LOW POWER LASER

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OBJECTIVES

- Define LASER.
- Describe the mechanisms of Laser production.
- Mention the characteristics of Laser Beam.
- Identify the different types of LASER.
- Explain physiological effects of LASER.
- Describe indication, contraindication& precaution of LASER therapy.
- Explain different methods of LASER application.

LASER

L ight

A mplification by

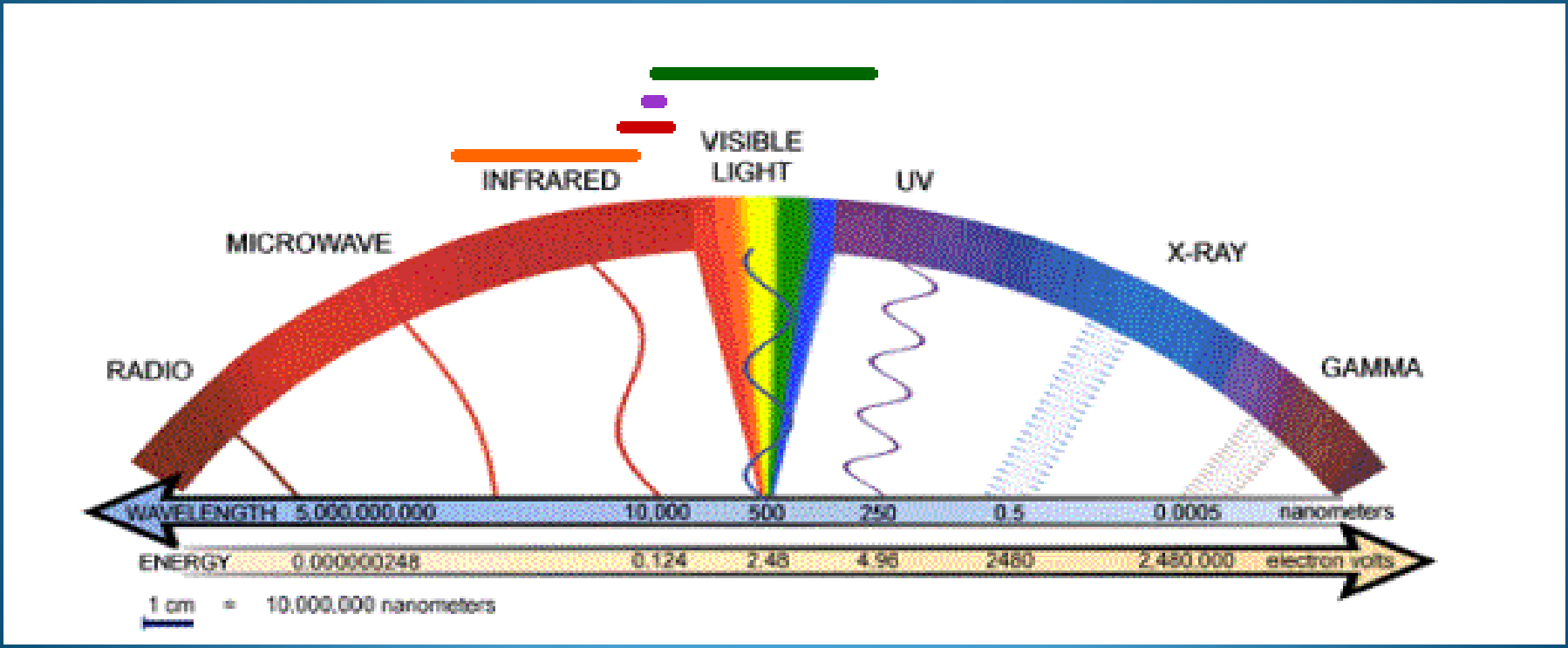
S timulated

E mission of

R adiation

LASER

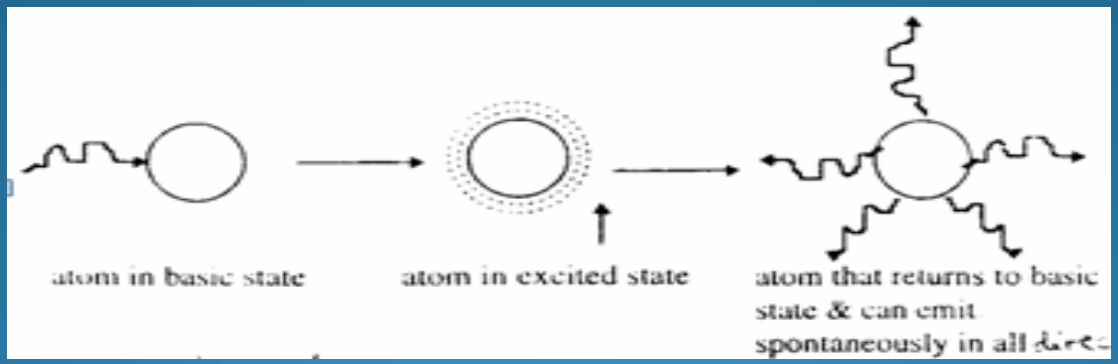
- ✓Electromagnetic radiation lies within that part of the electromagnetic spectrum between infrared and visible light.



PHYSICS OF THE LASER

- ✓Light energy transmitted through space as waves that contain tiny "energy packets" called photons.
- ✓Each photon contains a definite amount of energy depending on its wavelength (color).
- ✓If a photon of adequate energy level collides with an electron of an atom it causes atom to be in an excited state.

PHYSICS OF THE LASER

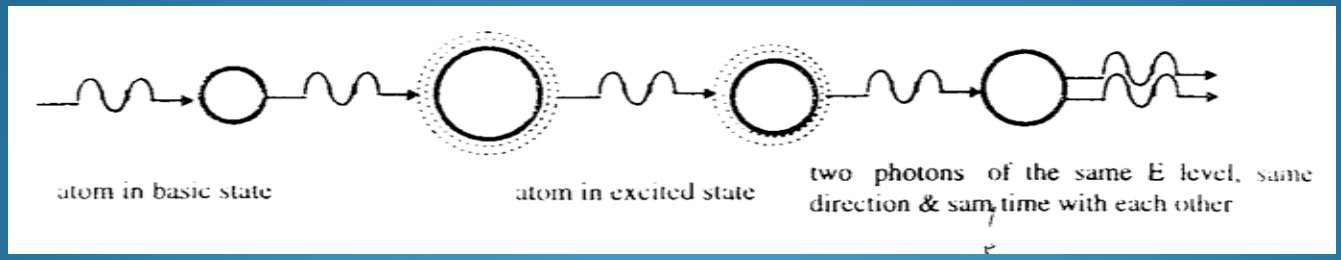


✓Atom stays in excited state momentarily then releases an identical photon.

✓Process is called spontaneous emission

STIMULATED EMISSIONS

✓A photon released from an excited atom would stimulate another similarly excited atom to de-excite itself by releasing an identical photon.

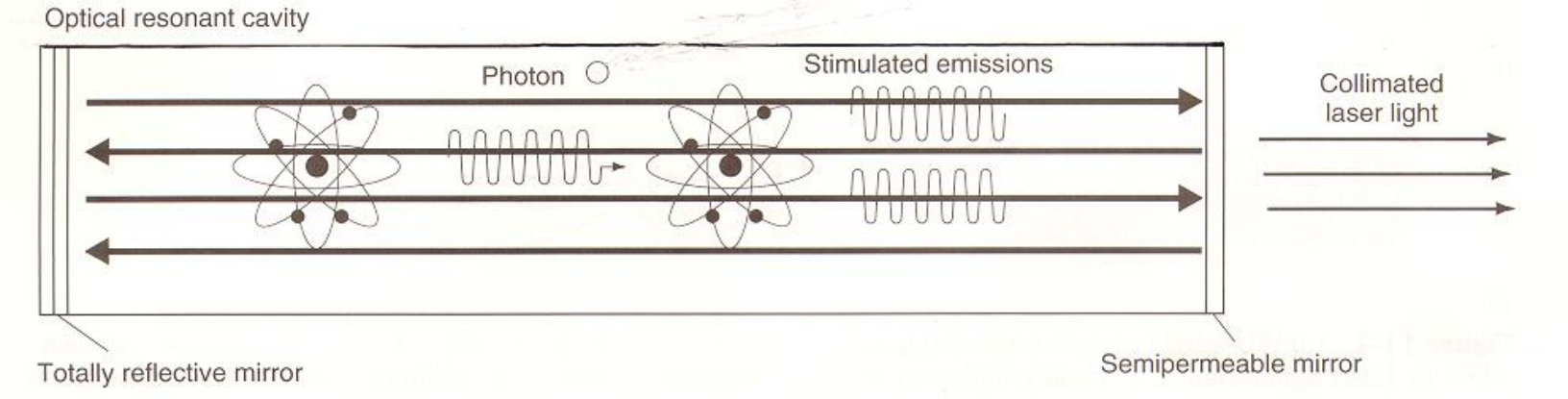


✓For stimulated emission to occur an environment must exist with unlimited excited atoms this is termed population inversion.

STIMULATED EMISSIONS

✓Population inversion caused by applying an external power source to lasing medium which releases more identical photons.

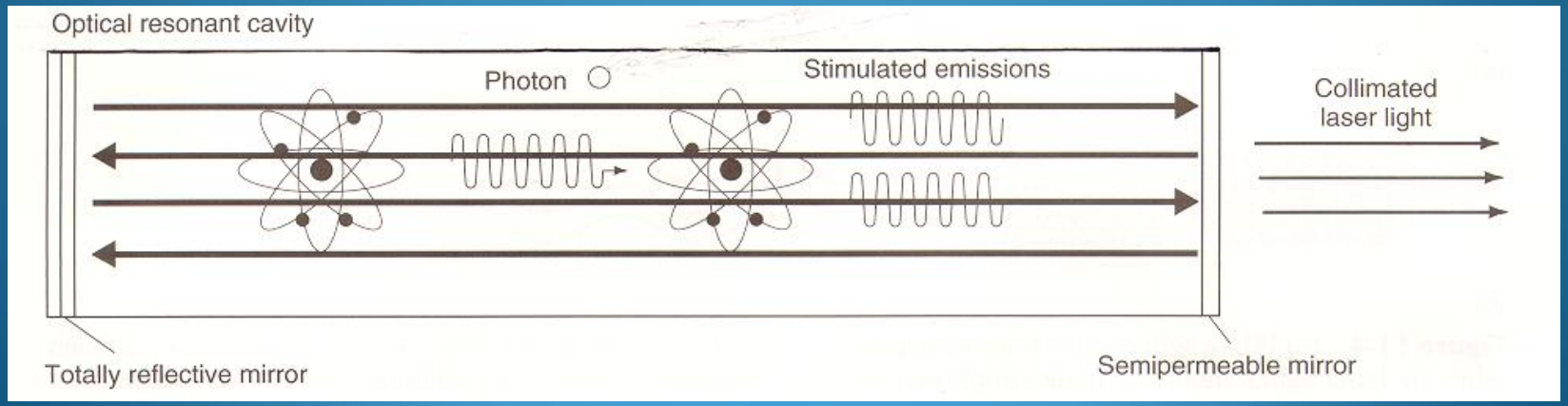
✓To contain and generate more photons mirrors are placed at both ends of a chamber.



STIMULATED EMISSIONS

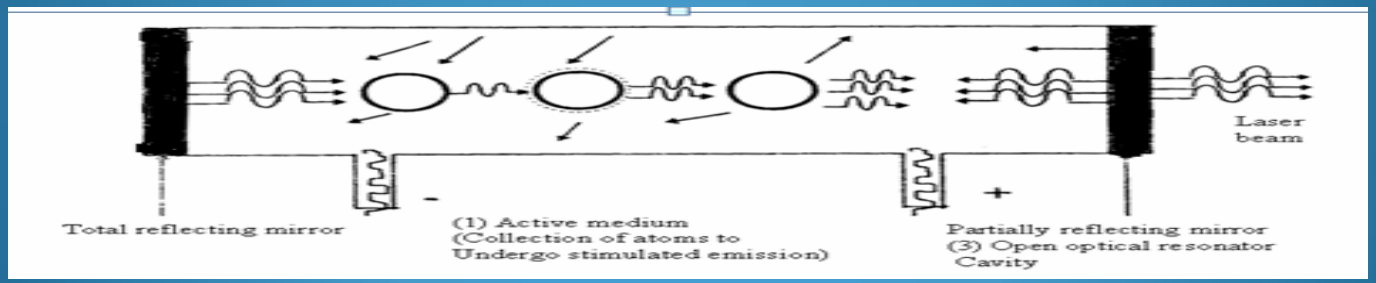
✓One mirror is totally reflective while the other is semipermeable.

✓Photons are reflected within chamber which amplifies the light and stimulates the emission of other photons from excited atoms



STIMULATED EMISSIONS

✓Eventually so many photons are stimulated that the chamber cannot contain energy and photons of a particular wavelength are ejected through the semipermeable mirror producing amplified light through stimulated emissions.



LASER GENERATORS

- ✓Power Supply.
- ✓Lasing Medium - gas, solid or liquid material that generates laser light.
- ✓Pumping Device - creates population inversion essential for laser operation.
- ✓Optical Resonant Cavity - chamber where population inversion occurs that contains reflecting surfaces.

STEPS FOR LASER PRODUCTION

a- Excitation

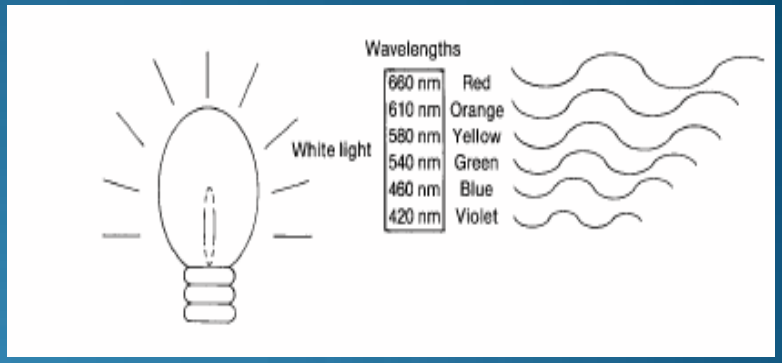
b-Spontaneous Emission

c-Stimulated Emission

- ✓ Production of photons further concentrated in the chamber by use of mirrors located on the ends of the chamber.

PROPERTIES OF LASER LIGHT

- ✓ a- Monochromatic: specificity of light in a single defined wavelength.



- ✓ b- Coherence: all photons are the same wavelength and are in phase with one another

- ✓ c- Collimation: photons move in parallel fashion with minimal divergence.

- ✓ white light is composed of many wavelengths superimpose their phases on one another and scatter in all direction.

TYPES OF LASERS

- ✓ Classified according to the nature of material between two reflecting surfaces.
  - Crystal lasers (solid state lasers)
    - synthetic ruby (aluminum oxide and chromium)
  - Gas lasers
    - helium neon (HeNe)
    - argon.
    - carbon dioxide (CO_2)
  - Semiconductor or diode lasers
    - gallium-arsenide (GaAs)
    - Gallium-aluminum-arsenide

- Liquid lasers use organic dyes as the lasing medium
- Chemical lasers extremely high power lasers used for military purposes

Laser Classification

- Laser equipment is grouped into four classes with simplified and well-differentiated safety procedures for each.
- Low power lasers used in treating sports injuries are categorized as Class I and II laser devices.
- Class I lasers, are considered non-hazardous to the body.

- All invisible lasers with average power outputs of 1 mW or less are class I devices.
  - GaAs lasers with wavelengths from 820 to 910 nm.
- Class II, or "low-power" lasers are hazardous only if a viewer stares continuously into the source.
  - Visible lasers that emit up to 1 mW average power, such as the HeNe laser.
- Class III, or moderate-risk, lasers can cause retinal injury within the natural reaction time
  - The operator and patient are required to wear protective eyewear.
  - Can not cause serious skin injury.

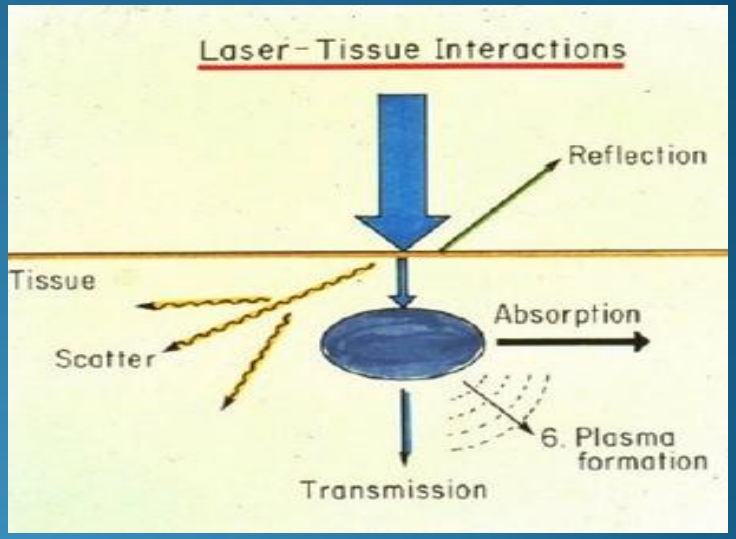
- Class IV, or high-power, lasers:
  - High risk of injury.
  - Diffuse reflections may harm the eyes and cause serious skin injury from direct exposure.

Low- Vs. High-Power Lasers

- High power lasers = "hot" lasers
  - Generate thermal responses.
  - used in medicine for surgical cutting and coagulation, ophthalmological, dermatological, oncological and vascular specialties.
- Low power lasers = “cold” lasers
  - Produce a maximal output of less than 1 mW.
  - Cause photo-chemical rather than thermal effects.

LASER TISSUE INTERACTION

- As any other electromagnetic radiation i.e. absorbed, reflected, transmitted, and refracted.



DEPTH OF PENETRATION DEPENDS ON

- Wavelength and frequency.
- Angle of incidence.
- The nature of the medium i.e. tissue type.

DEPTH OF PENETRATION

- Response that occurs from absorption termed Direct effect.
- Indirect effect is a lessened response that occurs deeper in the tissues.
- Absorption of HeNe occurs within first 2-5 mm of soft tissue with an indirect effect of up to 8-10 mm
- GaAs which has a longer wavelength directly absorbed at depths of 1-2 cm and has indirect effect up to 5 cm.
- Better for treating deeper tissues.

HELIUM-NEON LASERS

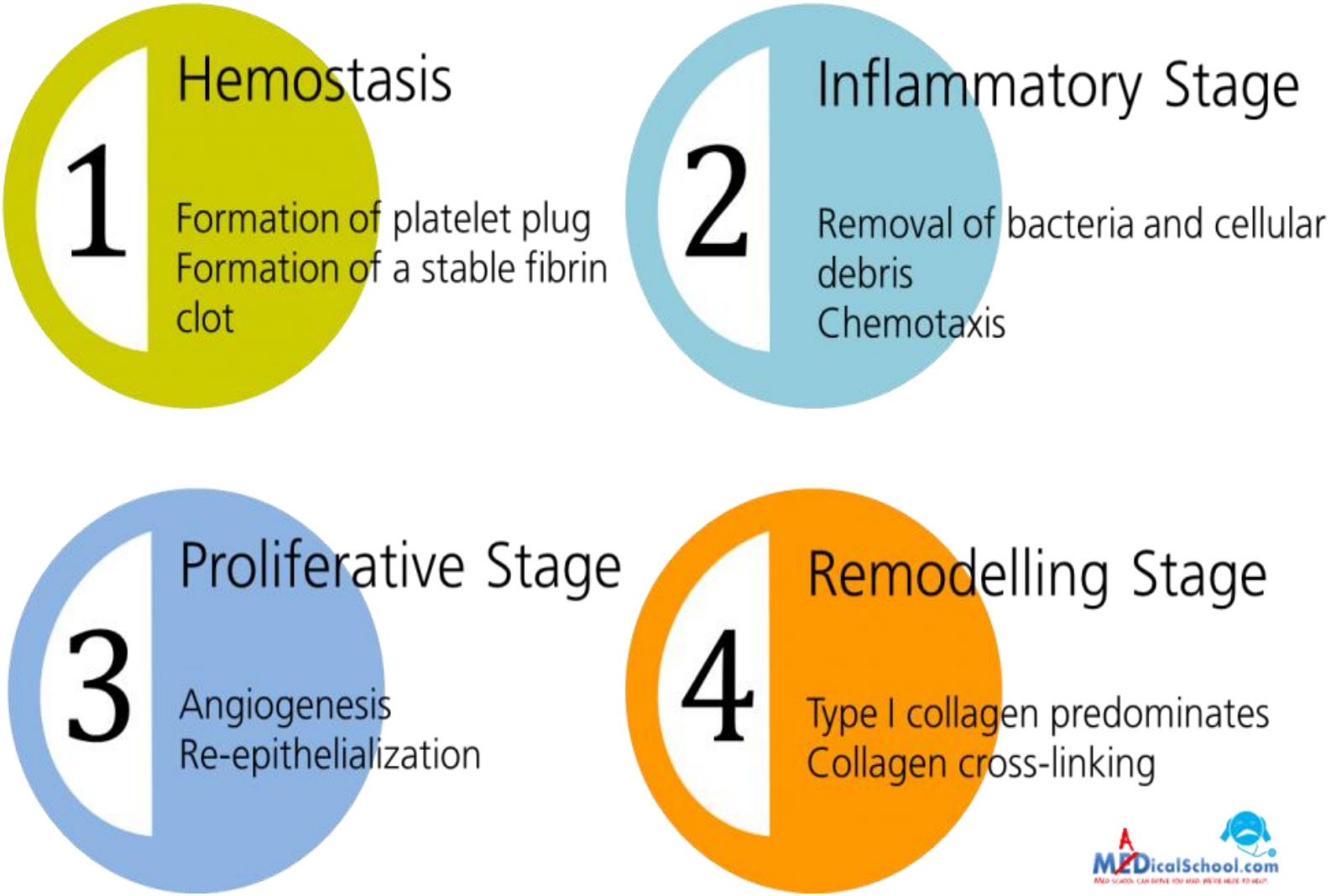
- HeNe (gas) lasers deliver a characteristic red beam with a wavelength of 632.8 nm.
- Laser delivered in a continuous wave and has a direct penetration of 2 to 5 mm and indirect penetration of 8 to 10 mm.

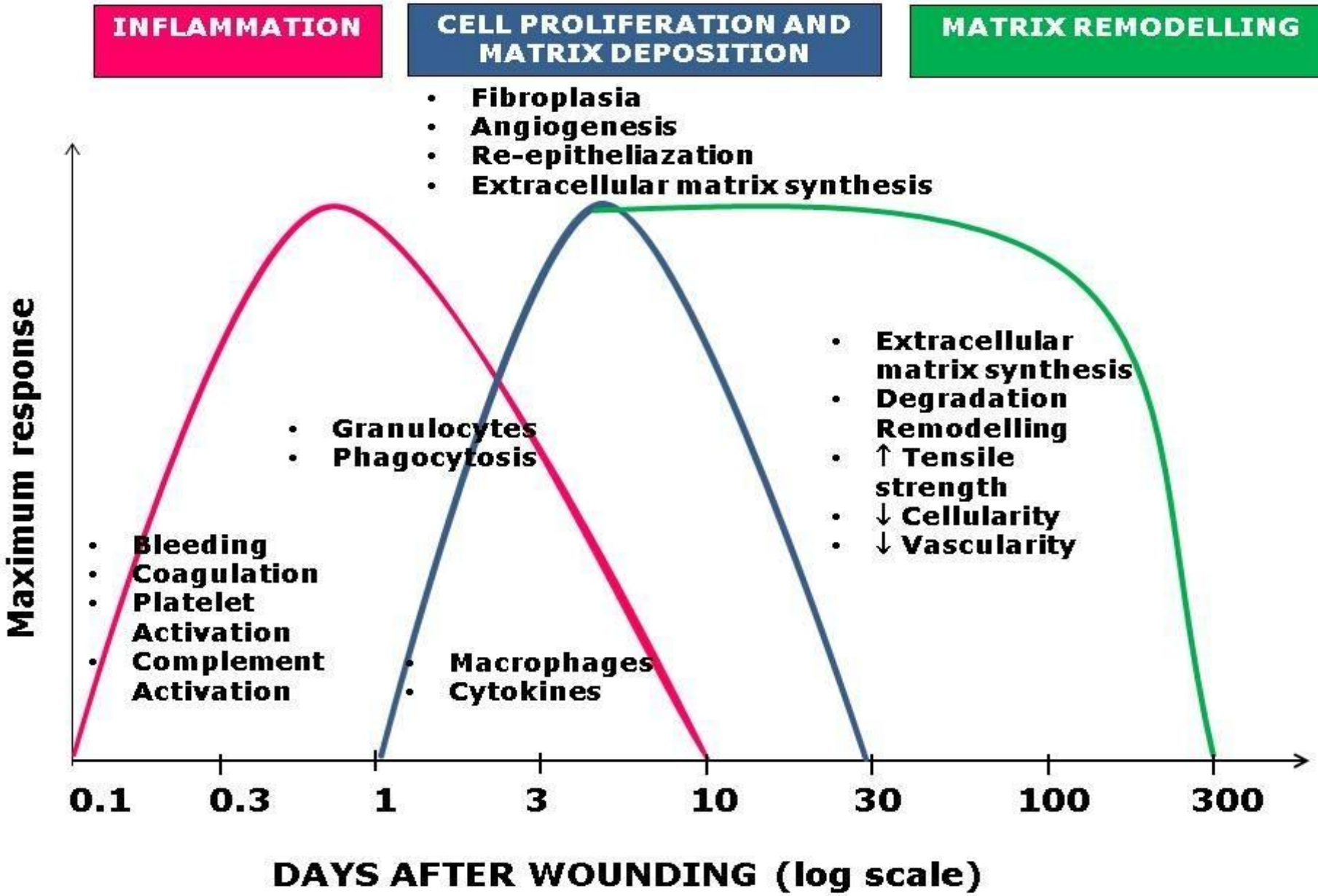
GALLIUM-ARSENIDE LASERS

- GaAs (semiconductor) lasers are invisible and have a WL of 904 nm Average power output of 0.4 m-watts.
- Direct penetration of 1 to 2 cm and an indirect penetration to 5 cm.

PHYSIOLOGICAL EFFECTS OF LASER

Stages of Wound Healing

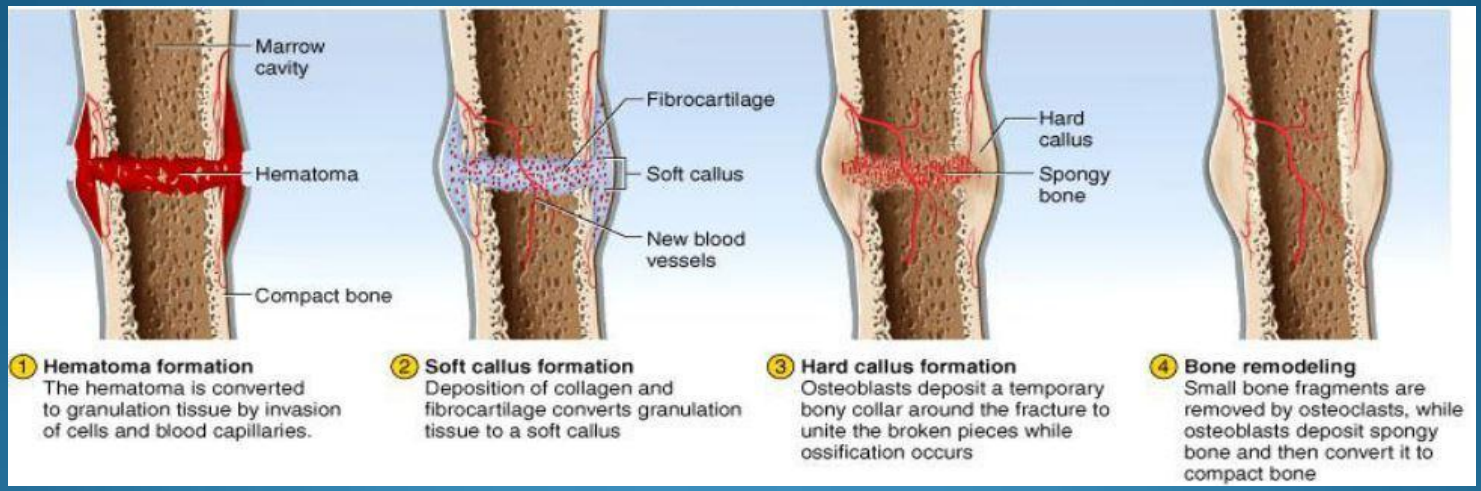



INFLAMMATION
CELL PROLIFERATION AND MATRIX DEPOSITION
MATRIX REMODELLING
• Fibroplasia
• Angiogenesis
• Re-epitheliazation
• Extracellular matrix synthesis
Maximum response
• Granulocytes
• Phagocytosis
• Extracellular matrix synthesis
• Degradation Remodelling
• ↑ Tensile strength
• ↓ Cellularity
• ↓ Vascularity
• Bleeding
• Coagulation
• Platelet Activation
• Complement Activation
• Macrophages
• Cytokines
0.1
0.3
1
3
10
30
100
300
DAYS AFTER WOUNDING (log scale)

FACILITATION OF WOUND HEALING

- ✓Improving circulation and inhibiting bacterial growth.
- ✓Stimulating Leukocytic, phagocytosis and fibroblast proliferation.
- ✓Stimulation of angiogenesis.
- ✓Enhancing cellular metabolism and ATP production.
- ✓Increase collagen synthesis and procollagen RNA levels.
- ✓Increase tensile strength of the wound.

ACCELERATION OF BONE HEALING



- ✓The rate of hematoma absorption.
- ✓Fibroblast and chondrocyte activity.
- ✓Blood vessel formation and calcium dep-osition.
- ✓Bone remodeling.

PAIN CONTROL

- The analgesic effects of laser may be due to:

✓Increased endogenous opoid production.

✓Increase the local release of neurotransmitters such as serotonin.

✓Decreased sensory nerve conduction velocity.

✓Indirect effect through Hastened healing and Anti-inflammatory effects.

✓Reducing interstitial swelling by stimulating the activity of lymphatic.

ANTI-INFLAMMATORY AND ANTI-EDEMATOUS EFFECTS

- ✓Enhance the natural defense mechanism through stimulating phagocytosis.
- ✓Decrease the level of prostaglandin (PGE2) that promote reduction of edema.
- ✓Dilatation and modulation of permeability of capillaries and lymphatic vessels.

IMMUNOLOGIC RESPONSE

- ✓Activation of phagocytes.
- ✓Stimulation of macrophages.
- ✓Stimulation of mast cell degranulation.

BIO-STIMULATION EFFECT

- ✓Improving nuclear activity.
- ✓Increasing cell metabolism.
- ✓Increasing cell proliferation.
- ✓Increasing cell motility.

INDICATIONS OF LASER THERAPY

- ✓Infected and Non- infected skin wound and ulcers.
- ✓Non-united fracture.
- ✓Acute and chronic inflammation of musculoskeletal system as osteoarthritis and rheumatoid arthritis.
- ✓Acute and chronic soft tissues injuries, such as tendon, ligaments, muscle and nerve injuries.
- ✓Neuropathic pain such as, trigeminal neuralgia, post-herpetic neuralgia and carpal tunnel syndrome.

CONTRAINDICATION

- ✓Cancerous tumors.
- ✓Direct exposure into the eyes.
- ✓Pregnancy.
- ✓Hemorrhaging regions.
- ✓Gonads.

PRECAUTIONS

- ✓Patients with epilepsy and fever, Anatomically, the gonads, epiphyseal plates of children, and sympathetic ganglia, should be avoided.
- ✓Patients with known Photosensitivity.
- ✓The operator should not attempt to stare directly into the beam.

DOSAGE

- ✓Dosage reported in Joules per square centimeter (J/cm2).
- ✓One Joule is equal to one watt per second
- ✓Dosage is dependent on:
  - Output of the laser in mWatts
  - Time of exposure in seconds
  - Beam surface area of laser in cm^2

- ✓Dosage should be accurately calculated to establish treatment guidelines for specific injuries.

DOSAGE

- ✓ After setting the pulse rate, which determines average power of laser, only treatment time per cm2 needs to be calculated

T_A = (E /Pav) x A

T_A = treatment time for a given area

E = millijoules of energy per cm^2

Pav = Average laser power in milliwatts

A = beam area in cm^2

DOSAGE

T_A = (E /Pav) x A

Example

To deliver 1 J/cm^2 with a 0.4 mW average power

GaAs laser with a 0.07 cm^2 beam area:

T_A = (1 J/cm^2/ .0004W) x 0.07cm^2

= 175 seconds or 2:55 minutes

CALCULATING TREATMENT TIMES

		Joules per Centimeter Squared (J/cm^2)						
Laser Type	**Average Power (mW)**	**0.05**	**0.1**	**0.5**	**1**	**2**	**3**	**4**
HeNe (632.8 nm) Continuous wave	1.0	0.5	1.0	5.0	10.0	20.0	30.0	40.0
GaAs (904 nm) Pulsed at 1000 Hz	0.4	8.8	17.7	88.4	176.7	353.4	530.1	706.9

- Charts are available to assist clinician in calculating treatment times for a variety of pulse rates

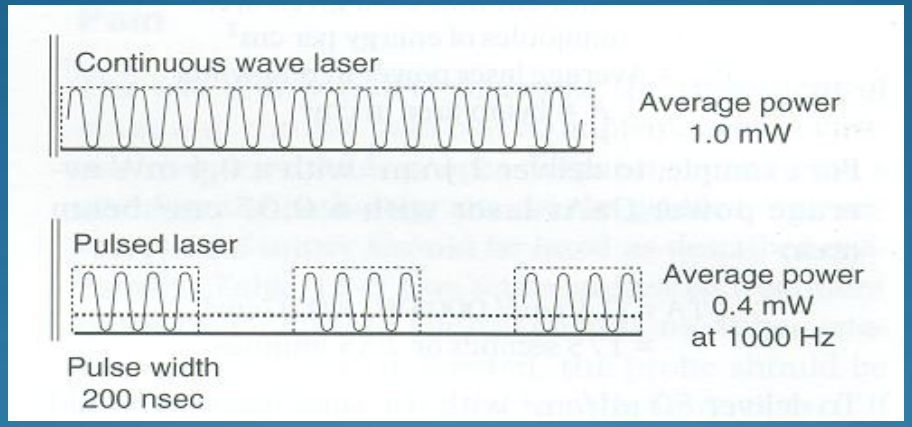
SUGGESTED TREATMENT APPLICATION

Application	Laser Type	Energy Density
TRIGGER POINT		
Superficial	HeNe	1–3 J/cm^2
Deep	GaAs	1– J/cm^2
EDEMA REDUCTION		
Acute	GaAs	0.1–0.2 J/cm^2
Subacute	GaAs	0.2–0.5 J/cm^2
WOUND HEALING (SUPERFICIAL TISSUES)		
Acute	HeNe	0.5–1 J/cm^2
Chronic	HeNe	4 J/cm^2
WOUND HEALING (DEEP TISSUES)		
Acute	GaAs	0.05–0.1 J/cm^2
Chronic	GaAs	0.5–1 J/cm^2
SCAR TISSUE	GaAs	0.5–1 J/cm^2

LASER SPECIFICATIONS

	Helium Neon (HeNe)	Gallium Arsenide (GaAs)
Laser type	Gas	Semiconductor
Wavelength	632.8 nm	904 nm
Pulse rate	Continuous wave	1–1000 Hz
Pulse width	Continuous wave	200 nsec
Peak power	3 mW	2 W
Average power	1.0 mW	.04–0.4 mW
Beam area	0.01 cm	0.07 cm
FDA class	Class II laser	Class I laser

PULSED VS. CONTINUOUS LASER



- Adjusting pulse rate alters average power which affects the treatment time if a specified amount of energy is required.
- With pulsed laser treatment times may be exceedingly long to deliver same energy density with a continuous wave laser

TECHNIQUES OF APPLICATION

CONTACT TECHNIQUE

✓probe should be applied with firm pressure and perpendicular to the treated area.

- Maximize irradiation or power density.
- Provide less reflection of incident.
- Allow the operator to press treatment probe into the tissue to treat deeper structures more effectively.

CONTACT TECHNIQUE

✓SPOT METHOD:

Isolated points are irradiated e.g., site of lesion, trigger points, tender points, nerve roots, acupuncture points, etc.

✓LINEAR METHOD:

Irradiation takes linear course along nerve course or painful points.

✓COMBINED METHOD:

combined spot and linear methods.

- The only exception for this technique is the open wounds where disposable film can be pulled over the end of the treatment head.

NON-CONTACT TECHNIQUE

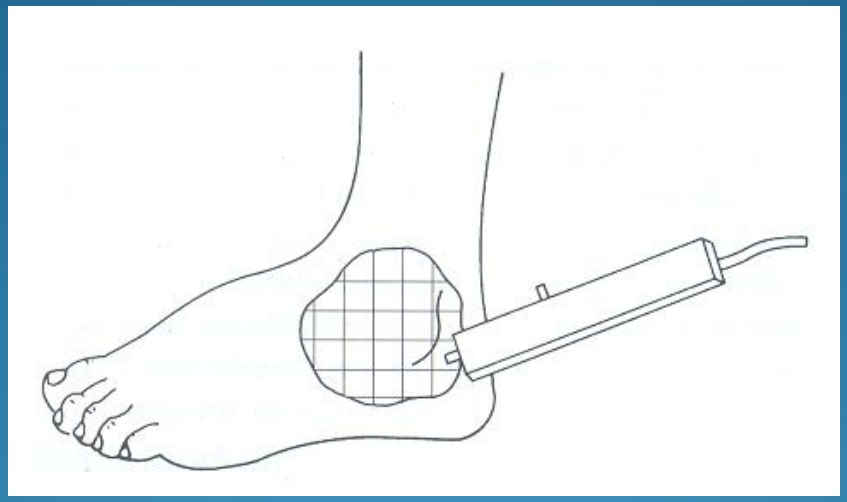
✓When contact technique is not applicable such as:

- Too painful points.
- opens wounds to prevent contamination.

✓The treatment head is held distant from the skin by about 0.5-1 cm in perpendicular manner.

- SCANNING
- GRIDDING

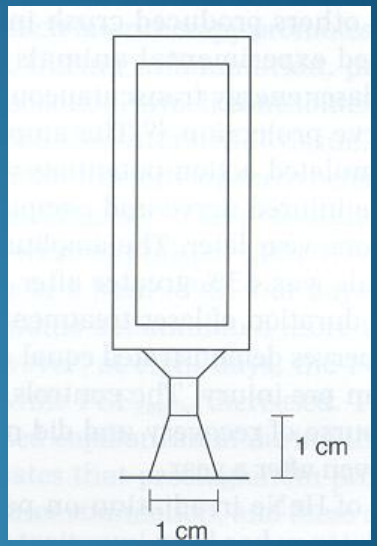
GRIDDING TECHNIQUE



- Treatment area divided into a grid of cm^2 with each cm^2 stimulated for specified time.
- Lines and points should not be drawn on skin because this may absorb some energy.

SCANNING TECHNIQUE

- No contact between laser tip skin.
- Applicator tip should be held 5-10 mm from wound.
- As distance from target increases amount of energy decreases.
- Not recommended to treat at distances greater than 1 cm.
- Beam should fill area 1 cm^2




THANK YOU