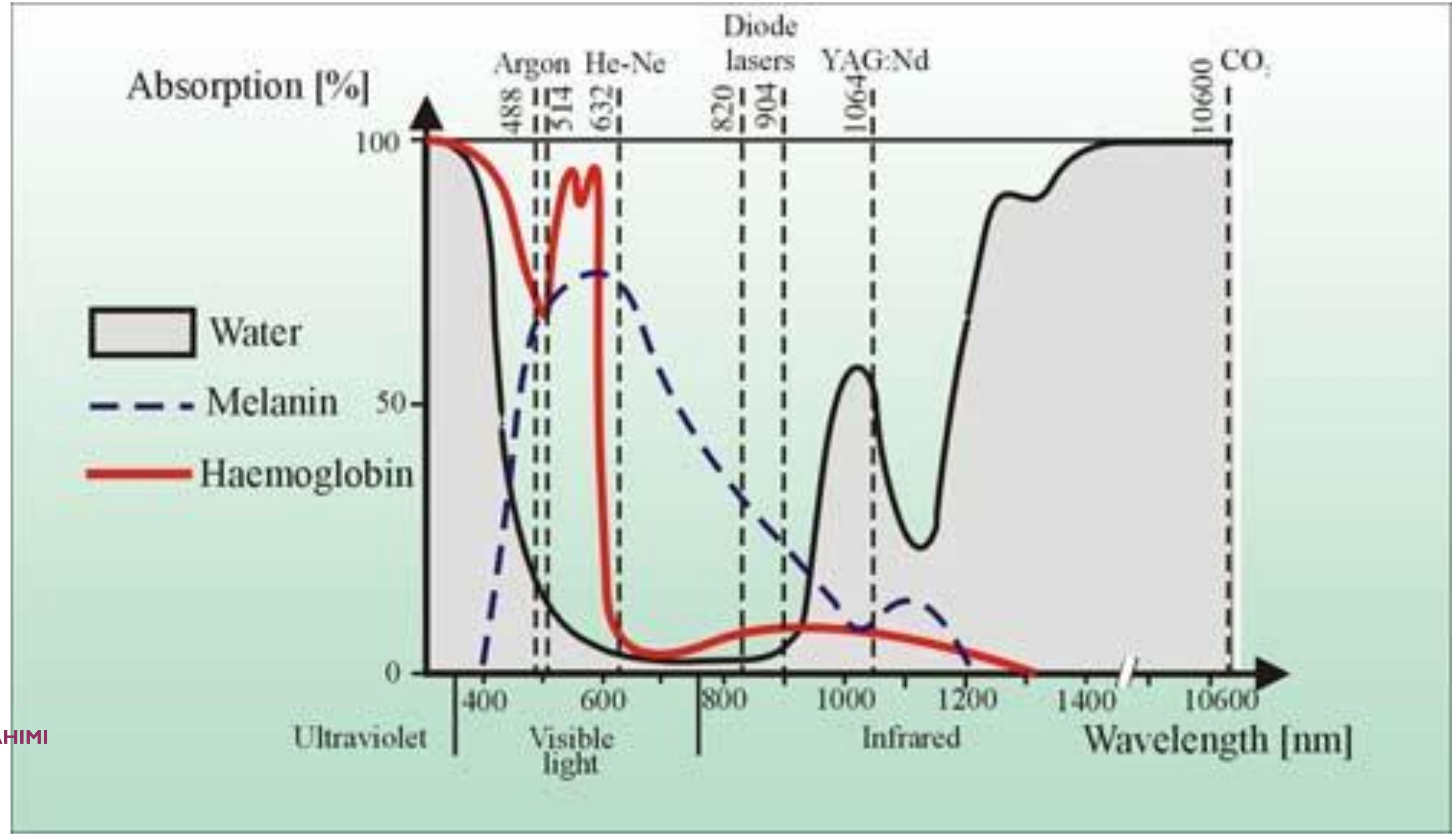

Laser -Tissue Interaction
Laser Beam
Coagulation
>60 º Centigrade
Hyperthermia
37-50 º Centigrade
Vaporization
100-150 º Centigrade
Carbonization
>200 º Centigrade
Tissue


LASER
Beam of Laser light (photons) striking skin
Absorption of photons by chromophores
Photobiomodulation
Photobiostimulation
Photobioinhibition
Wound Healing
Pain Modulation

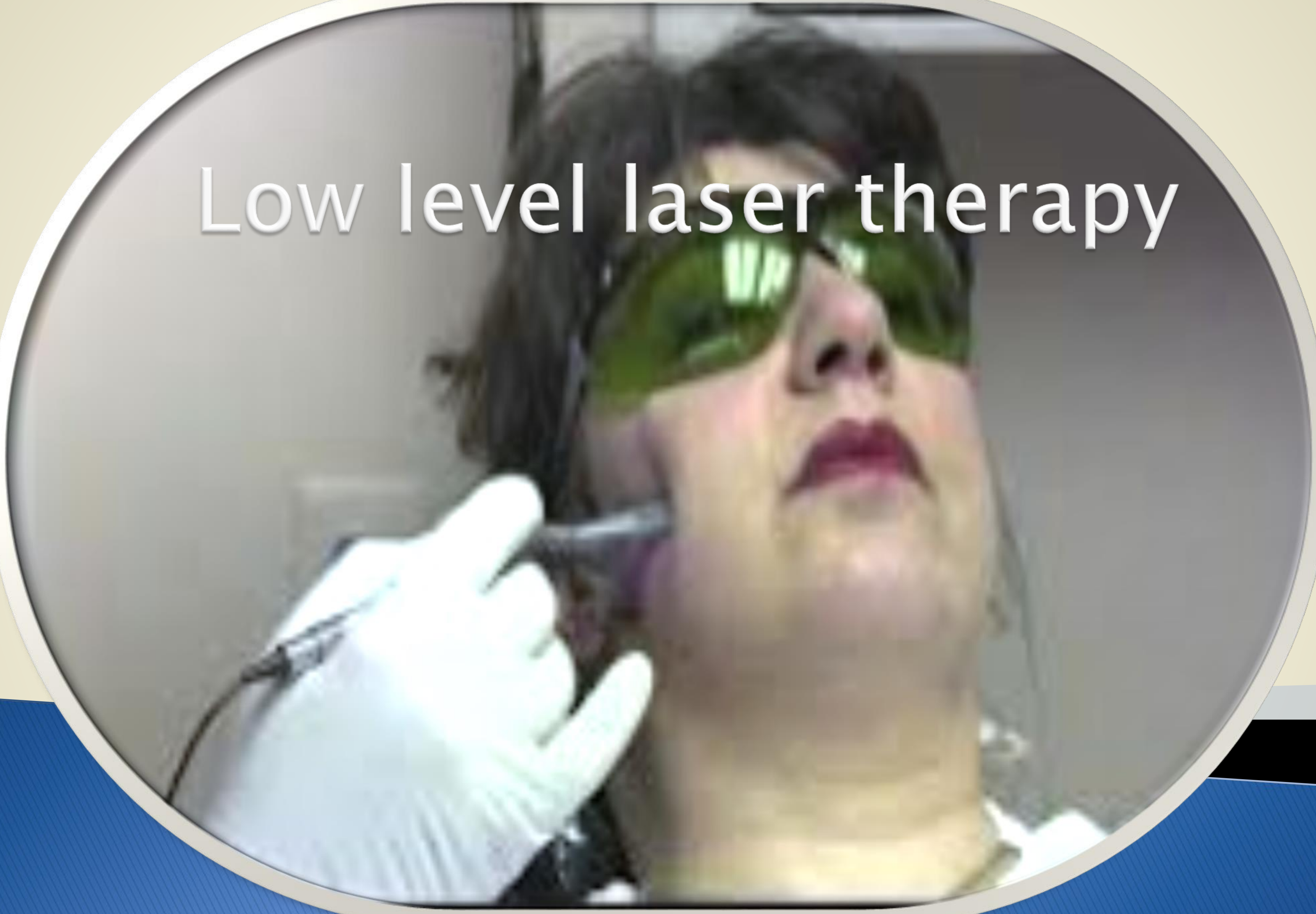
Why The Companies Attempt To Made Different Wave Length?

- **Chromophores**

THE KEY OF LASER



Low level laser therapy



Introduction

- The most usual LLLT procedures are carried out by irradiation of low-level or low-powered lasers to sites of injury in order to speed up cellular processes leading to better healing and decrease of inflammation and pain.
- Almost all LLLT treatments are conducted with red or near-infrared (NIR) light (600–1100 nm), with an output power of 1–1000 mW in a non-heating energy density (0.1– 100 J/cm2).

- In contrast with the past established name (low-level laser therapy), LLLT can be performed with varied sources of light like light-emitting diodes (LEDs), organic LEDs (OLEDs), and even, lamp or sun light filtered by monochromators.
- Some biological processes can be modulated by photochemical reactions triggered by photons of wavelength out of the optical window of 600–1100 nm, like blue, green and farinfrared.
- There are optimal parameters for LLLT, they usually stay somewhere between 1–1000 mW for power and (0.1–100 J/cm2) for energy density and **few minutes for time** exposure, however, not rarely one can find good results with parameters out of these standards.

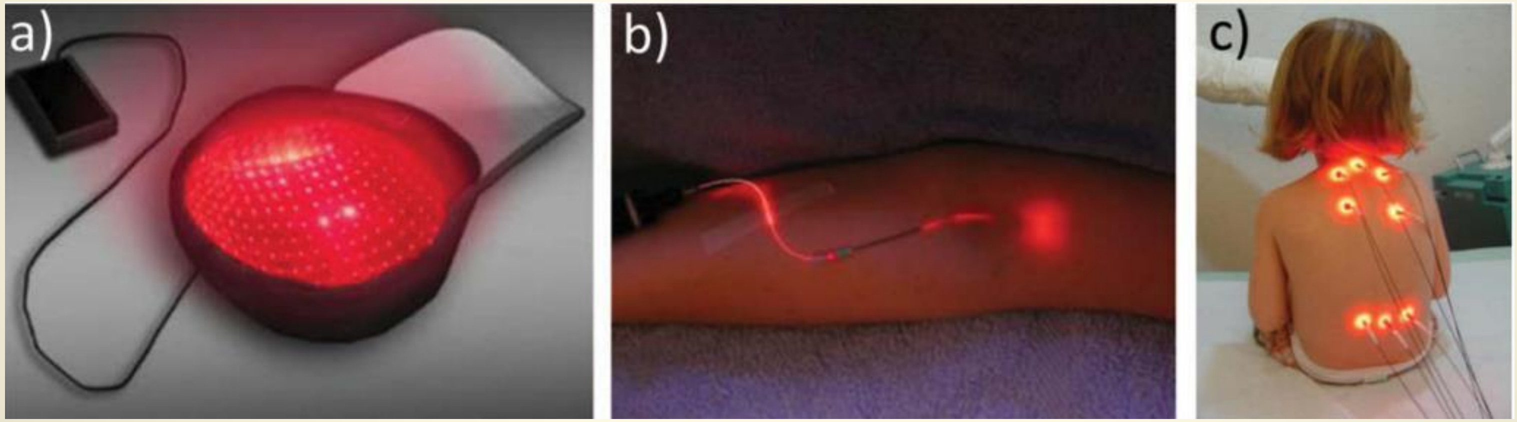
WHAT ARE THE CLINICAL EFFECTS OF LOW-LEVEL LASER (LIGHT) THERAPY?

- WOUND HEALING (SOFT TISSUE , HARD TISSUE)
- NERVE REGENERATION
- DECREASE OF INFLAMMATION
- DECREASE OF PAIN

Almost all LLLT treatments are conducted with red or near-infrared (NIR) light

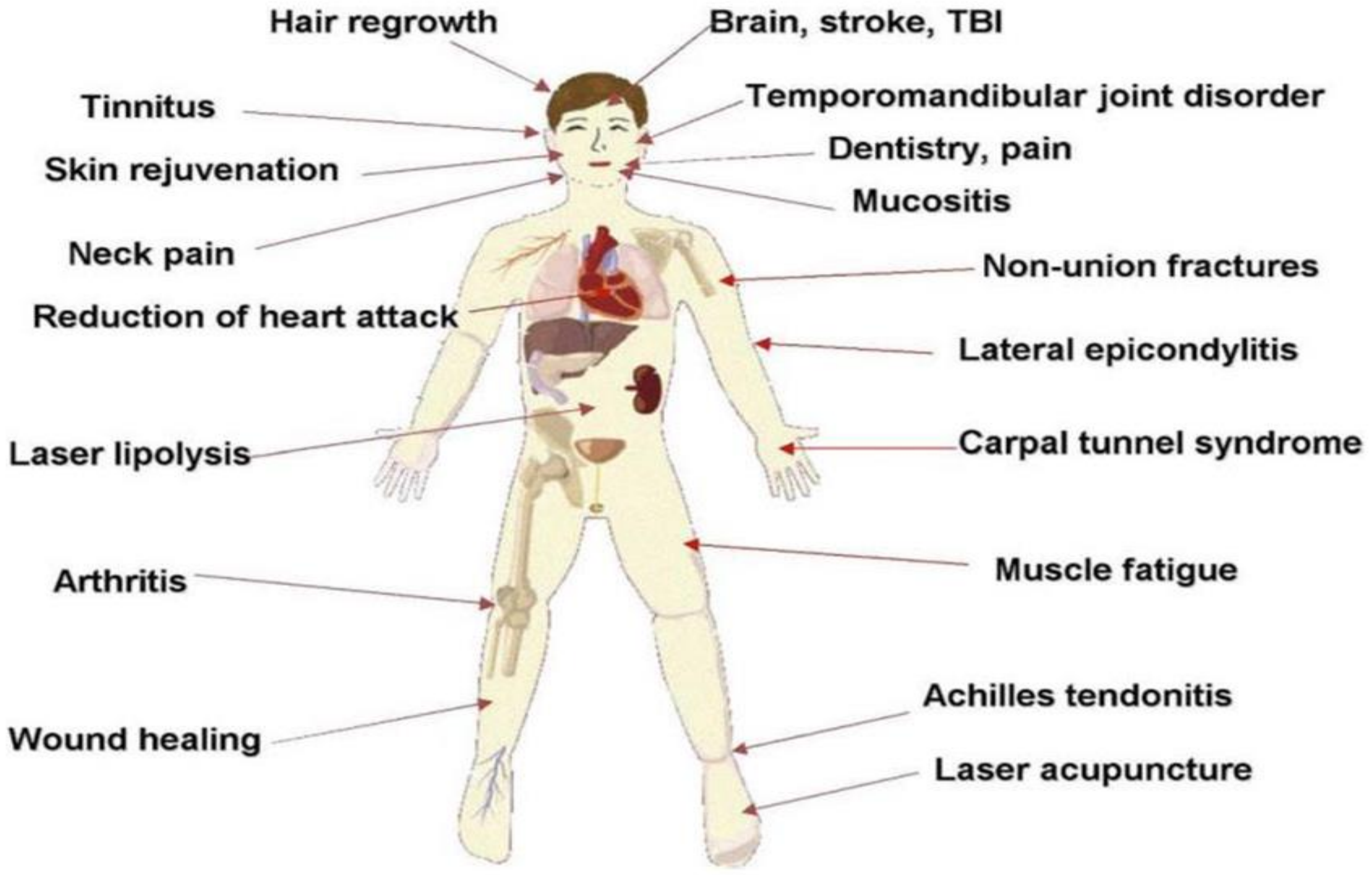
Deliver light

- Interestingly, there are many ways todeliver light in a specific tissue, it can be as usual as pointing laser to the skin, in contact or not; It can be by introduction of the light source in a body cavity (mouth, ear, nose, vagina, etc.); or even, intravenous or interstitial irradiation using an optical fiber inside a needle (or catheter) to go through tissues



WHAT IS THE LOW LEVEL LASER

LOW LEVEL LASER (LLL) IS A SPECIAL TYPE OF LASER THAT EFFECTS ON BIOLOGIC SYSTEMS THROUGH NON-THERMAL EFFECTS



شکل 1– کاربردهای مختلف درمان با لیزرهای کم توان[5]

FIGHT AGAINST DISEASES

- The LLLT empower the contemporary clinicians with a modern and transdisciplinary way to fight against diseases and other undesired conditions in humans and other animals.

WHAT IS LOW-LEVEL LASER (LIGHT) THERAPY?

- laser with
  - No thermal
  - No cutting
  - No vibration
  - No vaporizations
  - No ablation
  - No carbonization
  - No coagulation

LLLT

- Patients Are Unable To Believe That A Real Effect Has By That "Little Light"
- LLLT Remains Controversial Even Among Researchers And Clinicians
- **The Reasons Of Controversy:**
  - The Poor Understanding About The Biochemical Mechanisms.
  - The Large Number Of Parameters Related To LLLT.
  - The Fact That The LLLT Parameters Must Be Personally Adapted.

LLLT

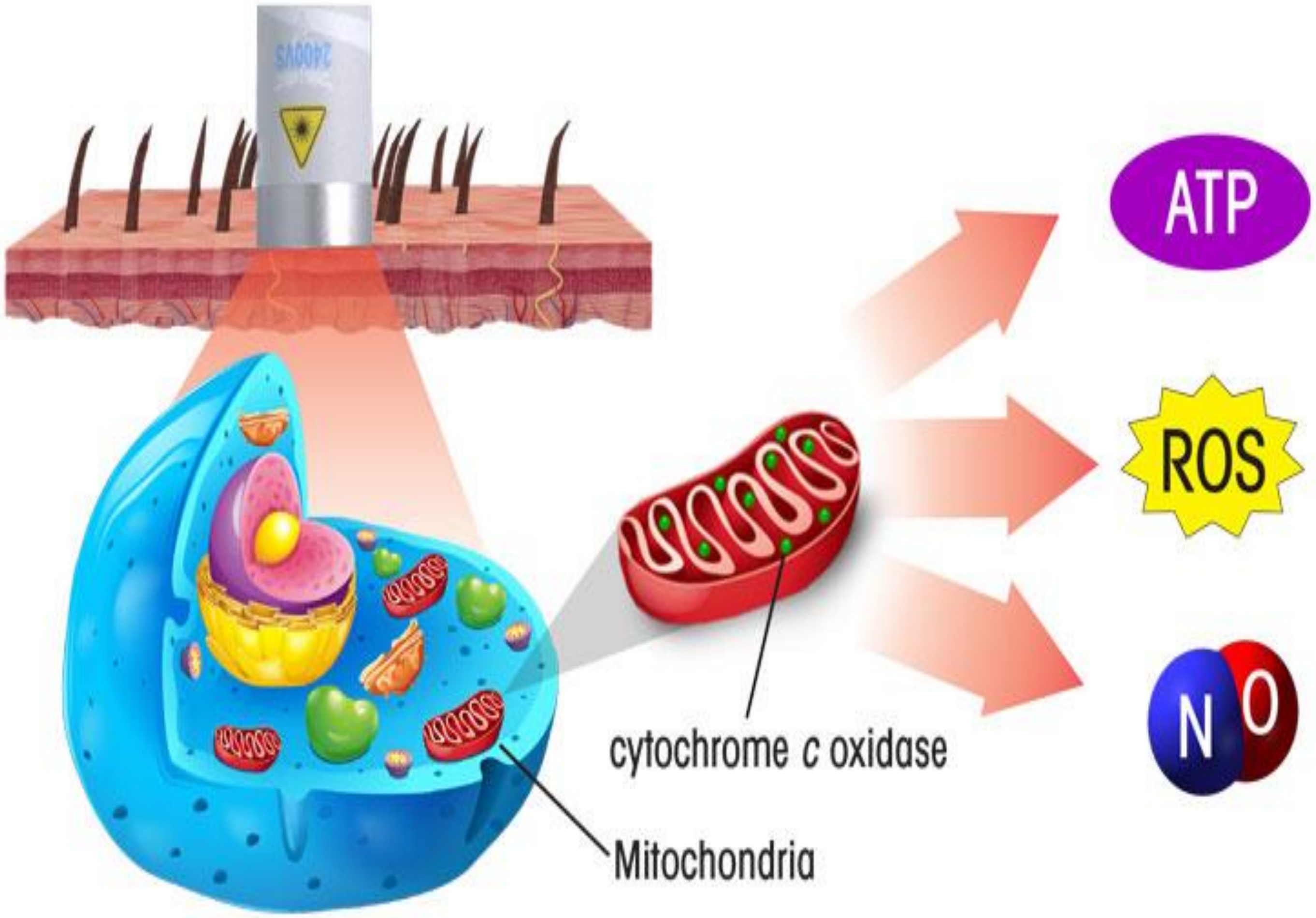
- The LLLT is more than an alternative kind of treatment
  - ***NEW METHOD TO CONTROL CELLS AND ORGANISMS***

- LLLT do not cause any visible or tangible change to the tissue right at the moment of the treatment

PARAMETERS

- To define a specific LLLT procedure it is necessary to specify many parameters such as the **wavelength, fluence, power density, pulse structure, and timing.**
- A mistake in the choice of the parameters to each patient can lead to a less effective or even negative outcome of the therapy

A MECHANISM OF LASER THERAPY IN TISSUE



An increase in ATP, the main energy source for the majority of cellular functions, **increases the cell's ability to fight infection and accelerates the healing process**

The modulation of ROS activates transcription factors **positively impacting cellular repair and healing**

The release of NO, a potent vasodilator, **increases circulation, decreases inflammation** and enhances the **transport of oxygen and immune cells** throughout the tissue

1 Laser light at a wavelength of 670nm, 808nm or 904nm is delivered to the tissue via a probe in **contact mode** with the surface of the skin.

2 The light enters the cell's mitochondria and is absorbed by the chromophores, including the protien cytochrome *c* oxidase (CCO) which then **increases its activity**.

3 As a result of this heightened activity, three molecules are affected: Adenosine Triphosphate (ATP), Reactive Oxygen Species (ROS) and Nitric Oxide (NO) lightforce™

therapy lasers

Wound healing and NO

- wound healing is essential for recovery of the integrity of the body.
- The inducible isoform (iNOS) is synthesized in the early phase of wound healing by inflammatory cells, **mainly macrophages.**
- However many cells participate in NO synthesis during the proliferative phase after wounding.
- NO released through iNOS regulates
  - collagen formation
  - cell proliferation
  - wound contraction in distinct

- Nitric oxide (NO) is a signaling molecule that plays a key role in the **pathogenesis of inflammation.**
- **Anti-inflammatory effect under normal physiological conditions.**
- **NO is a pro-inflammatory mediator that induces inflammation due to over production in abnormal situations.**
- NO is synthesized and released into the endothelial cells by the help of NOSs that convert **arginine into citrulline** producing NO in the process.
- **Oxygen** and **NADPH** are necessary co-factors in such conversion.

LLLT-Induced Production of ROS

- Reactive oxygen species are reactive molecules containing oxygen, product of the normal metabolism of oxygen.
- ROS have important role in homeostasis and cell signaling.
- Environmental stress can cause a dramatic increase in ROS production (Devasagayam et al., 2004).
- Examples of ROS include: superoxide, hydrogen peroxide, singlet oxygen, and hydroxyl radical.
- Photosensitizers such as Cox, flavins, and porphyrins, NADPH oxidase respond to LLLT
- Cox is the main chromophore responding to LLLT and produces ROS (Lubart et al., 2005).

Role of Reactive Oxygen Species

- Oxidative stress : imbalance between the production of ROS and the biological system's ability to readily detoxify the ROS
- ROS has an important role in cell :
  - signaling pathways from mitochondria to nucleus
  - regulating cell cycle progression
  - protein synthesis, nucleic acid synthesis
  - enzyme activation.
- Increased ROS → redox activity of cell → transcriptional changes

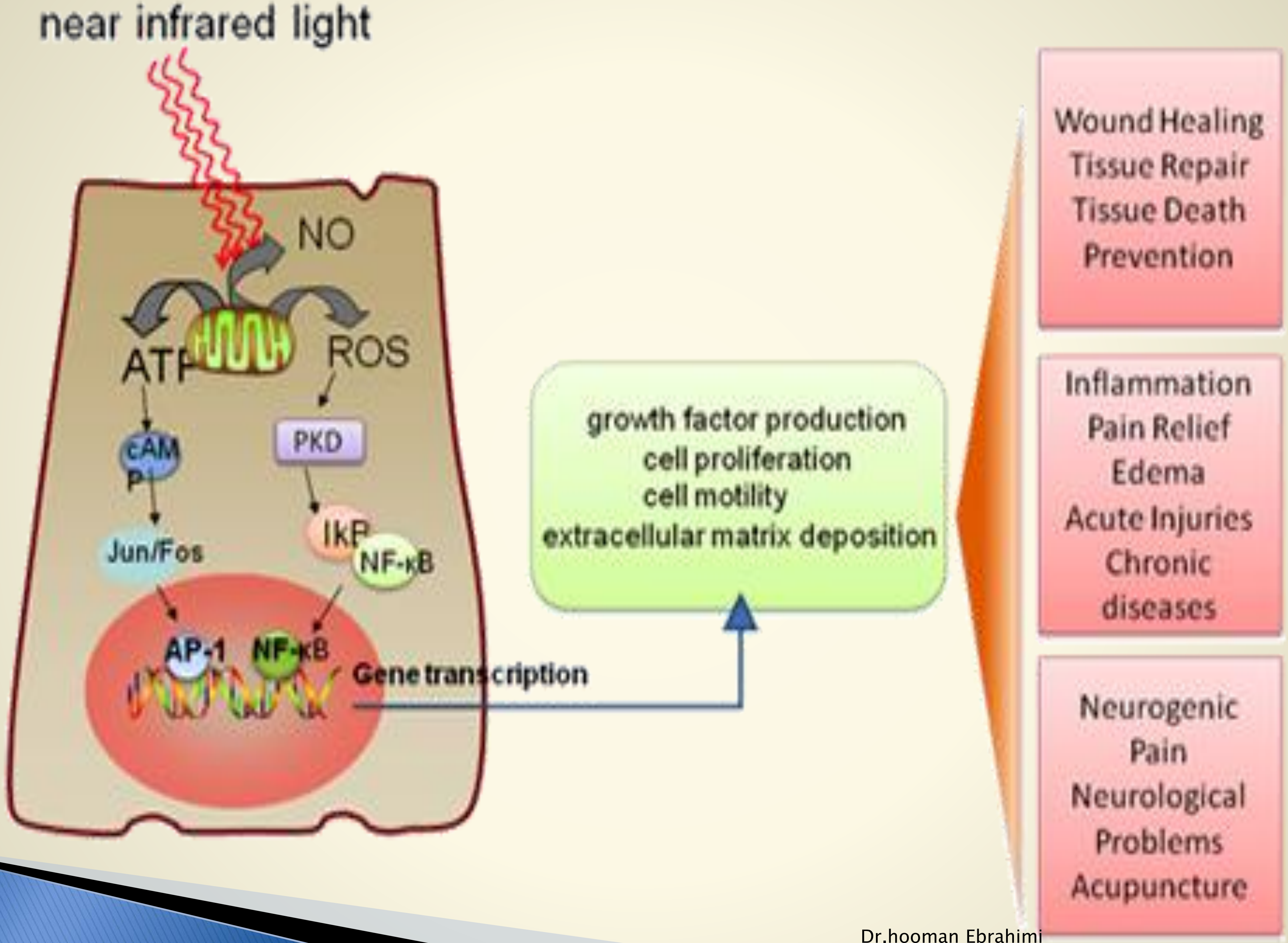
Cellular Response to Increased ROS (Oxidative Stress)

- response to oxidative stress :
  - increased gene expression
  - activation of various intracellular signaling pathways for genes
    - for the repair and maintenance of cellular homeostasis.

Reactive Oxygen Species (ROS) and Gene Transcription

Increased ROS generation and cell redox activity have been reported

- **The redox state of a cell regulates cellular signaling pathways that control gene expression.**
- Modulation of the cellular redox state can activate or inhibit signaling pathways.
- Changes in redox state induce the activation of numerous intracellular signaling pathways
  - nucleic acid synthesis
  - protein synthesis
  - enzyme activation
  - cell cycle progression


near infrared light
NO
ATP
ROS
cAMP
PKD
Jun/Fos
IkB
NF-κB
AP-1
NF-κB
Gene transcription
growth factor production
cell proliferation
cell motility
extracellular matrix deposition
Wound Healing
Tissue Repair
Tissue Death
Prevention
Inflammation
Pain Relief
Edema
Acute Injuries
Chronic
diseases
Neurogenic
Pain
Neurological
Problems
Acupuncture

Effect of low level laser on

wound healing

Wound healing process

- inflammatory phase
- proliferative phase
- remodeling phase

inflammatory phase

- Migration of …..To the wound
- - macrophages
- - lymphocytes
- - platelets
- - neutrophils

proliferative phase

- Increase in fibroblasts

remodeling phase

- Recreation of extracellular matrix
- Deposit collagen

ACTION ON WOUND HEALING

- The cellular responses observed in vitro after LLLT are broadly classified as increases in metabolism, migration, and proliferation and increases in synthesis and secretion of various proteins.
- Low-level laser therapy has also shown to cause vasodilation with increased local blood flow.
- This vasodilation not only brings in oxygen but also allows for greater traffic of immune cells into the tissue

EFFECT ON ANGIOGENESIS

- The Red and infrared light promotes vascular endothelial development and angiogenesis.
- This property is significant for both the consideration of tissue healing and when applying laser to highly vascularized tissues.
- Laser is contraindicated in highly vascular tissues, e.g., neoplasms.
- Dourado et al reported an increased angiogenesis at different wavelengths (635 and 904 nm) with greater response to 635 nm as compared to 904 nm at lower doses while higher doses of 635 wavelengths appeared to be less effective than 904 nm wavelength.
- Cury et al demonstrated benefit from both 660 and 780 nm but the shorter wavelength was effective only at higher doses and longer wavelength was effective at both high and low doses.

MODULATION OF INFLAMMATION

- laser inhibits inflammatory catabolic mediators that **suppress** collagen synthesis and cell proliferation.
- Low-level laser therapy reduces neutrophil influx into chronically inflamed tissues or fluid-filled spaces and may stimulate production of antiinflammatory metabolites, such as cyclooxygenase 1 (COX-1) and cyclooxygenase 2 (COX-2).
- Laser also helps in reducing edema which is an important factor in patient discomfort, and retards nutrient exchange in inflamed tissues

INCREASE IN OXYGEN AVAILABILITY

- It is suggested that laser promotes dissociation of oxygen from oxyhemoglobin in the tissue capillary beds
- thus making more oxygen available for oxidative metabolism and ATP production.
- Very few studies that exist have produced equivocal or contradictory results on this.
- Asimova and Thanh found increased oxygen levels in the skin of patients after irradiation with a **635-nm wavelength at a dose of 0.23 J/cm2.**
- Whereas, Heu et al found no change in the free oxygen levels in human skin when using a **660-nm wavelength at a dose of 5.73 J/cm2 for 15 minutes**

EFFECT ON VASODILATION

- Low-level laser therapy may increase local circulation via smooth muscle relaxation that results in vasodilation.
- This can be due to an induction of NO_2 in the perivascular tissue.
- Carrera et alshowed that laser therapy increases vasodilation in acute surgical wounds.
- Study by Heu et al failed to find any change in local circulation in healthy tissues.
- An older study by Mi et al suggested that laser may increase the deformability of the erythrocyte molecule with implications for both increasing the rate of erythrocyte flow through peripheral capillary beds and availability of the hemoglobin molecule within the red blood cells.

International Journal of Laser Dentistry, January–April 2015;5(1):1–5

- Although, it appears that most cells respond to

Low-level Laser Therapy but wavelengths between 630 and 980 nm, different cell types may respond to different portions of the spectrum.

- Laser light of 635 nm at a dose of 0.43 J/cm2 stimulates an increase in osteoblast numbers and activity in cell cultures
- osteoblast cultures respond better to laser light in the 790 to 830 nm range rather than the 660 to 690 nm range at equivalent doses.
- no effect was found with 904-nm light.
- phototherapy in the 630 to 690 nm range promotes increased adhesion and proliferation of endothelial cells.

- Few in vitro studies have found that cell cultures respond best to moderate doses of infrared energy and the optimum dose may differ among cell types.
- Around 15 J/cm2 in fibroblasts and 3 J/cm2 in keratinocytes (both at 780 nm).
- In all the cases, higher doses essentially had a negative effect.
- A few investigators [Deise et al14, Kreisler et al15] suggested that there can be a cumulative effect to successive laser treatments administered 24 hours apart. The timing of therapy may also play a role.
- Yu et al studied cultured keratinocytes and fibroblasts that were irradiated at a dose of 0.5 to 1.5 J/cm2 with a helium–neon (HeNe) laser and found a significant increase in basic fibroblast growth factor (bFGF) release from both keratinocytes and fibroblasts and a significant increase in nerve growth factor release from keratinocytes.
- Recently, Akgul et al reported that postponing the onset of LLLT after acute inflammatory phase showed better results.

- In an animal study by Farouk et al influence of various laser wavelengths (442, 514, 632, 670, 780, 830, and 10600 nm) on the healing of oval full-thickness wounds in Sprague-Dawley rats was evaluated and the accelerated wound closure was from 7.7 to 29% in healing days.
- A HeNe laser at a wavelength of 632.8 nm gave the best acceleration in the healing days (29%).
- This study showed wavelength dependency, treatment schedule dependency, and dose dependency of photons in wound healing.
- Fibroblast absorption and wound healing acceleration is maximal at 632.8 nm, indicating that the acceleration of wound healing is not credited to laser skin transmission.
- A HeNe laser at 632.8 nm with an incident power density of 10.53 mW/cm2 gave the optimum wound healing acceleration, indicating the non-dose rate dependency of laser photons in enhancing wound healing.