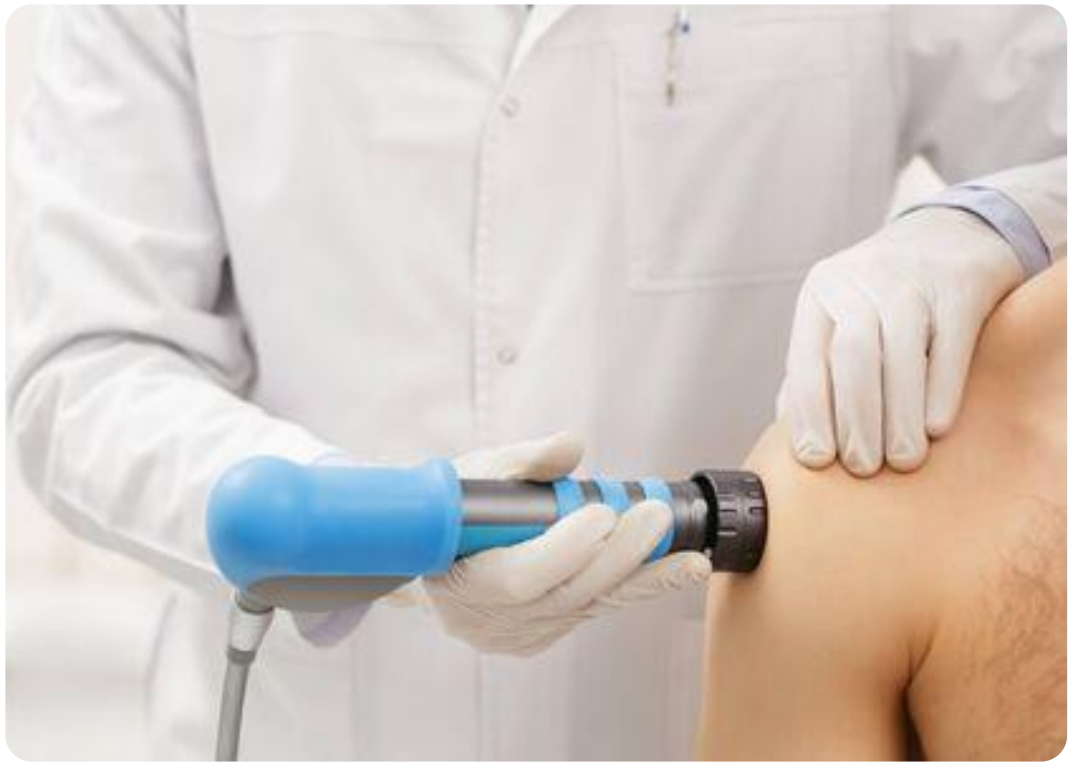

عن أبي الدرداء رضي الله عنه عن النبي صلى الله عليه وسلم أنه قال:
"من سلَكَ طريقًا يلتمسُ فيهِ علمًا سَهَّلَ
اللَّهُ لَهُ طريقًا إلى الجنَّةِ." (صحيح الترمذي)
EDC
لجنة الدعوة الإلكترونية
E-Dawah Committee
www.edc.org.kw


رَبِّ اشْرَحْ لِي صَدْرِي
وَيَسِّرْ لِي أَمْرِي
وَاحْلُلْ عُقْدَةً مِن لِسَانِي
يَفْقَهُوا قَوْلِي

INTRODUCTION TO ELECTROPHYSICAL AGENTS



Dr. MOHAMED GAMAL ABOU ELYAZEED ALI

LECTURER OF PHYSICAL THERAPY

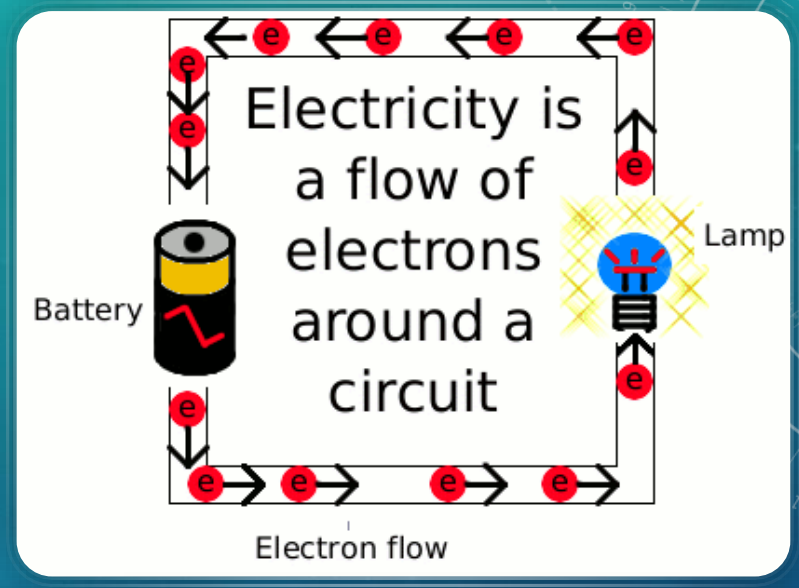
SOUTH VALLEY UNIVERSITY

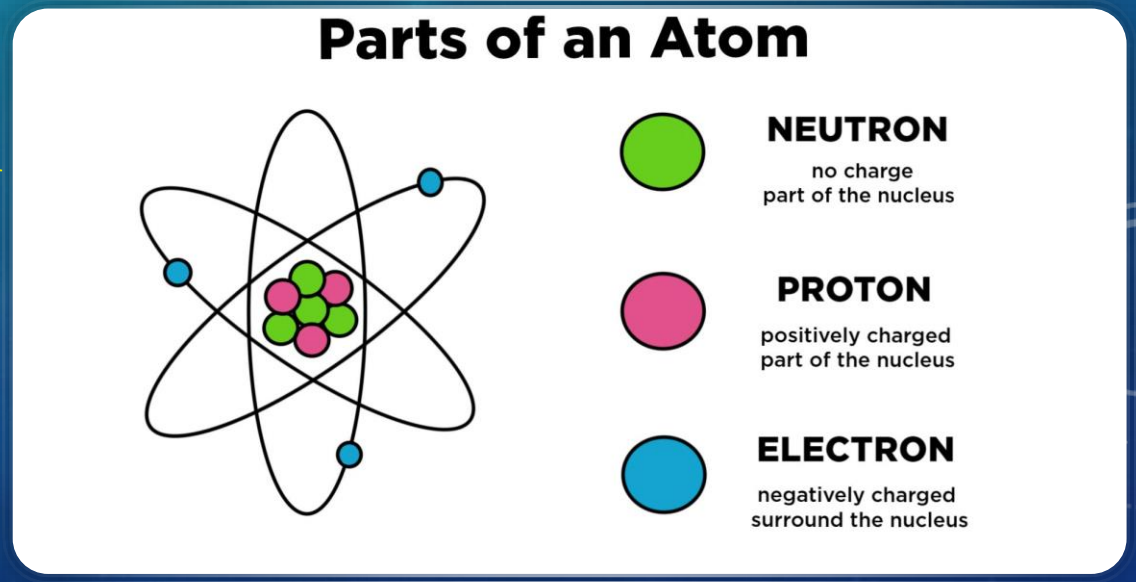
- **ELECTRICITY** IS A RESULT OF THE MOVEMENT OF ELECTRONS.

- **Electricity** is the force created by an imbalance in the number of electrons at two points

1. **Negative** pole an area of high electron concentration **(Cathode)**

2. **Positive** pole and area of low electron concentration **(Anode)**





*THERAPEUTIC MODALITIES: ROLES IN REHABILITATION:

Modalities as Part of the Comprehensive Plan

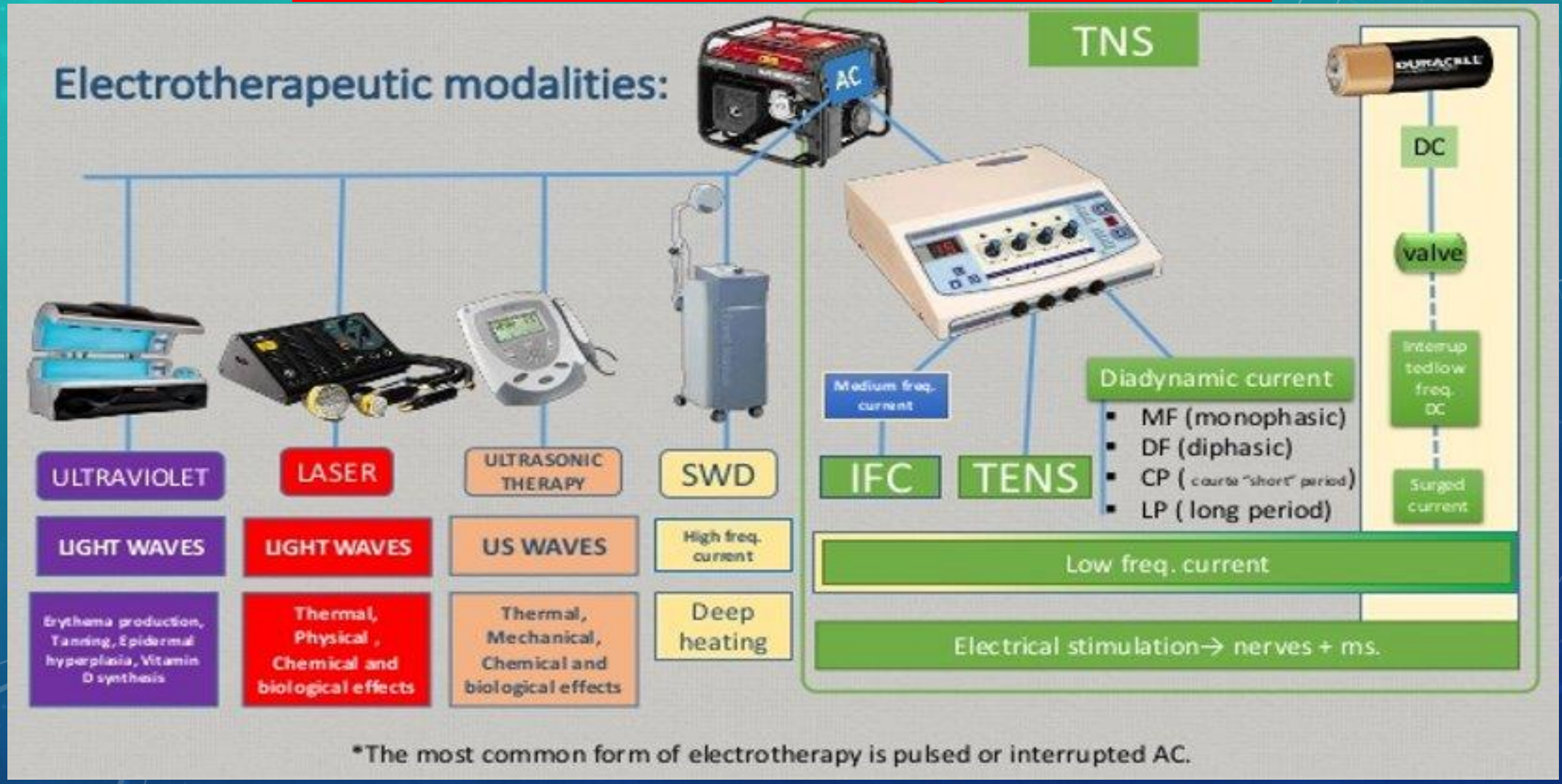
*TYPES OF THERAPEUTIC MODALITIES:

-**Thermal Modalities:** Cold and Heat
-**Electromagnetic Modalities**
-**Mechanical Modalities**

*CLINICAL APPLICATIONS OF THERAPEUTIC MODALITIES:

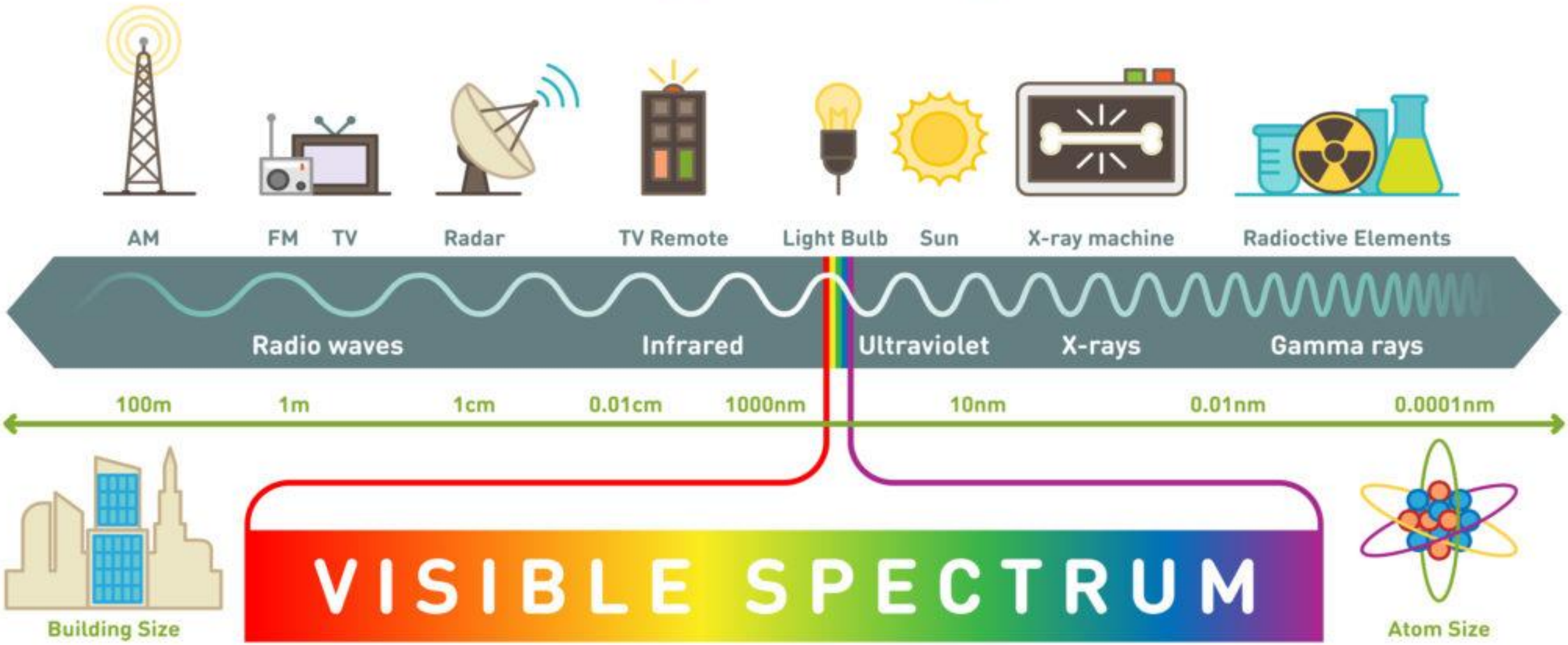
1) Modulation of Pain
2) Alteration of Skeletal Muscle Performance: Facilitation and Inhibition
3) Decreasing Inflammation and Facilitating Tissue Healing
4) Increasing Tissue Extensibility: Flexibility and Range of Motion

Different electrotherapy modalities



*The most common form of electrotherapy is pulsed or interrupted AC.

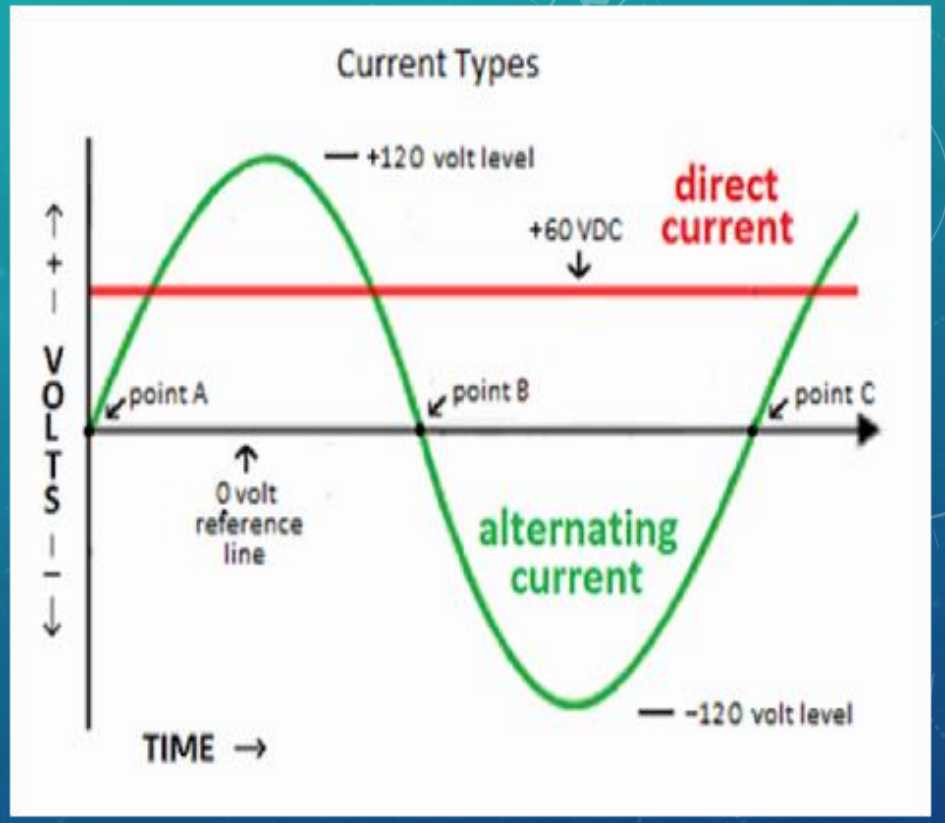
Electromagnetic Spectrum



Types of electric currents:

1. Direct current (DC)-

Is a **continuous unidirectional flow** of Charged particles with duration of at least 1 second.

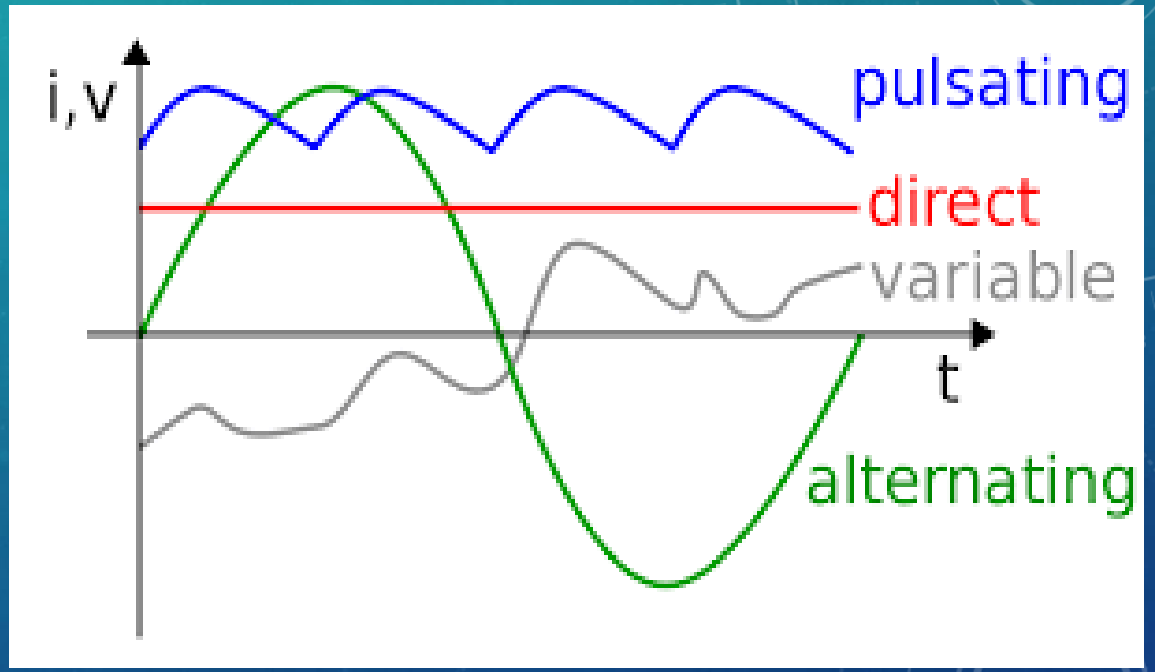


- Because one electrode is always positive and one is always negative, there is an accumulation of charge. This accumulation of charge is called chemical or **Polarity effect**.
- **DC** has a strong chemical effect on tissues and can be delivered continuously to promote absorption of medication through the skin **(Iontophoresis)**.

2. Alternating current (AC)-

Is an **uninterrupted bidirectional flow** of charged particles changing direction at least once a second.

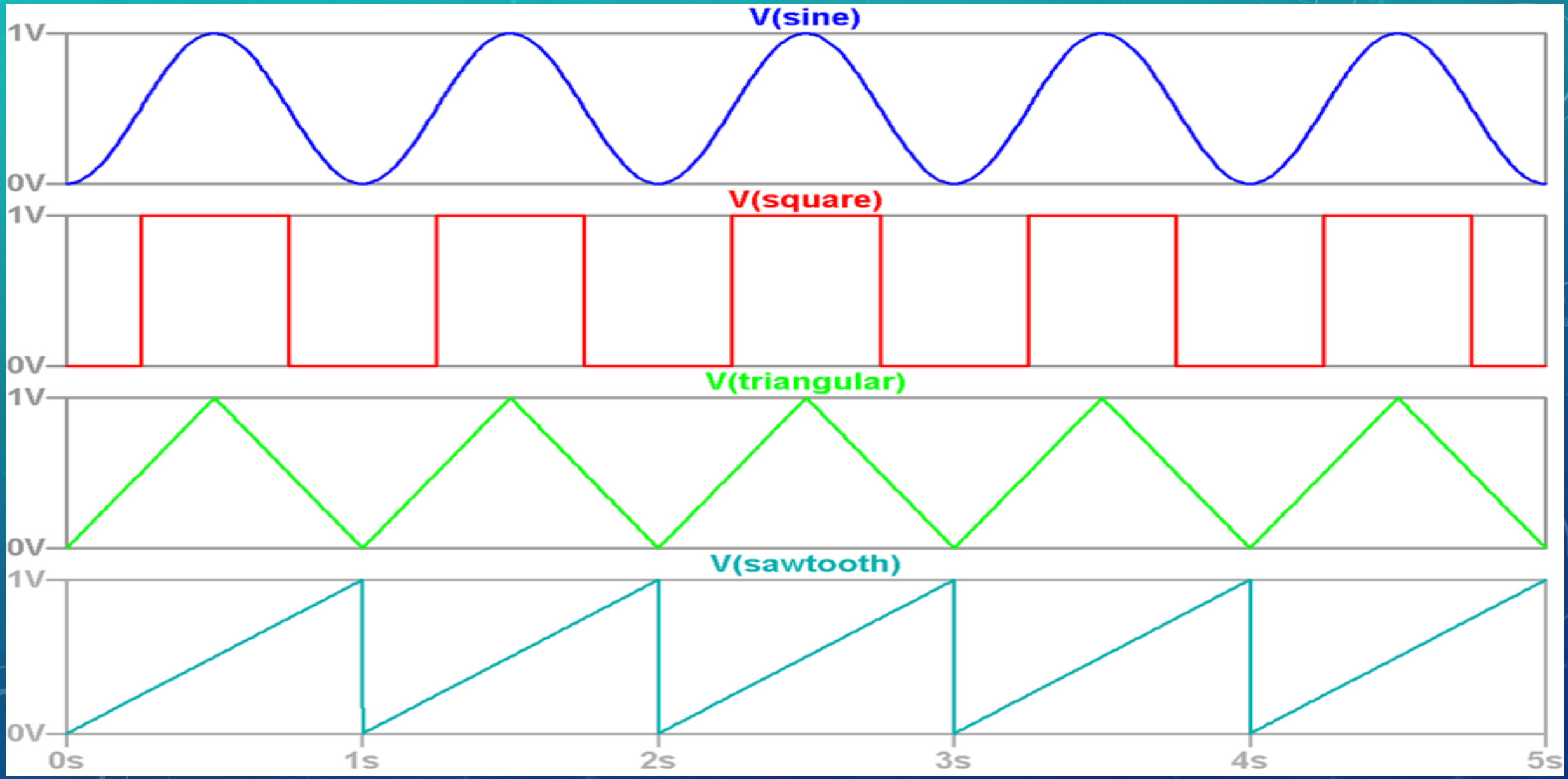
• **AC** can also be delivered in an interrupted form, sometimes referred to as **Bursts**.



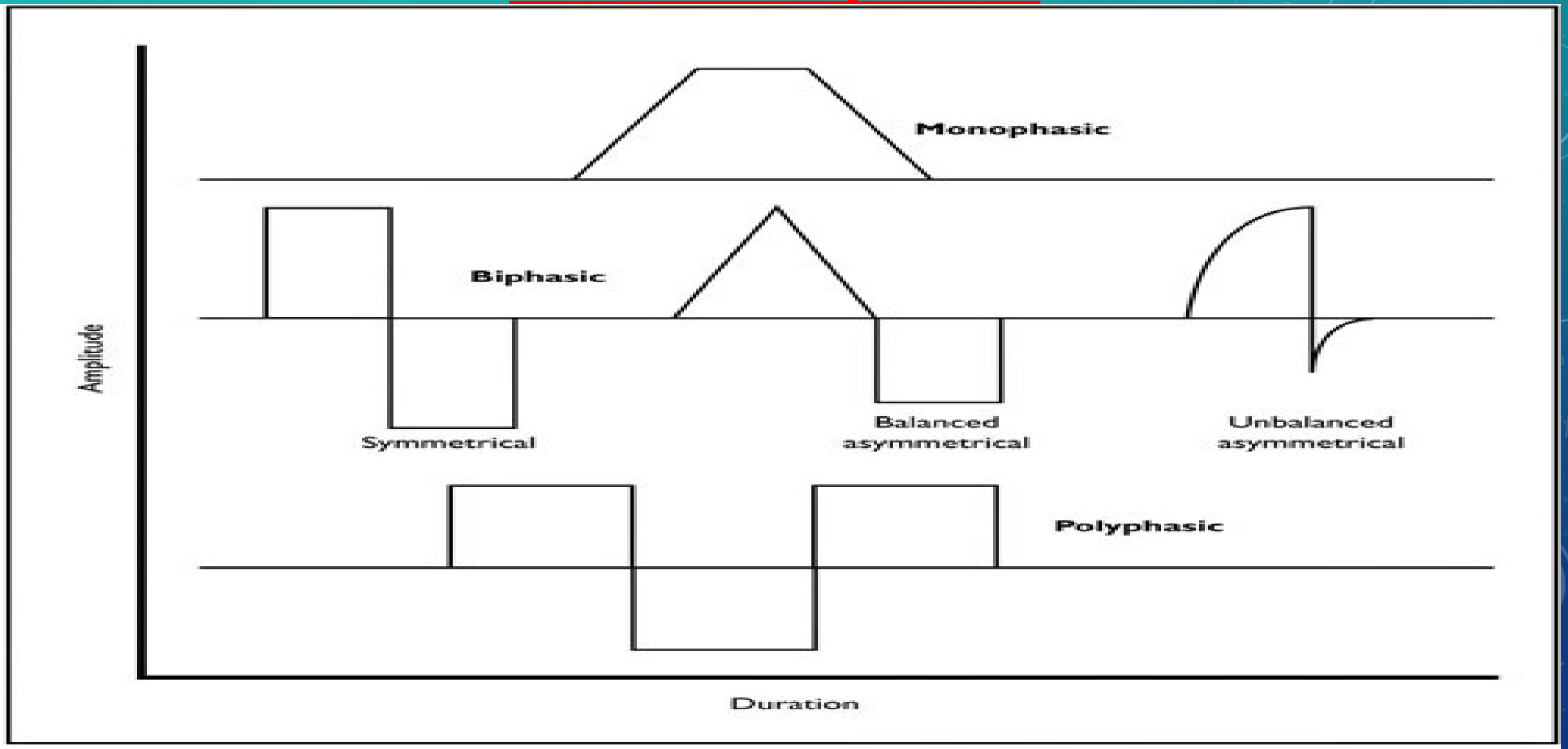
3. Pulsed current-

Is the **unidirectional** (like DC) or **bidirectional** (like AC) flow of charged particles periodically **ceasing for less than 1 second** before the next electrical event.

Different pulse shapes

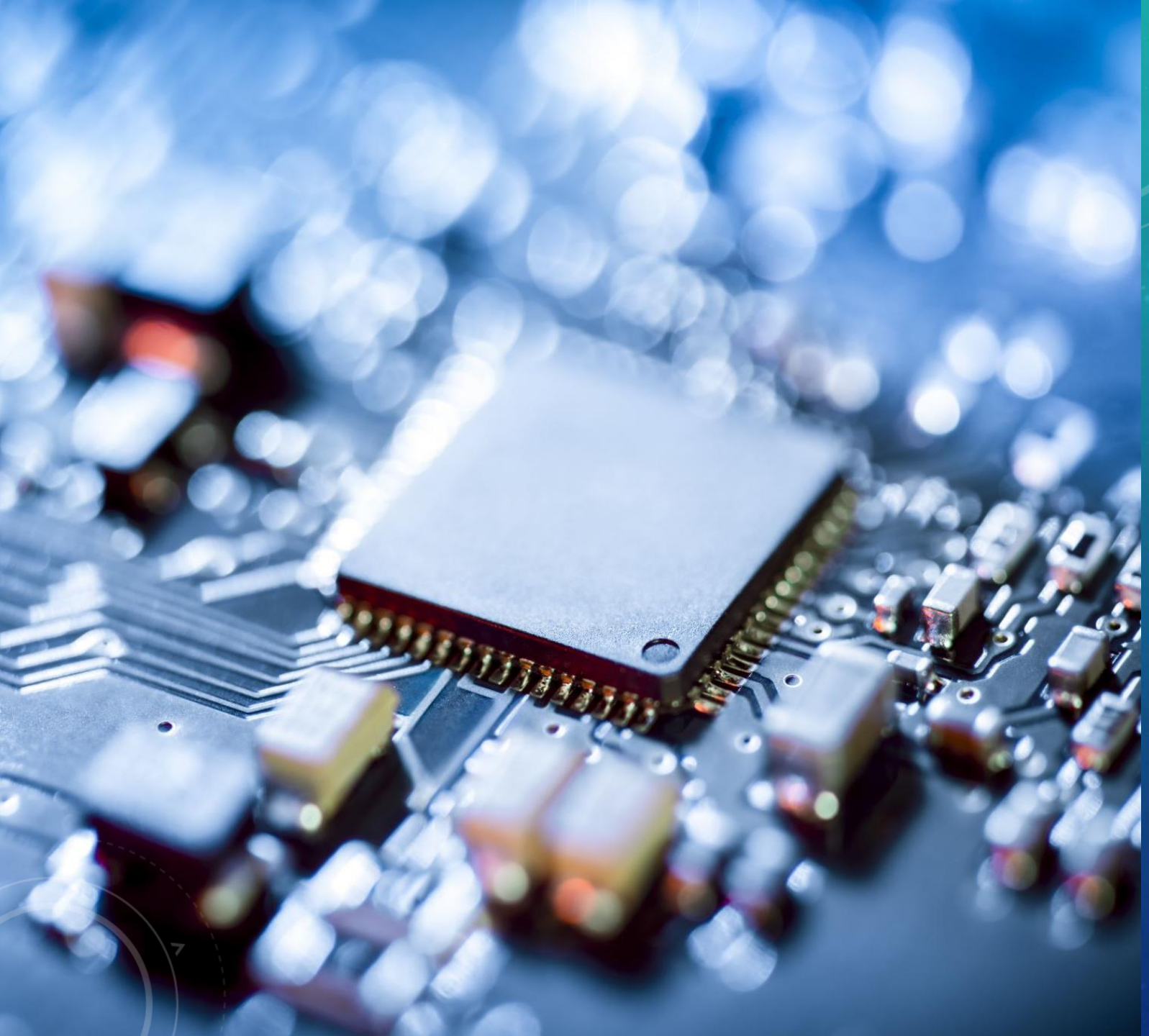


Number of pulses



Waveform selection:

- The **symmetrical biphasic** waveform is cited as **most comfortable** waveform.
- The **biphasic waveforms** were **most preferred**.
- **Asymmetrical balanced biphasic** may be a better for **small muscles**.
- **Monophasic** and **symmetrical biphasic** waveforms were found to generate muscle contractions with **greater torque** than polyphasic waveforms and they were also **less fatiguing**.
- **Monophasic** waveforms are most appropriate for **wound healing.**



ELECTRICAL CURRENTS ACCORDING TO FREQUENCY

1-Low Frequency Currents

- Current with frequency from **1-1000 Hz**.

- **Low frequency currents** can stimulate both **sensory** and **motor nerves**, with the **best effect** from **1-100 Hz**.

- **Examples:** **Direct current** (DC), **faradic current** (FC), **Diadynamic current** (DD), **High voltage pulsed stimulation** (HVPS), **transcutaneous electrical nerve stimulation** (TENS).

2-Medium Frequency Currents

- Current with frequency from **1000 to 10000Hz**
- Can only stimulate **sensory** and **motor** nerves **too after modulation**
- **Examples:** **Interferential current** (IF) or **Russian current** (RC).

3-High frequency currents

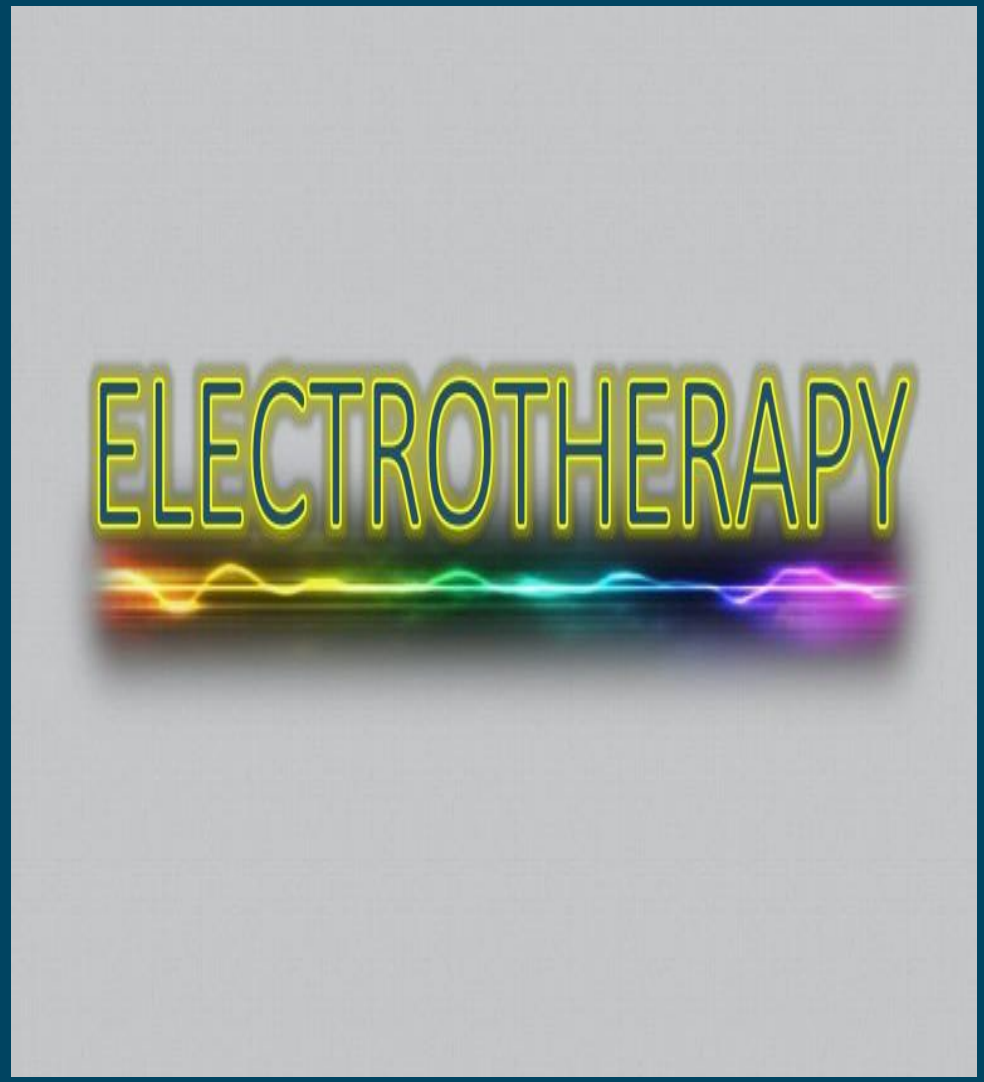
- Current with frequency > **10000Hz**
- At this frequency, the current has **no direct effect** on **sensory** and **motor** nerve.
- **Examples:** **Pulsed Short-wave Diathermy** (PSWD) or **Ultrasound** (US).

Electrical stimulation currents such as:

- Faradic current
- TENS
- Diadynamic
- HVPGC
- Interferential (IFC)
- Russian Current

Electromagnetic waves such as:

- Infrared (IR)
- Ultraviolet (UV)
- Pulsed Shortwave
- Microwave



Mechanical waves such as:

- Ultrasound
- Extracorporeal Shockwave

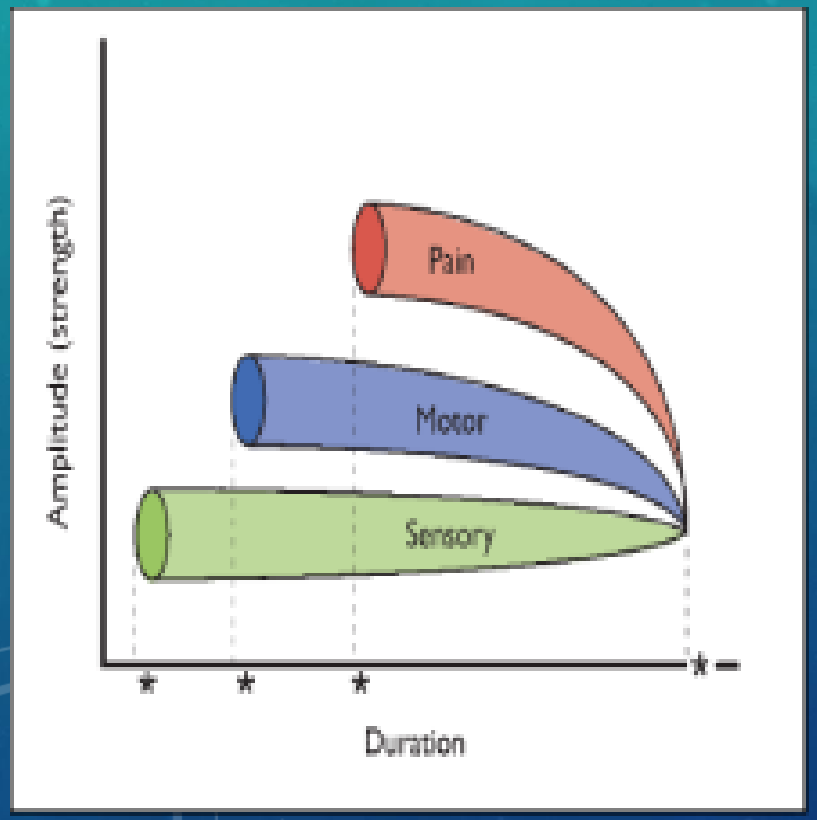
Visible light such as:

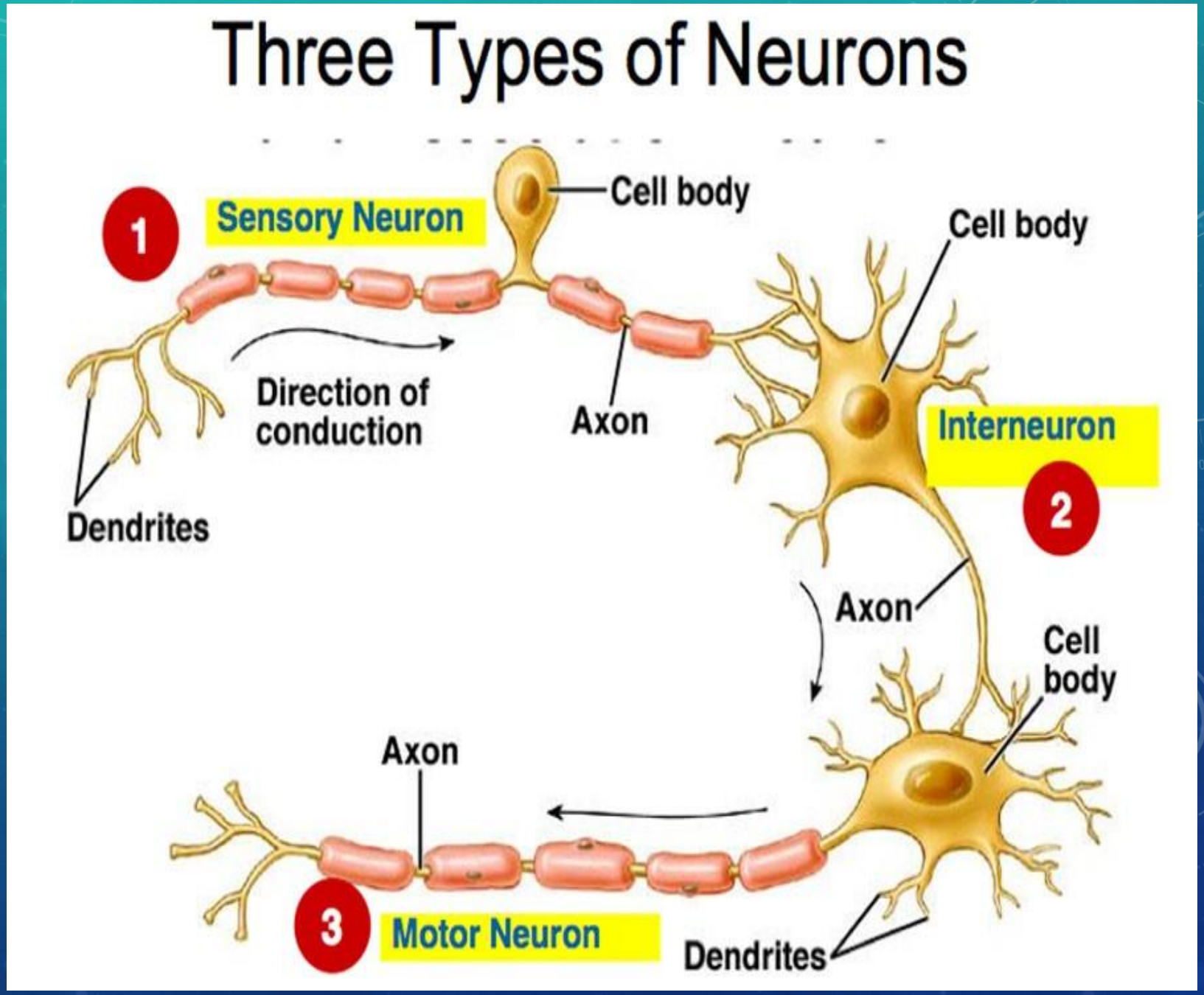
- LASER
- Light therapy (Bioptron)

Special units such as:

- Biofeedback
- Intermittent compression


ATTENTION
PLEASE


Amplitude (strength)
Pain
Motor
Sensory
Duration


Three Types of Neurons
1
Sensory Neuron
Cell body
Direction of
conduction
Axon
Dendrites
Cell body
Interneuron
2
Axon
Cell
body
Axon
3
Motor Neuron
Dendrites

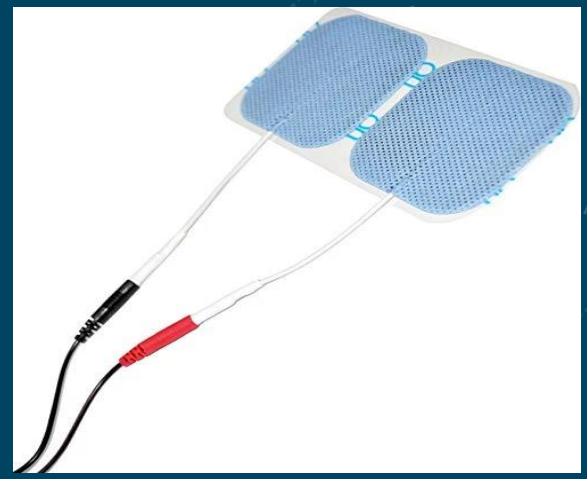
Levels of Electrical Stimulation

Subsensory	**No nerve fiber activation** **No sensory awareness**
Sensory	**Non noxious paresthesias** **Tingling, prickling, or pins and needles** **Cutaneous A-beta nerve fiber activation**
Motor	**Strong paresthesias** **Muscle contraction** **A-alpha nerve fiber activation**
Noxious	**Strong, uncomfortable paresthesias** **Strong muscle contraction** **Sharp or burning pain sensation** **A-delta and C fiber activation**

Types of Electrodes

1.Metal Plate Electrodes - early version, limited sizes, required wet sponge conduction medium, difficult to be secured

2.Carbon - Impregnated Rubber Electrodes - degrade over time and become non-uniform with "hot spots", many shapes and sizes, rinse and dry after each use and replaced every 12 months to ensure conductivity.



3.Self-Adhering or Single use Electrodes - flexible conductors, convenient application, no strapping or taping to keep in place, used most frequently these days.

Techniques

➢ Monopolar Technique

- **Active electrode** over **target** area (**Smaller**)
- **Dispersive electrode** another **remote** site (**Larger**)
- Used with wounds, **iontophoresis**, Edema.

➢ Bipolar Technique

- **Two active electrodes** placed over target area (**Equal in size**)
- Used for muscle weakness, **Neuromuscular facilitation** and spasms.

➢ Quadripolar Technique

- **Two electrodes** from **two separate stimulating channels** positioned so, the currents intersect as criss-cross **Interferential Current**.


Thank
you!


سبحانك اللهم
وبحمدك أشهد أن
لا إله إلا أنت
استغفرك وأتوب
إليك


قال رسول الله صلى الله تعالى عليه وآله وسلم :
فضل العالم على العابد
كفضل القمر على سائر الكواكب
سنن الترمذي : ٢٦٨٢


قال الله تعالى :
قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا
عَلَّمْتَنَا ۖ إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيمُ

ELECTROTHERAPY

MECHANISMS OF PAIN

By:

Dr. Mohamed Gamal AbouElYazeed Ali

Lecturer of Physical Therapy

South Valley University

MECHANISMS OF PAIN

*Pain is the most common complaint and the most prevalent symptom that requires intervention among patients in rehabilitation programs.

*Pain perception is influenced by various factors such as cultural differences, motivation, emotional states, and past experiences with pain **(Sluka., 2009)**.

*Pain is undoubtedly the main reason people seek treatment from health professionals **(Turk et al., 2011)**.

*The International Association for the Study of Pain (IASP) defines **pain** as “an unpleasant sensory and emotional experience associated with actual or potential tissue damage” that has physiologic and psychological aspects.

TYPES OF PAIN

1) Acute Pain:

-**Acute pain** is a symptom that results from injury and/ or disease that causes or can cause tissue damage through infection, trauma, or the progression of a metabolic disorder.

-**Acute pain** is described as pain lasting less than 12 weeks (i.e., 3 months).

-**Acute pain** is typically well-located and defined, depending on the type of tissue involved. Superficial (e.g., skin) pain is typically sharp and easy to locate. On the other hand, acute deep-tissue pain from muscles, joints, or viscera can be diffuse and difficult to locate.

-The clinical treatment of **acute pain** can be pharmacological or nonpharmacological, involving rehabilitation or surgery.

-**Acute pain** is often associated with changes in heart rate, blood pressure, and even respiratory rate, measurement of vital signs is warranted.

2) Chronic Pain:

-**Chronic pain** is commonly defined as persistent or recurrent pain existing for 3 to 6 months or pain that persists beyond the normal time expected for the healing of injured tissue.

-**Chronic pain** follows acute pain and is also associated with structural and functional changes in the central nervous system that require multiple therapeutic approaches.

-**Central sensitization**, or the amplification of neural signaling within the central nervous system that underlies pain hypersensitivity, is a characteristic of **chronic pain**.

-The persistence of **chronic pain** associated with injury or disease, such as diabetes or arthritis.

-**Chronic pain** is no longer considered a symptom and may even be considered a disease itself.

-Generally, **chronic pain** is associated with physical, emotional, social, and financial disability.

-As **chronic pain** is difficult to manage, Clinicians must rely on a **multidisciplinary approach** and should involve more than one therapeutic modality.

3) Referred Pain:

-**Referred pain** is defined as pain that occurs at a site remote from the source of the disease or injury, usually a visceral or muscle source.

-It is generally believed that **referred pain** occurs due to the convergence of cutaneous, visceral, and skeletal muscle nociceptors on the common nerve root of the spinal cord.

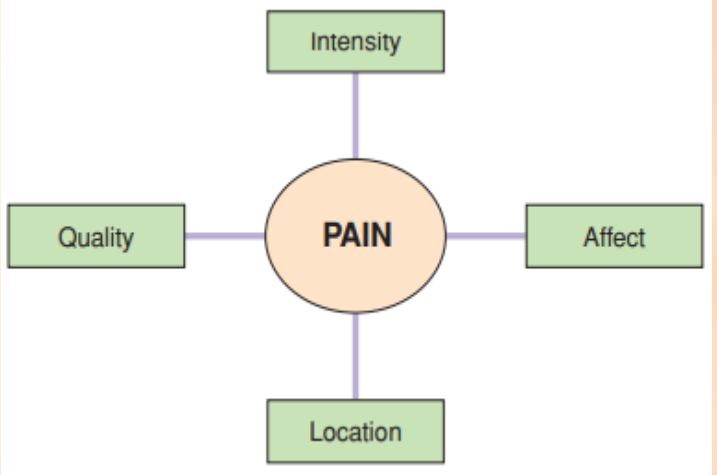
-The **brain** interprets the afferent input as arising from cutaneous structures because of the higher proportion of cutaneous afferents converging on second-order transmission neurons.

-A common example is **referred pain** that radiates to the left shoulder, arm, jaw, or chest during angina or **myocardial infarction**.

-###Treating pain of unknown or unidentifiable origin is considered a **contraindication** tosome common pain modalities like TENS. Masking undiagnosed pain with TENS can postpone proper treatment and lead to a worsening of the underlying condition ###.

Acute	Chronic
Sudden	Gradual
Related to tissue damages	Poorly related to tissue damages
Lasts days to weeks	Lasts months to years
Localized	Diffuse and/or referred
Limited to physical signs and symptoms	Often associated with psychological, emotional, or social distress
Serves biologic purpose (self-protection)	Serves no biologic purpose
Normal use of therapy	Often related to abusive use of therapy

DIMENSIONS OF PAIN



A. Intensity:

*Pain intensity may be defined as how much a person hurts **(Jensen et al., 2011)**. Intensity is the dimension of pain most frequently assessed by clinicians.

*In most cases, the more intense the pain, the more aggressive the treatment delivery and the less rapid the discharge. Inversely, the lesser
the pain is, the less aggressive the treatment and the more rapid the patient's discharge.

B. Quality:

*It refers to the specific physiologic sensations associated with pain. It reveals how the person feels or senses the pain (e.g., burning, itching).

*This dimension is very informative in determining the cause or nature of pain. C.

C. Affect:

*The affective dimension of pain is very complex because it relates to the degree of emotional arousal—that is, the changes in action readiness caused by the sensory experience of pain **(Jensen et al., 2011)**.

*Pain affect is a mental state triggered by an implicit or explicit appraisal of a threat. In **chronic pain**, the emotional aspects can come to dominate the clinical picture.

*This pain dimension is very important to clinicians and helps them determine the extent to which the patient is emotionally affected by his or her pain condition. This information can help to make a better choice of pain therapy—a **psychological** versus **somatic approach**, for example.

D. Location:

*Pain location is defined as the perceived location(s) of pain sensation that patients experience on or in their bodies.

*Assessing pain location is important because the number of locations and sites indicated by the patients may be related to physical and psychological functioning **(Jensen et al., 2011)**.

The process of pain experience is made of five distinct and successive physiologic phases:

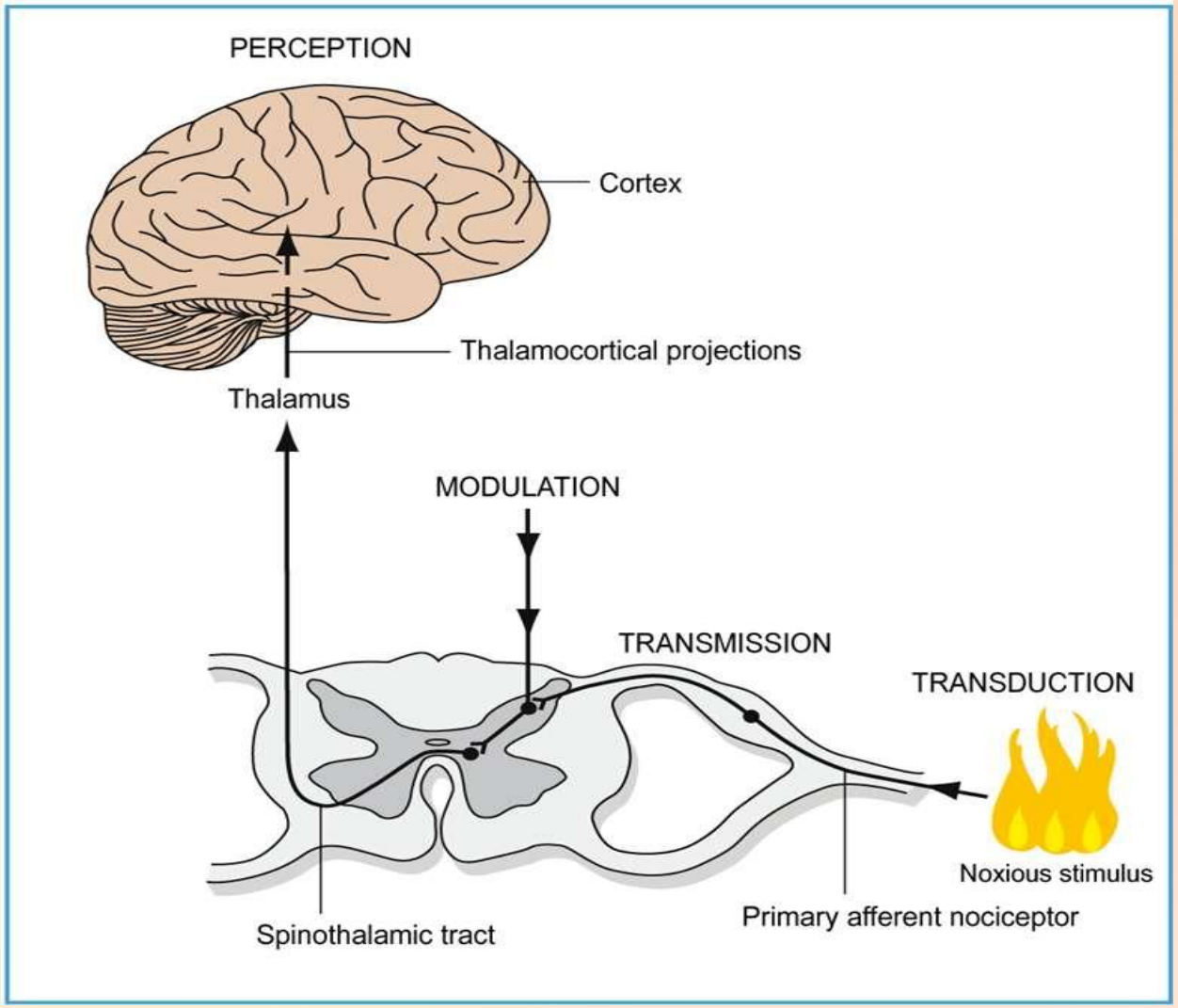
1) Transduction

2) Peripheral transmission

3) Modulation

4) Central transmission

5) Perception

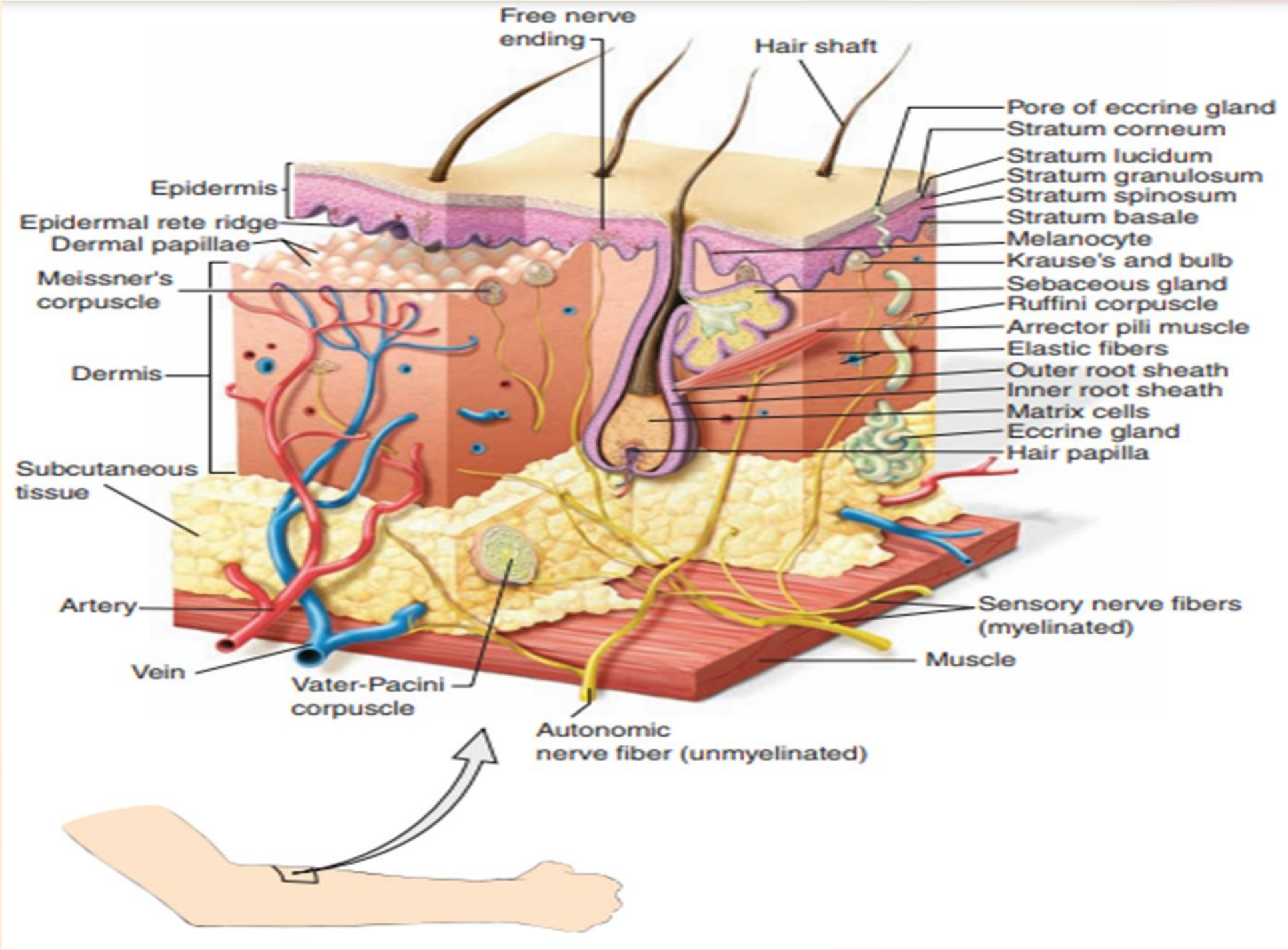


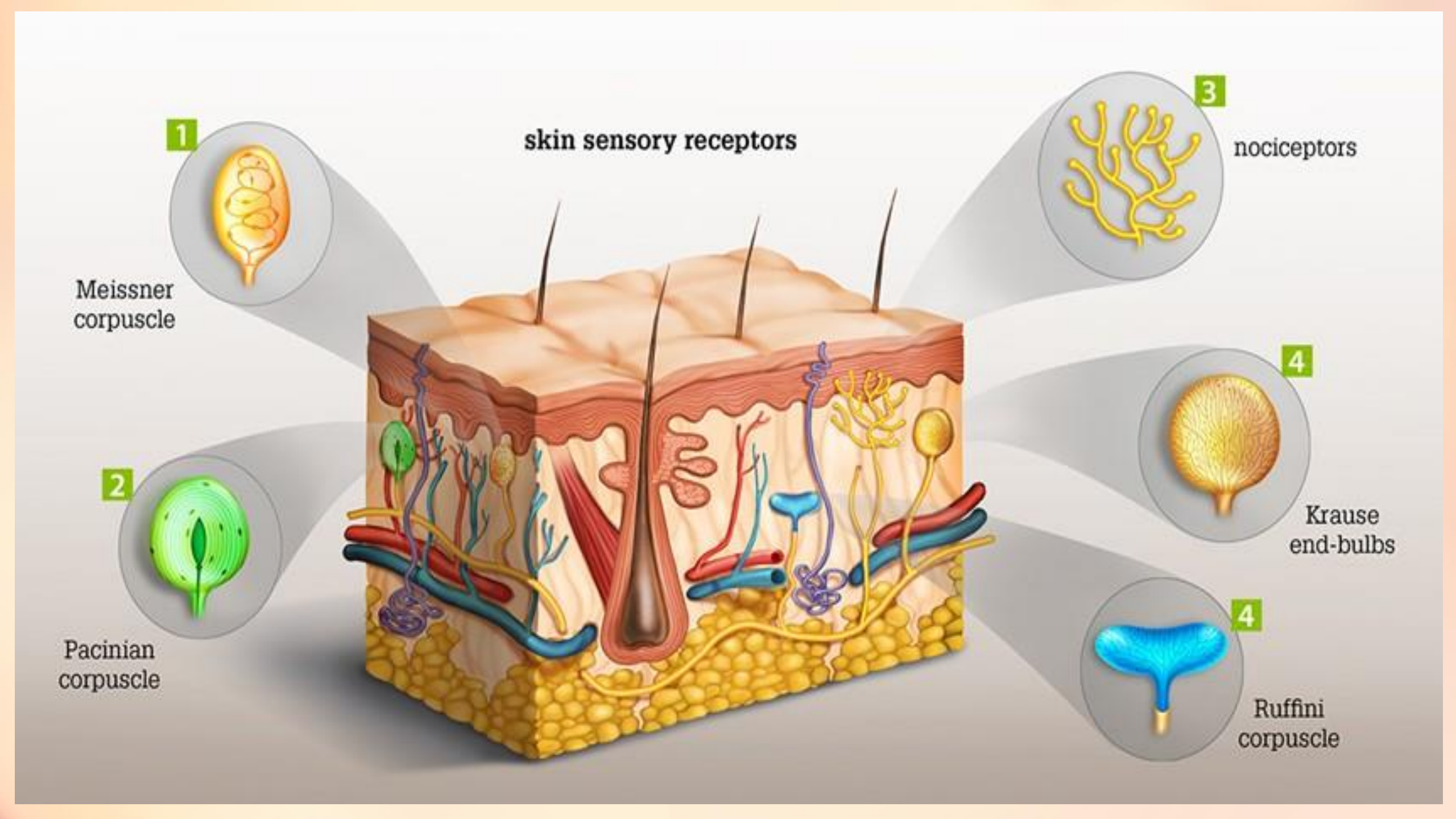
***Nociceptors:** Most **nociceptors** have a high stimulation or activation threshold and, as a result, do not respond to everyday stimuli **(Mense, 2003)**. This means, for example, that the **nociceptors** in our skin are not activated when we are sitting (compression of the gluteal skin area) or when muscle nociceptors are not activated when we are walking (muscle fiber contraction and elongation).

*Only when their activation thresholds are exceeded is a noxious stimulus message generated. **Nociceptors** respond to **intense** mechanical, thermal, and chemical stimuli capable of damaging the tissues surrounding them. Stimuli that activate **nociceptors** are called noxious stimuli. Cutaneous mechanoreceptors, such as Meissner and Pacinian corpuscles and Merkel tactile disks, provide us with the senses of touch, pressure, and vibration. Cutaneous thermoreceptors provide our thermal sense for detecting **heat** (**Ruffini corpuscles**) and **cold** (**Krause end bulbs**).

*It is important to always keep in mind that the pain threshold is the level of noxious stimulus required to alert the individual to a potential threat to tissue. Pain tolerance, on the other hand, is a measure of how much pain a person can or will withstand **(Sikes, 2004)**. Both pain threshold and pain tolerance can vary greatly between individuals.

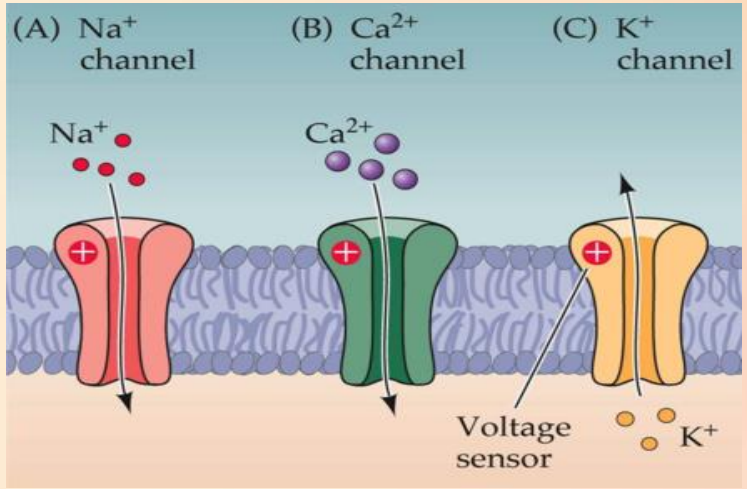
Cutaneous Sensory Receptors




skin sensory receptors
1
Meissner corpuscle
2
Pacinian corpuscle
3
nociceptors
4
Krause end-bulbs
4
Ruffini corpuscle

1. Transduction Phase:

*Transduction is the phase of converting energy (i.e., of mechanical, thermal, and chemical forms) affecting **nociceptors** at the site and around the wound into electrical energy, which generates action potentials that lead to the production of nerve impulses. As stated previously, pain initially develops in nociceptors, the specialized nerve endings that are activated by **strong** mechanical and thermal stimuli, and by chemical substances produced and released (inflammatory response) in the tissue at the wound site.



*This **transduction**, or conversion, of energy results from a change in the nociceptor's structural confirmation with the formation of pores (**ionic channels**) within its cell membrane. Ion exchanges in and out of the nociceptor's cell membrane generate action potentials leading to the production of nerve impulses, which will subsequently be transmitted along specialized sensory afferent fibers toward the spinal cord.

*For **transduction** to occur, the quantum of physical energy available at the tissue injury site must be large enough, or intense enough, to exceed the nociceptor's membrane threshold of activation.

2. Peripheral Transmission Phase:

*The **peripheral transmission** phase includes the propagation or transmission of nerve impulses generated as a result of transduction from the nociceptors to the spinal cord.

*The terminal ends of the nociceptors—that is, the free nerve endings—connect with the spinal cord through **two distinct afferent sensory nerve fibers**: **A-delta fibers** and **C fibers** **(Wright, 2002; Weisberg et al., 2006)**.

*The noxious message, now coded in nerve impulses, is transmitted to the dorsal horn of the spinal cord along these two afferent sensory fibers, whose cell body (neuron) resides in the dorsal root ganglia.

*Impulse transmission in the **A-delta fibers** occurs more rapidly than in the **C fibers** (approximately 15 m/s vs. 1 m/s) because the axons of the former are **lightly myelinated** (larger in diameter), whereas those of the latter are **unmyelinated** (smaller in diameter).

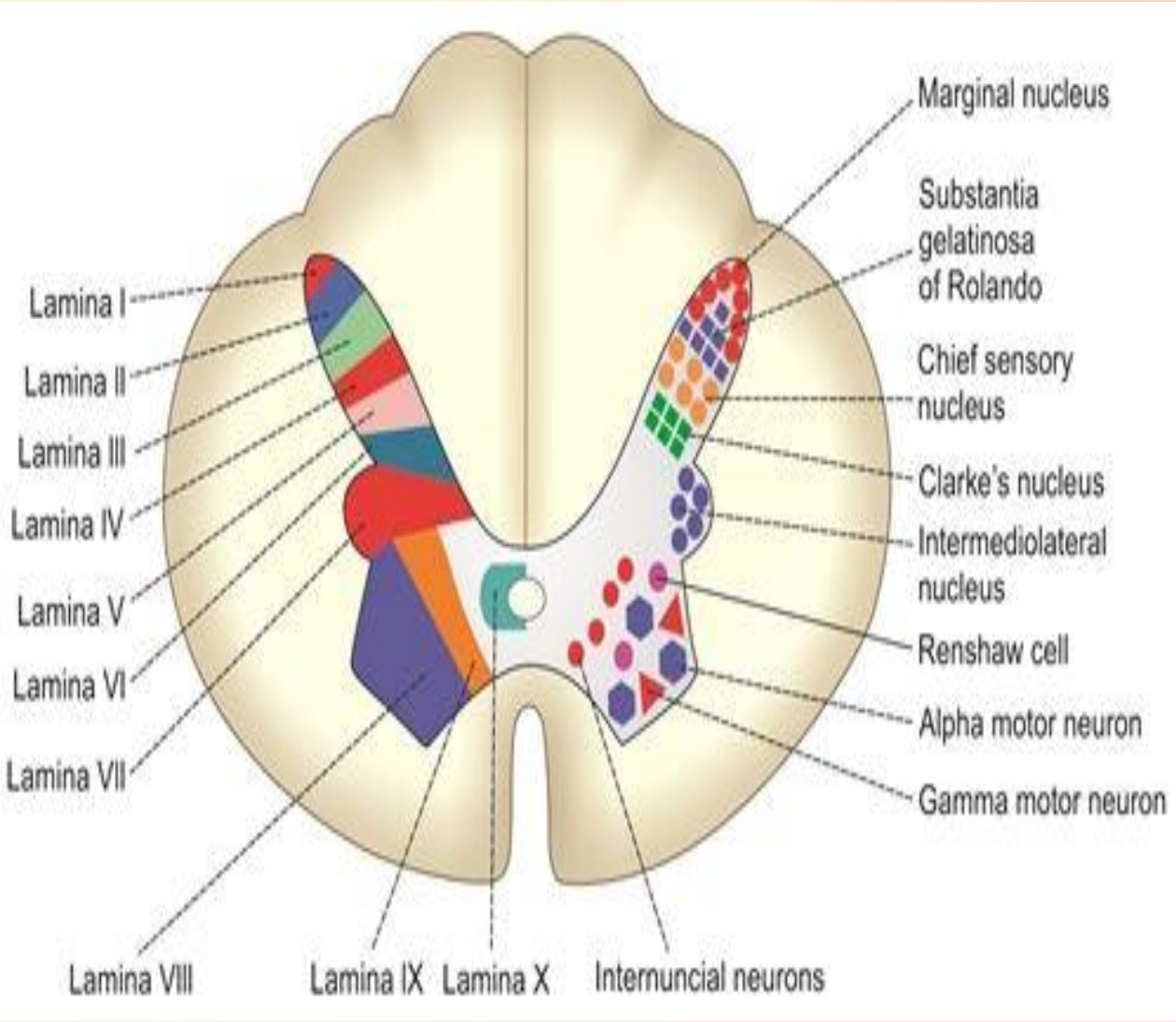
***A-delta fibers** conduct mechanical as well as thermal noxious stimuli. **C fibers**, on the other hand, conduct mechanical, thermal, and chemical noxious stimuli.

3. Modulation Phase:

*__Modulation__ is the third phase leading to the experience of pain. This phase is characterized by a diminution, suppression, or amplification of pain (hence the word modulation).

*Research has shown that **pain modulation** occurs because of the action of nociceptive nerve impulses on the spinal gating system located in the dorsal horn of the spinal cord **(McMahon et al., 2006)**.

*Because **pain modulation** reflects the action of our own thoughts and emotions, it is logical that the two remaining phases, central transmission (fourth phase) and perception (fifth phase), are addressed before the modulation phase.

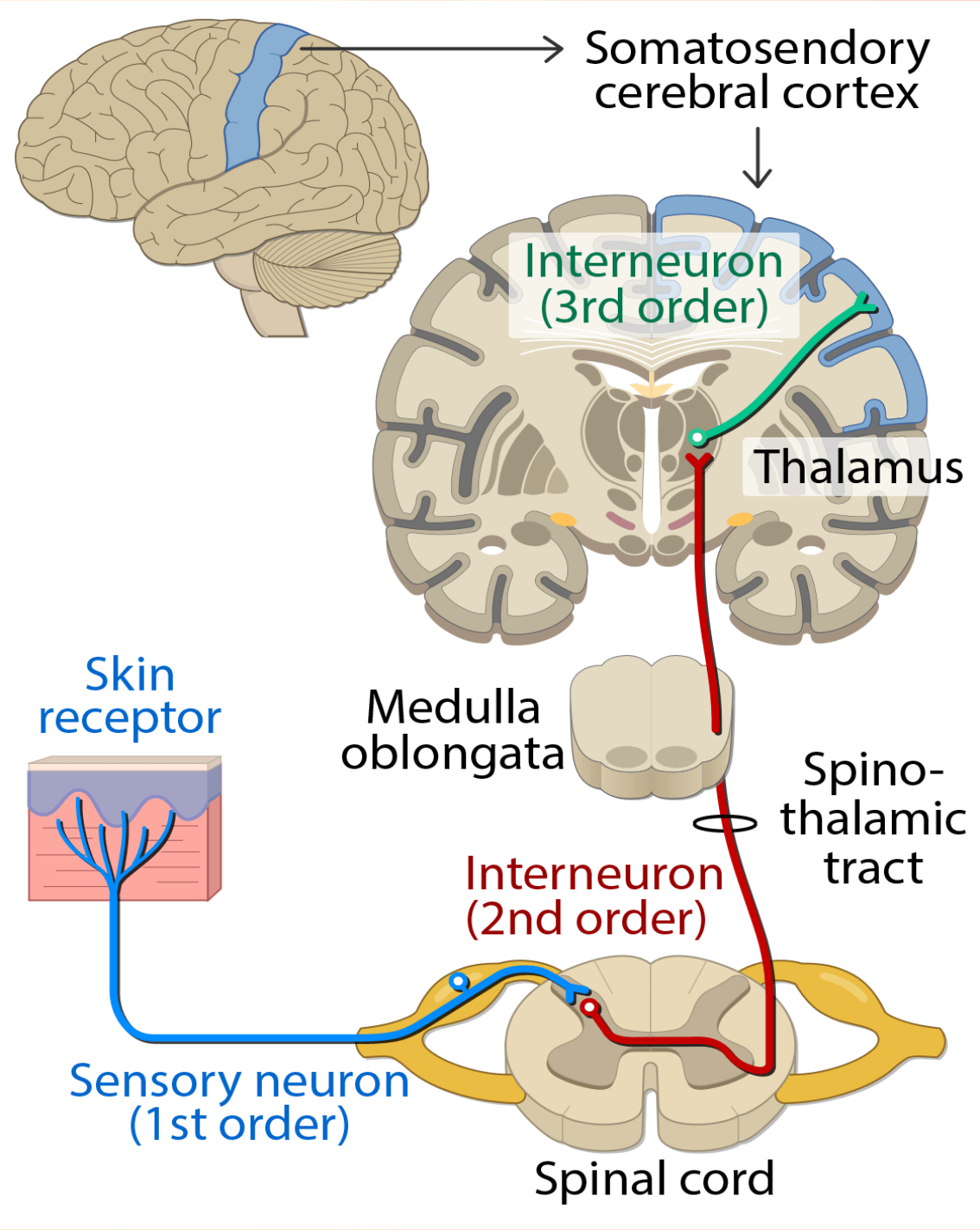


4. Central Transmission Phase:

*__Central transmission__ is the phase that encompasses the ascending transmission, or projection, of nociceptive nerve impulses, generated by the spinal pain-transmitting neurons, also referred to as T neurons.

*The __lateral spinothalamic tract__ has two types of T neurons: fast-conducting, lightly myelinated A-delta fibers and slow-conducting, unmyelinated C fibers, representing the pathway of the __second-order neurons__ from the dorsal horn of the spinal cord to the thalamus.

*__The third-order neurons__, a new set of nerve impulses carrying the nociceptive message from the thalamus to the cortical neurons for pain perception to finally occur.

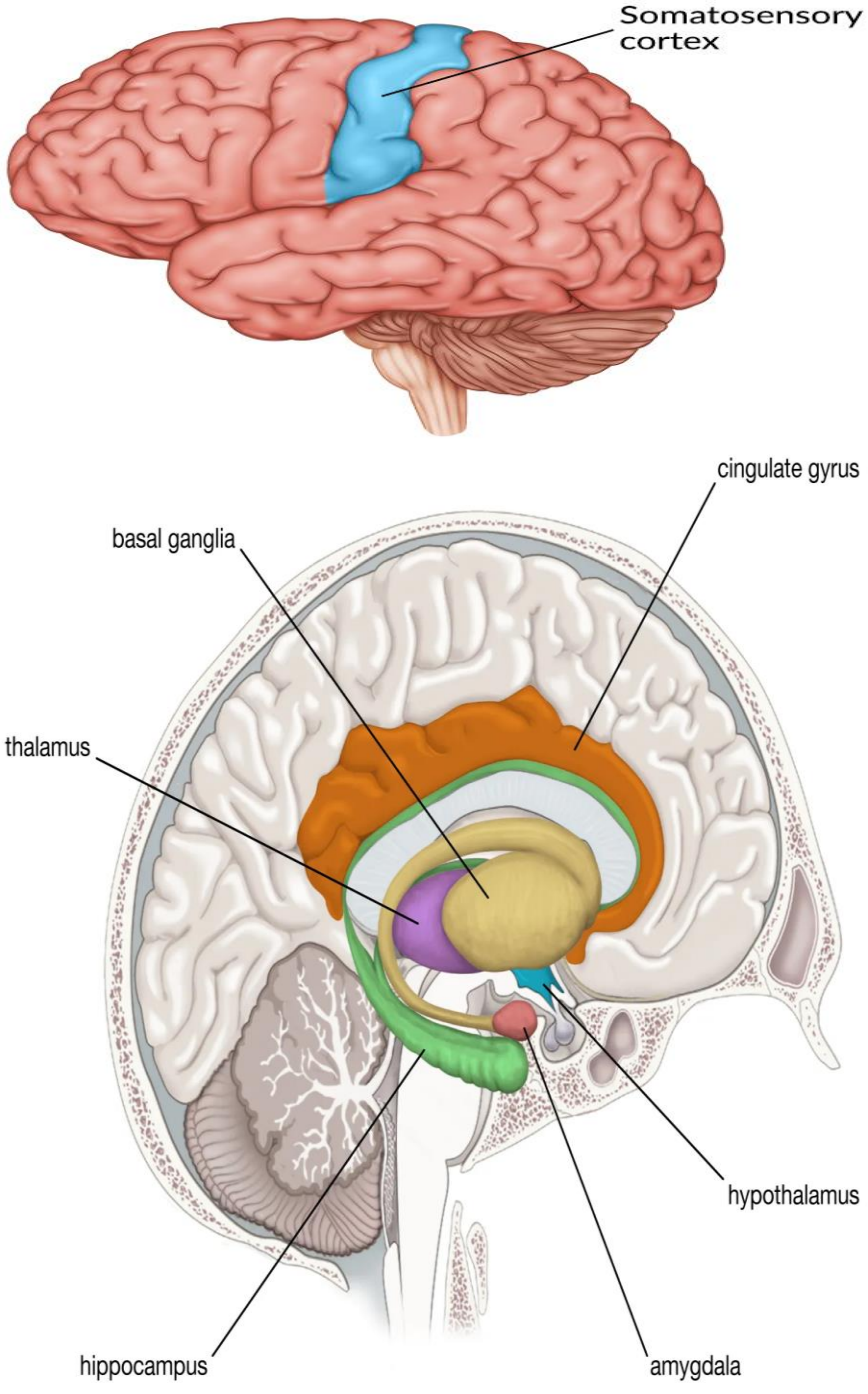


5. Perception Phase:

*__Perception__ relates first to the detection of pain and subsequently to the determination of its meaning **(Bushnell et al., 2006)**. During this crucial phase, nociception (the organic aspect) finally becomes a pain (the cognitive aspect). It is also during this phase that pain is **processed**.

*There is evidence from brain imaging and electrophysiologic studies that different cortical regions may be preferentially involved in different aspects of the complex experience of pain **(Melzack et al., 2008)**. Most evidence suggests that the **somatosensory cortex** is more important for the perception of spatial and temporal features, such as the location and duration of pain, whereas the **limbic system** is more important for the emotional and motivational aspects of pain **(Bushnell et al., 2006)**.

*As soon as we perceive pain, we try to modulate it downward.



SOMATIC PAIN MODULATION

A. The Spinal Gating System:

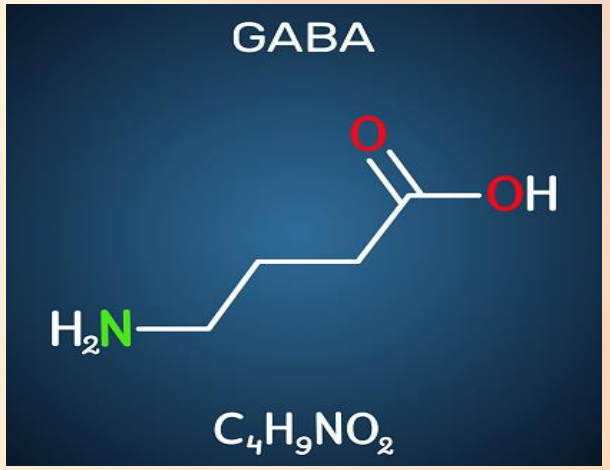
*According to the **gate control theory**, pain is perceived only if the spinal gate is open. It thus follows that to suppress the perception of pain, we need therapeutic interventions designed to close this gate.

*The gating system is located in the **dorsal horn of the spinal cord**, more precisely within the anatomic **laminae II** and **V**.

*The **gating effect** (open or closed) occurs after physiologic interaction between the inhibitory neurons located in the **substantia gelatinosa** (**SG**) and the **pain-transmitting neurons** (**T**) located deeper in the dorsal horns.

*The fast-conducting, lightly myelinated A-delta fibers and slow-conducting, unmyelinated C fibers, have an inhibitory effect on the neurons of SG and an excitatory effect on the T neurons. **Whereas** the large-diameter, heavily myelinated A-beta (mechanoreceptors) fibers have an excitatory effect on the neurons of the **SG** and an inhibitory effect on the **T** neurons.

*Different **mechanical stimulation techniques** like massaging the skin area over and around the site of pain, joint mobilization, tissue heating, and electrical stimulation, can potentially activate the **mechanoreceptors** attached to the very fast-conducting, large-diameter A-beta fibers.



*The large-diameter A-beta fibers induce the secretion of Gamma-aminobutyric acid (GABA), the common inhibitory neurotransmitter in the central nervous system. Also, stimulation of A-beta fibers inhibits the production of both:

1) Glutamate, the chemical substance that triggers the firing of the second-order neuron of acute pain perception.

2) Substance P, the chemical substance that triggers the firing of the second-order neuron of acute pain perception.

*As a result of GABA release and inhibition of glutamate production, there is an excitatory effect on neurons of the SG and an inhibitory effect on the T neurons that block the ascending signals and prevent the firing of the second-order neuron and so on, pain perception at the higher centers.

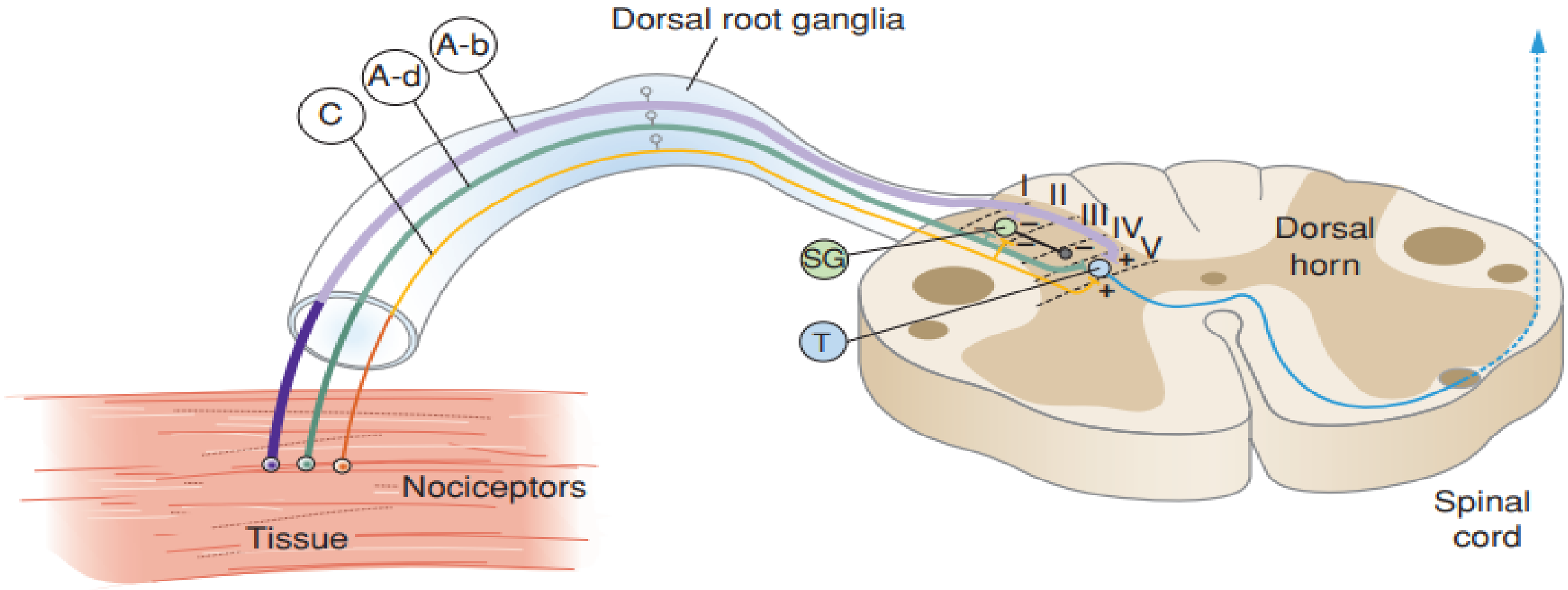


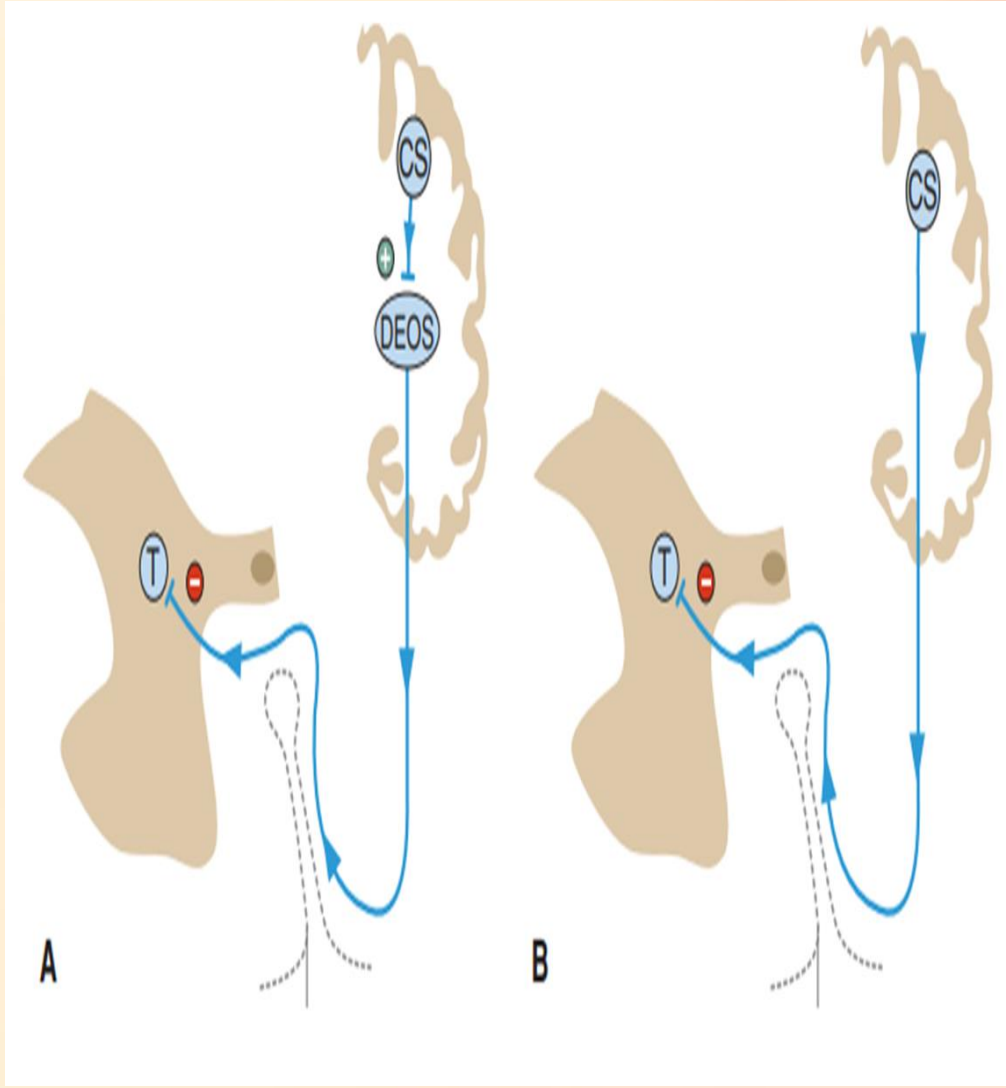
FIGURE 4-5 Schematic representation of the spinal gate control theory of pain. This gating system occurs at the level of the pain-transmitting neurons (T neurons [*T*]) and is under the powerful inhibitory action trigger by the neurons contained in the substantial gelatinosa (*SG*). Nociceptors buried in tissues are connected to the spinal cord through the larger A-beta (*A-b*) and A-delta (*A-d*) and smaller C afferent sensory (*C*) fibers, whose neurons (first order) are located in the dorsal root ganglia. These three fibers make synaptic contact with both the inhibitory neurons located in the SG and T neurons (second order) located deeper in the dorsal horn of the spinal cord.

B. Descending Endogenous Opiate System (DEOS):

*The **DEOS** originates primarily from neurons located in the periaqueductal gray matter (PAG) and the nucleus raphe magnus (NRM) areas, both located in the midbrain.

*The **DEOS** exerts a descending (from central to spinal level) inhibitory effect (closing the gate) on the T neurons by **releasing endogenous opiate**, morphinelike substances known as **enkephalins**, **endorphins**, and **Serotonin** into the bloodstream and cerebrospinal fluid.

*Research also suggests that the **patient's cognitive** (thoughts) and **emotional responses** to painful events can also inhibit the spinal gating system simply with positive modification of the patient's thoughts and emotional response to pain which leads to activation of the **DEOS**.




Thank
you!


سُبْحانك
اللّهُمّ وبحمدك
أشهدُ أنْ لا إله إلاّ أنتَ
أستغفرُك وأتوبُ إليك


قال ﷺ: "من سلك طريقاً يلتمسُ فيه علماً،
سهل اللّه له به طريقاً إلى الجنة"


وَقُل رَّبِّ زِدْنِي عِلْمًا
طه ١١٤
Islamiyatsb

ELECTROTHERAPY

SOFT TISSUE HEALING PROCESS

By:

Dr. Mohamed Gamal AbouElYazeed Ali

Lecturer of Physical Therapy

South Valley University

Soft-Tissue Healing Process

*The Healing Phases:

A. Hemostasis Phase

B. Inflammatory Phase

C. Proliferative Phase

D. Remodeling/Maturation Phase

A. Hemostasis Phase:

*The first phase of healing, called hemostasis, is characterized by the arrest of bleeding at the wound site.

*This phase usually lasts a few seconds or, in case of moderate to severe pathologies that involve multiple well-vascularized tissues, up to several minutes.

*It involves the process of blood clotting and subsequent dissolution of the clot **(Delforge, 2002a)**. The hemostatic response to injury is a complex series of regulatory events that require the interaction of both cellular elements and blood plasma proteins.

*The initial hemostatic mechanisms that occur within seconds after the blood vessel trauma include vasoconstriction and the development of a temporary hemostatic plug in the damaged vessels.

*Coagulation, or blood clotting, is the secondary hemostatic mechanism through which the initial platelet plug in the damaged vessels is reinforced **(Delforge, 2002a)**.

*The presence of a blood mass outside the blood vessels is called a hematoma. Hemostasis is the body's emergency response to a pathology, of which the aim is to prevent hemorrhaging.

B. Inflammatory Phase:

*The inflammatory phase relates to the process of inflammation, of which the aim is to clean the wound of its cellular debris, preparing it for the deposition of new, repaired, or regenerated tissues. Inflammation, from the Latin word inflammare, means “to set on fire.”

*It is a localized tissue response initiated by pathology. There are **six clinical cardinal signs and symptoms** associated with this phase. These are erythema, hyperthermia, edema, pain, muscle spasm, and dysfunction.

***Erythema** is skin redness resulting from capillary engorgement.
***Hyperthermia** results from erythema.

*__Edema__ is caused by fluid accumulation in the interstitial spaces resulting from cell injuries.
*__Pain__ that results from the activation of nociceptors caused by damaged tissues, triggers the reflex **muscle spasm**.
*Finally, these combined symptoms cause temporary partial to total **dysfunction**.

*This phase is a **time-dependent process**, characterized by vascular, chemical, and cellular events that lead to the proliferative phase of healing.

*The inflammatory phase may last hours, days, or weeks depending on the severity of the pathology. It is the **crucial phase of healing**— without it, no tissue healing is possible.

C. Proliferative Phase:

*The inflammatory phase is followed by the proliferative phase, which deals with the formation and proliferation of new and immature repair tissues to replace the damaged tissues.

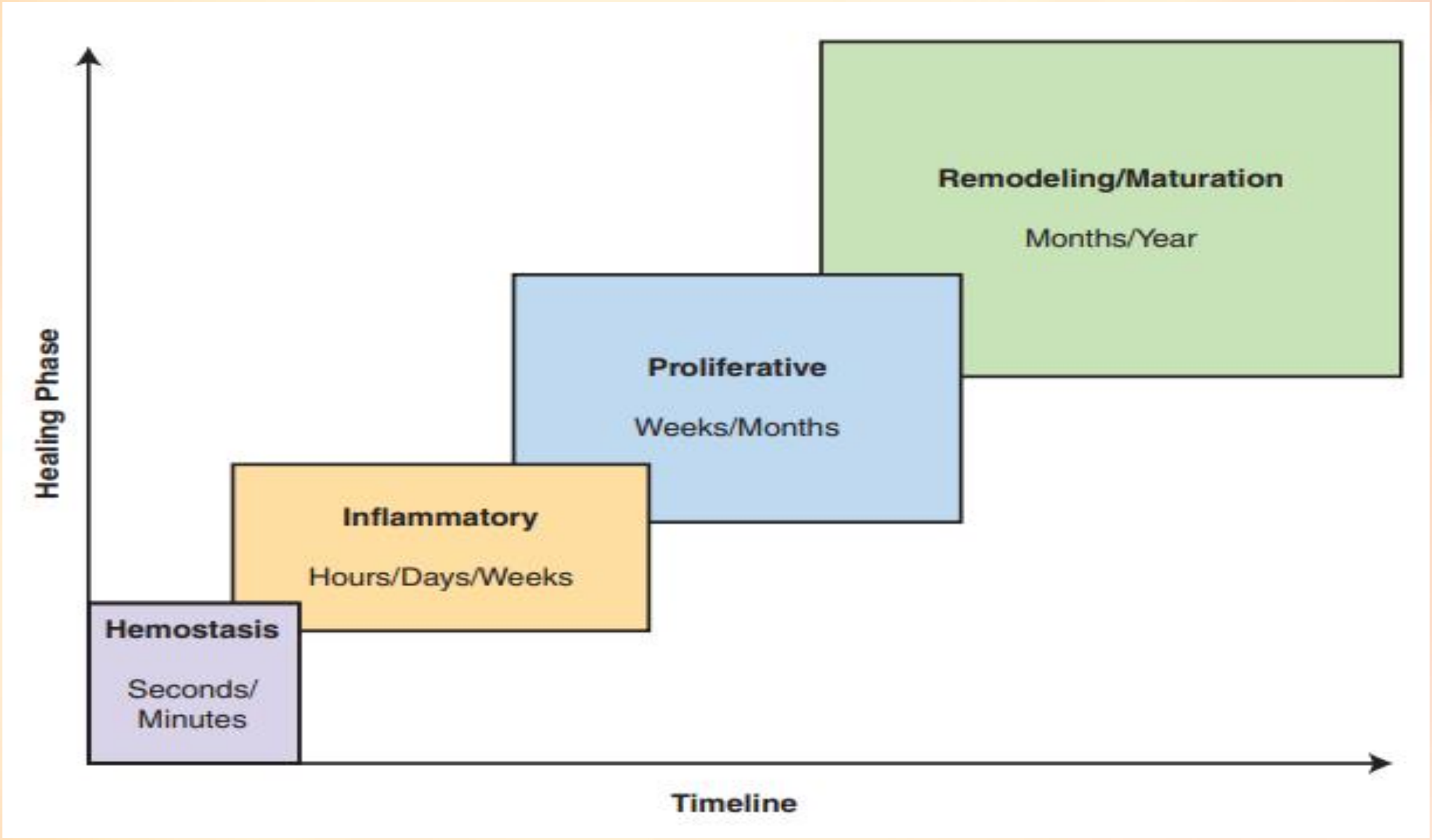
***Fibroplasia** and **angiogenesis** are key processes during this phase. **Fibroplasia** is the formation of fibrous tissue. **Angiogenesis** is the process of growing new blood vessels. These processes are concomitant with all the other cellular responses during this phase of healing.

*The proliferative phase may last for weeks and sometimes months depending on the severity of the pathology and the type of soft-tissue affected.

D. Remodeling/Maturation Phase:

*The fourth and final phase of healing is the **remodeling** (fiber alignment) and **maturation** (increase of mechanical strength) of immature tissue to form the most structurally functional tissue possible at the wound site.

*This phase usually lasts for months, sometimes more than a year, depending, again, on the severity of the pathology and the type of tissue affected.


Healing Phase
Remodeling/Maturation
Months/Year
Proliferative
Weeks/Months
Inflammatory
Hours/Days/Weeks
Hemostasis
Seconds/
Minutes
Timeline

*Tissue Regeneration and Repair:

*Tissue healing is defined as the natural response to pathology through which damaged and dead tissue is replaced by living tissue **(Delforge, 2002a)**.

*The purpose of this healing process is to restore the structural and functional continuity of body tissues that has been disrupted by the pathologic processes **(Martinez-Hernandez et al., 1990)**.

*Research has shown that injured soft tissues heal through one of two primary mechanisms: regeneration and repair **(Martinez-Hernandez, 1994)**.

*__Regeneration__ refers to the restoration of tissue that is identical in structure and function to the tissue that has been damaged or destroyed.

*__Repair__, on the other hand, involves fibrous scar formation, which alters the normal structure and functional properties of the affected tissues.

*__Soft-tissue healing__ occurs, in most cases, through a combination of regeneration and repair mechanisms.

*Healing Quality:

*Qualities of soft-tissue healing may be defined as ideal, acceptable, minimal, and failed **(Leadbetter, 2001)**.

*__Ideal healing__ is obtained when the wound is totally replaced by normal tissue structure, function, and appearance. This implies regeneration, meaning that the repaired tissue is identical to the original one.
*__Acceptable healing__ is observed when the healed wound shows almost normal structure and appearance, and less than optimal function.
*__Minimal healing__ is obtained when the healed wound shows minimal normal structure and appearance, and partial function.
*__Failed healing__ is present when the repair tissue shows abnormal structure, appearance, and function.

*Regardless of the therapeutic interventions used, **ideal healing is rare**. **Minimal to acceptable healing**, through the formation of scar tissue (repair mechanism) is **the best outcome** that practitioners and patients can look for.

Factors Influencing Tissue Healing

Maximizing Factors	Impeding Factors
Good general health status	Poor general health status
No comorbidity	Comorbidities
Younger age	Older age
Proper nutrition	Malnutrition
Active lifestyles	Sedentary lifestyle
Good compliance with treatment	Poor compliance with treatment


Thank
you!


سُبْحانك
اللّهُمّ وبحمدك
أشهدُ أنْ لا إله إلاّ أنتَ
أستغفرُك وأتوبُ إليك


قال ﷺ: "من سلك طريقاً يلتمسُ فيه علماً،
سهل اللّه له به طريقاً إلى الجنة"


وَقُل رَّبِّ زِدْنِي عِلْمًا
طه ١١٤
Islamiyatsb

ELECTROTHERAPY

INFRARED RADIATION

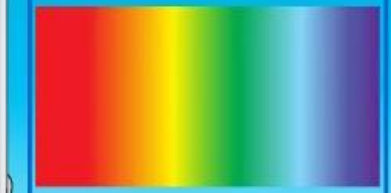
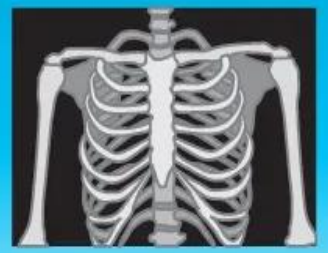
By:

Dr. Mohamed Gamal AbouElYazeed Ali

Lecturer of Physical Therapy

South Valley University

Types of Electromagnetic Radiation

radio	microwaves	infrared	visible light	ultraviolet	X-rays	gamma rays
						
used to broadcast radio and television	used in cooking, radar, telephone and other signals	transmits heat from sun, fires, radiators	makes things able to be seen	absorbed by the skin, used in fluorescent tubes	used to view inside of bodies and objects	used in medicine for killing cancer cells

Definition of Infrared Radiation

***Infrared radiation (IRR)** is electromagnetic radiation that lies within that part of the electromagnetic spectrum between visible light and microwave radiation—the radiation characterized by wavelength extended from 760nm to 1 mm.

*An **infrared radiation** is a superficial thermal agent. Any heated body emits infrared radiations that can be subdivided into three regions or bands, A, B, and C according to their wavelength,

TYPES OF INFRARED RADIATIONS

Type	Wavelength	Penetration
IR (A) (short or near IR)	760 -1400 nm	5 mm (to dermis)
IR (B) (long or far IR)	1400- 3000 nm	Up to 1 mm (to epidermis)
IR (C)	3000nm - 1 mm	Not used therapeutically

Sources of Infrared Radiations

1- Luminous I.R sources:

Luminous lamps are produced by electrically heated filament made of tungsten in an evacuated glass bulb which contains an inert gas at a low pressure; part of the glass bulb is silvered to provide a reflector. Power levels emitted range from 250-1500W.

Emission: luminous sources emit mainly:

-70% short IR 24% long IR

-5% visible light

-1% UV rays

2-Non-luminous I.R sources:

Non-luminous sources produce IRR from non-glowing sources such as moist hot packs and non-luminous lamps. Non-luminous rays are produced by electrically heated resistance wire coiled on a cylinder of insulating material such as porcelain. The resistance wire serves as the heater, and the cylinder becomes the radiation source.

Emission: non-luminous sources emit:

-mainly long IR: radiation (with about 10% short IR).

Power levels emitted range from 250-1000W.

*Absorption and penetration of IRR:

IRR is strongly absorbed near the skin surface, and the heat is carried to the deeper tissues by conduction and by the circulating fluids.

***The absorption of IRR and the maximal penetration of the rays will depend upon the following variables:**

1. Frequency or wavelength of the rays.
2. Angle of incidence of the rays.
3. The intensity of the emitting source.

Physiological Effects of IRR

1-Cutaneous vasodilatation

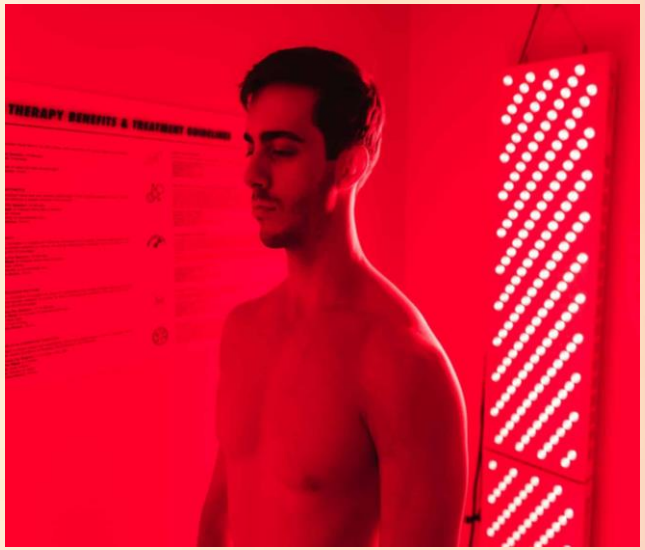
2-Increase in metabolism

3-Increase tissue extensibility

*N.B: Because increasing tissue extensibility alone will not decrease soft tissue shortening, infrared must be used in conjunction -with stretching and ROM exercises.

4-Pain control

***The heat produced by IRR leads to relief of pain by:**



-Increased pain threshold.

-Stimulation of the sensory nerves leads to inhibition of pain at the level of the spinal cord.

-Decreased activity of muscle spindles leads to decreased muscle spasm and muscle relaxation.

-Removal of waste products as a result of improving circulation and increasing venous return thus removing the source of pain.

N.B: Heat produced by infrared stimulates thermal heat receptors, so the patient is aware of heating.

Therapeutic Uses of IRR:

1- Relieve of pain.
2- Reduction of muscle spasm.
3- Acceleration of healing (stimulation of incisional wound healing).
4- Sub-acute and chronic inflammation of the musculoskeletal system.
5- Prior to stretching and mobilization exercises.
6- Some skin conditions as fungal infections.

Contraindications for IRR:

1- Acute inflammation.
2- Damaged or infected tissue.
3- Lack of local thermal sensitivity.
4- Impaired local circulation.
5- Local areas of recent, bleeding.
6- Over or near malignant tissue.
7- Unreliable patients: - very young or very old people.
8- Following deep X-ray therapy.

Clinical Application

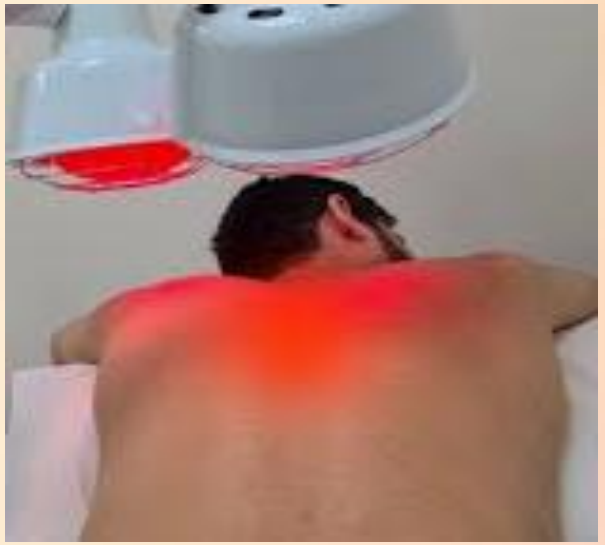
*Preparation of patient:

1- Place the patient in a comfortable position with the area to be treated exposed.
2- Inspect the area to be treated for any contraindications.
3- Explain to the patient the sensation that should be experienced (mild to moderate warmth).
4- Clean the area and remove any metal to prevent the concentration of heat.
5- The skin to be treated is examined and the thermal sensation is tested.

***Thermal sensation** is tested through the application of two test tubes, one contains **hot water** (**45º C**), and the other contains **cold water** (**15º C**) and ask the patient is asked to distinguish between them.

Setup and application

1-If a **non-luminous lamp** is chosen, switch it on at least 5 minutes before treatment to allow time for it to warm up and reach its maximum emission.

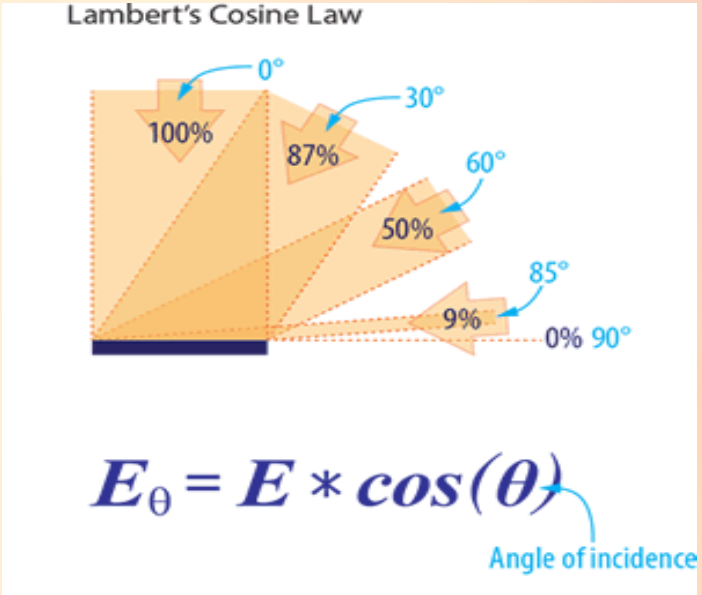


*A **luminous lamp** needs no warm-up.

2-Place the lamb so that the distance from the source of heat is approximately **50-75 cm** away from the patient.

***Practical Note:** Due to the increased absorption of the longer wavelengths by the top layers of the skin, the non-luminous units apparently feel hotter than the luminous ones at equal distances and power levels. So, place **non-luminous lamps** at slightly greater distances (**75-105cm**) and, at **an angle of 45º**.

3-Adjust the **luminous lamp** so the energy will strike the tissue at a right angle (**90º**), based on the **cosine law**.



4-Instruct the patient **not to touch any part of the lamp** or to move during treatment and to report any discomfort or excessive heating.

5-The **intensity of heating of IR** is controlled by changing the distance of the lamp from the patient.

6-The **duration** of treatment is from **10-15 minutes** as it is only part of a treatment, not a treatment in itself.

7-After termination of treatment inspects the treated area. Usually, there is mottled (patchy) **erythema** without any discomfort.

Hazards and Potential Dangers

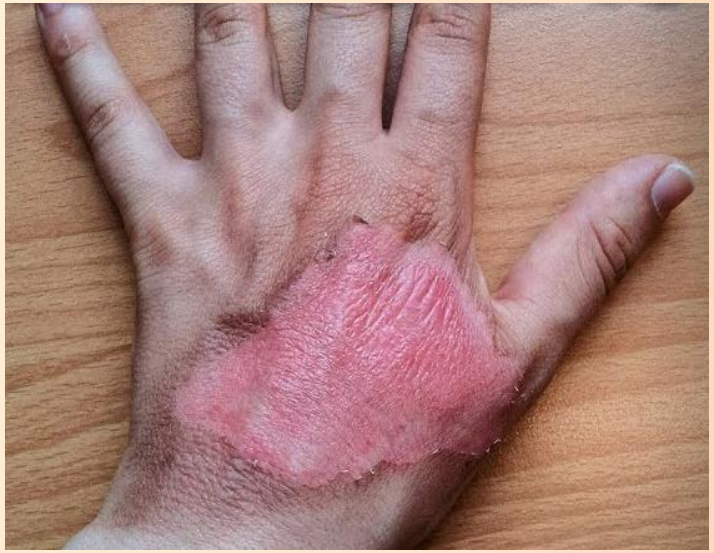
***Burns:** The main danger of IR treatment is a burn.

Burns are always a potential risk if:

1-heat is too intense.

2- the patient is not fully aware of the level of heating or,

3- unable to communicate effectively.



***Eye Damage:** For patient comfort, and to avoid eye surface drying and possible irritation, eyes should be covered with a light towel, or the head turned away during an exposure.

* كل الشكر للأستاذ الدكتور أمير صالح لمساعدته فى تحضير المادة العلمية للمحاضرة*


Thank
you!


سُبْحانك
اللّهُمّ وبحمدك
أشهدُ أنْ لا إله إلاّ أنتَ
أستغفرُك وأتوبُ إليك


قال ﷺ: "من سلك طريقاً يلتمسُ فيه علماً،
سهل اللّه له به طريقاً إلى الجنة"


وَقُل رَّبِّ زِدْنِي عِلْمًا
طه ١١٤
Islamiyatsb

ELECTROTHERAPY

SHORTWAVE DIATHERMY

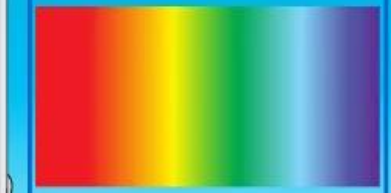
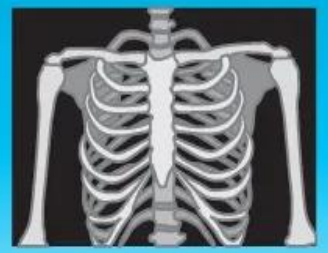
By:

Dr. Mohamed Gamal AbouElYazeed Ali

Lecturer of Physical Therapy

South Valley University

Types of Electromagnetic Radiation

radio	microwaves	infrared	visible light	ultraviolet	X-rays	gamma rays
						
used to broadcast radio and television	used in cooking, radar, telephone and other signals	transmits heat from sun, fires, radiators	makes things able to be seen	absorbed by the skin, used in fluorescent tubes	used to view inside of bodies and objects	used in medicine for killing cancer cells

Definition of Shortwave Diathermy

*__Shortwave Diathermy (SWD)__ is the use of shortwave electromagnetic energy for heating deep soft tissues such as muscles and joints.

*The word **Shortwave** refers to the shortwave electromagnetic band, or region, of the electromagnetic spectrum, and the word diathermy means “through heat” (dia = through; thermy = heat).

*The **resistance** offered by soft tissues to the passage of **shortwave** electromagnetic energy causes them to heat up.

Physical Principles of Diathermy

*__Diathermy__ devices deliver electromagnetic waves to the tissues of the body. The most common diathermy device in use today delivers **27.12 MHz** frequency waves from the short wavelength radio wave section of the electromagnetic spectrum and is commonly referred to as **shortwave diathermy (SWD)**.

*Devices that deliver electromagnetic waves from the microwave range are known as **microwave diathermy (MWD)**. The frequency most commonly used for microwave diathermy is **2,450 MHz**.

TABLE 6–10. Radio Frequencies Approved by the FCC for SWD/MWD and PEMF

Frequency (MHz)	Wavelength	Type of EM Radiation
13.56	22 m	SWD/PEMF
27.12*	11 m	SWD/PEMF
40.68	7.5 m	SWD/PEMF
915.00	33 cm	MWD
2450.00	12 cm	MWD

Types of Shortwave Diathermy

1- Capacitive Applicators: The capacitive method of SWD (also known as the electric field method) uses an applicator system that requires that the patient's tissues become part of a capacitor.

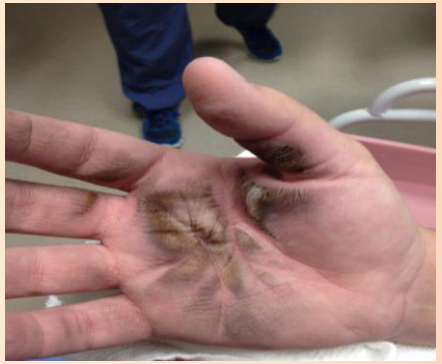
*A **capacitor** is a device that can store electrical charge and consists of two conducting objects placed near each other and usually separated by a dielectric.

*The **capacitive electrodes** cause an oscillating electric current to flow through the body tissues between the electrodes.

*Resistance to current flow in the tissue results in tissue heating.

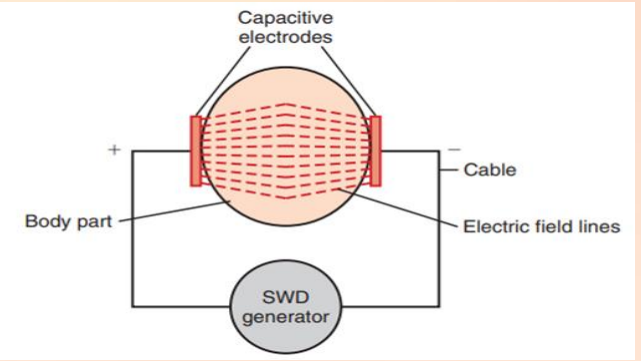
*Capacitive SWD devices have adjustable arms with metal plates (electrodes) at their ends.

*Most capacitive SWD plates have a glass or plastic guard surrounding each metal plate to prevent contact between the electrode and the patient's skin.



*A severe electrical burn may occur if either the therapist's or the patient's skin contacts the bare metal plate of the diathermy device.

*A single layer of terrycloth toweling should be placed between the plate guards and the patient's skin to prevent the concentration of the electric field on perspiration that may accumulate on the skin.



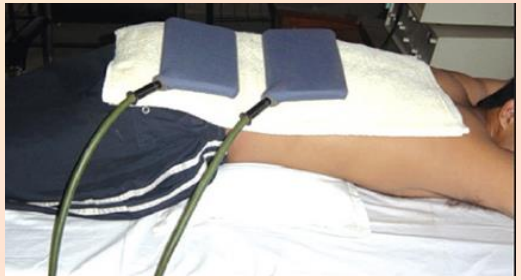
*Most plates can be adjusted by about 3 cm within the guard. The plastic plate guard should be located about 2 to 10 cm from the skin for optimal heating, and the metal plate should be as far from the skin as the guard allows (at least 2.5 cm).

*As the plate-to-skin distance increases, heat perception decreases.

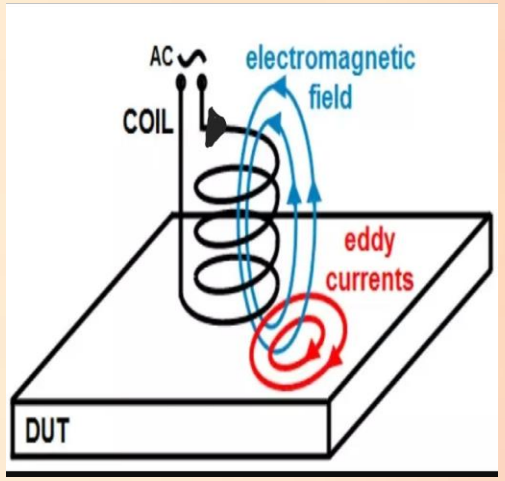
*Capacitive SWD can be positioned in two possible options:

1) **Contraplanar arrangement:** the plates are placed on each side of the body part so that the body part creates a biological capacitor.

2) **Coplanar arrangement:** it requires positioning the plates parallel on the same body surface.

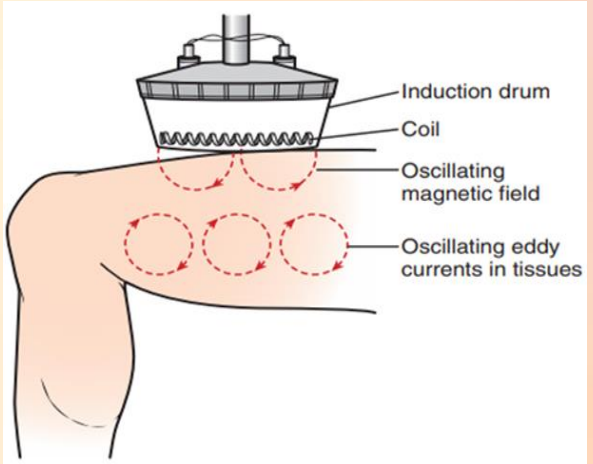


2-Inductive Applicators: The inductive method of SWD (also known as the magnetic field method) requires an inductive applicator that creates an oscillating magnetic field that induces "eddy" currents in body tissues.



*These **eddy currents** flow along pathways of higher conductivity, causing heating in these tissues. The greatest density of eddy current activity—and therefore the greatest amount of heating—occurs in low-impedance (high-conductivity) tissues containing the highest electrolyte content, such as **skeletal muscle** and **blood**.

*Two types of inductive coil applicators can be used to deliver the magnetic field energy to the patient: **drums** or **sleeves**.



1)Drum applicators: contain a coil-shaped cable that is contained within a rigid plastic insulator housing.

-There are two types of drum applicators:

A) Amonode: is a drum used to treat a single-body surface and requires a single-layer of terrycloth toweling to create additional spacing and moisture absorption from the skin.

B) A diplode: is a hinged drum that allows one or more body part surfaces to be treated simultaneously.

2)An induction sleeve: is a new method of delivering diathermy to a patient. Sleeves are designed to fit around a body part, such as the elbow and forearm, providing a circumferential treatment effect.

-The advantages of diathermy sleeves include their portability and ease of application.

-A disadvantage is their heating ability is limited to moderate tissue temperature increases.

__Key Point__ The electromagnetic waves produced by diathermy devices will not cause depolarization of nerves or muscles. and **will not cause cell mutations**.

Continuous versus Pulsed Shortwave Diathermy

*There is growing evidence to suggest that over the past two decades, the use of **PSWD** may have surpassed **CSWD** as the delivery mode of choice.

*A possible explanation for this shift may be that the application of **PSWD**, associated with less stray radiation, is safer for the operator. Another likely reason the use of **PSWD** is on the increase is that a much greater number of clinical studies have been published over the past years showing that low-wattage PSWD can induce a significant deep heating response in human soft tissues.

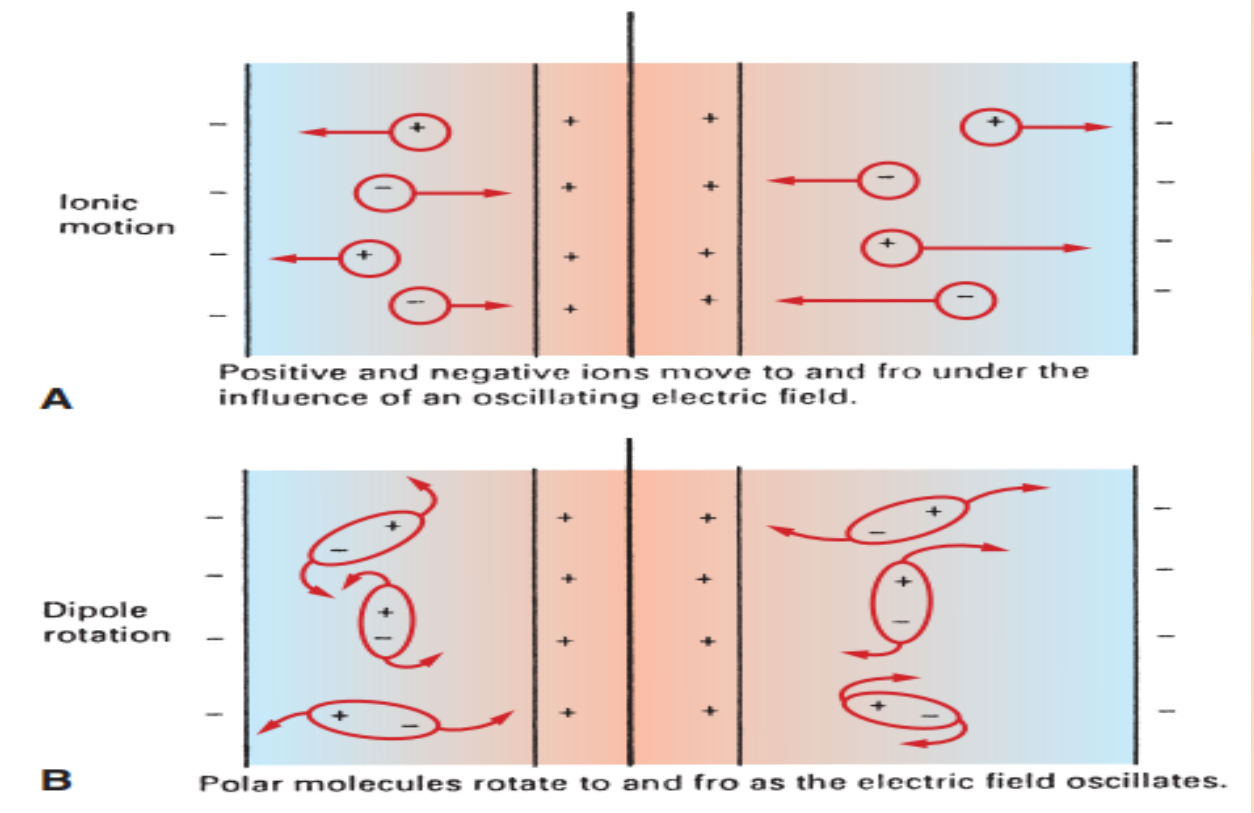
Physiological Effects of SWD

*There is a theoretical consensus in the literature that the thermal effects induced by the application of SWD, are primarily caused by two mechanisms: **ionic oscillation** and **dipole rotation**.

1) Ionic oscillation: Soft tissues contain billions of charged particles or ions, such as sodium (Na+), potassium (K+), and chloride (Cl−). When these ions are exposed to the high-frequency oscillating current generated by the device, they are presumed to move or oscillate, in response to the oscillating electric (capacitive) and eddy (inductive) current field **(Scott, 2002).**

2)Dipole rotation: Soft tissues also contain billions of dipolar, or water, molecules—hydrogen (H+) and oxygen (O−).

When these dipoles are exposed to this same high-frequency oscillating current, the bipolar molecules are also presumed to rotate in response to the oscillatory current field **(Scott, 2002)**.



*The **combined effect** of these microscopic oscillatory and rotational movements of particles is the production of **kinetic energy**, which is then converted into **thermal energy**.

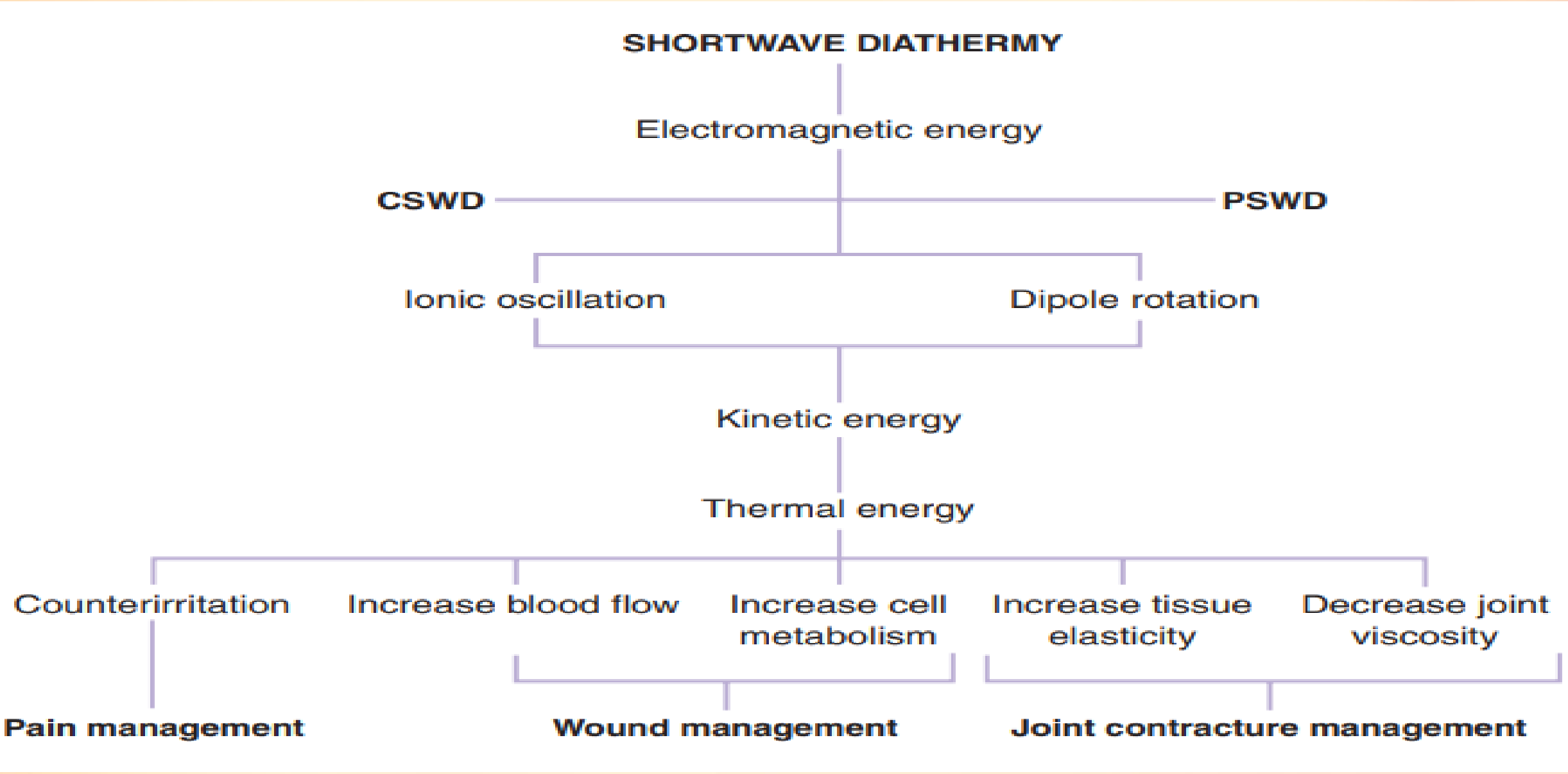
Therapeutic Effects of SWD

*The **therapeutic goal** with SWD is to elevate the temperature of deeper of soft tissues to the desired temperature window, which ranges **between 36°C and 45°C** (97°F and 113°F).

*The proposed therapeutic effects of SWD are counterirritation, increased blood flow, increased cell metabolism, increased tissue elasticity, and decreased joint viscosity.

*As a result, **SWD** is used primarily for the management of pain and wounds as well as for the management of joint contracture.

Therapeutic Uses of SWD:



Primary effects of PSWD:

1- Increased number of WBCs and fibroblasts in a wound.

2- Improved rate of edema dispersion.

3- Encourages absorption of hematoma.

4- Reduction (resolution) of the inflammatory process.

5- Prompts a more rapid rate of fibrin fiber orientation & and deposition of collagen.

6- Encourages the repair and healing of fractures.

7- Stimulation of osteogenesis.

8- Improved healing of the peripheral nervous system.

Instructions for SWD Application

-Remove the clothing from the treated area of the patient and examine it **before and after** treatment.

-Assess the patient's sensitivity using either hot or cold test tubes.

-Replace any damp bandages or dressings with dry ones.

-Ensure that all metal objects are **taken away** from the treatment area.

-Allow the patient to rest for an adequate period after treatment until the skin has cooled, especially in adverse weather conditions or for elderly individuals.

-Position the patient on a **non-metallic chair** and use **mattresses without metal components**. The patient should be placed in a comfortable position with minimal movement or preferably no movement during treatment. Even slight movements during the treatment could alter the electrical impedance in the circuit, potentially leading to increased current flow and a risk of burns.

-Inform the patient that they will experience a **mild and pleasant sensation of heat**, and any burning or discomfort should be reported immediately.

-Start the patient's circuit at a low output level and then adjust it to the required level.

Clinical Application of SWD

*__Acute conditions:__

•Mean power of less than 3 Watts.

•Using narrower (shorter duration) pulses and a higher repetition rate may be beneficial.

•Time: 10 minutes is probably sufficient

*__Subacute Conditions:__

•Mean power of between 2 and 5 Watts.

•As the condition becomes less acute, use wider (longer duration) pulses

•Time: 10 - 15 mins.

*__Chronic Conditions:__

•Mean power of more than 5 Watts is usually required in order to achieve a reasonable tissue response.

•Pulses of longer duration are probably of benefit if there is a choice.

•Time: 15 – 20 mins.

Contraindications for SWD:

1- Pacemakers.
2- Pregnancy.
3- Current tissue bleeding.
4- Malignancy.
5- Active tuberculosis.
6- Severe circulatory compromise or deficit.
7- Unreliable patients: - very young or very old people.
8- Deep X-ray therapy or other ionizing radiations (in the last 6 months).

Precautions for SWD:

1- Avoid active epiphyseal regions in children

2- Avoid specialized tissues (e.g., eye and genitalia)

*__Pregnant__ physiotherapists or others with concerns may want to ask a colleague to turn the **SWD / PSWD** machine on.

*Almost all modern machines will turn off automatically.

*It is considered unwise to operate two **SWD / PSWT** without maintaining a separation of **at least 3 meters**.


Thank
you!


سُبْحانك
اللّهُمّ وبحمدك
أشهدُ أنْ لا إله إلاّ أنتَ
أستغفرُك وأتوبُ إليك


قال ﷺ: "من سلك طريقاً يلتمسُ فيه علماً،
سهل اللّه له به طريقاً إلى الجنة"


وَقُل رَّبِّ زِدْنِي عِلْمًا
طه ١١٤
Islamiyatsb

ELECTROTHERAPY

THERAPEUTIC ULTRASOUND

By:

Dr. Mohamed Gamal AbouElYazeed Ali

Lecturer of Physical Therapy

South Valley University

Introduction of Ultrasonic Therapy

*__Ultrasound (US)__ is a form of mechanical energy, not electrical energy.

*Mechanical vibration at increasing frequencies is known as **sound energy**.

*The normal human **sound range** is from 16 Hz to something approaching 15-20,000 Hz.

*__ULTRASOUND__ means greater than the speed of sound, the frequencies used in therapy are typically between **1 MHz** and **3 MHz** (1MHz = 1 million cycles per second).

TABLE 20-1 SPECTRUM OF THERAPEUTIC ULTRASOUND

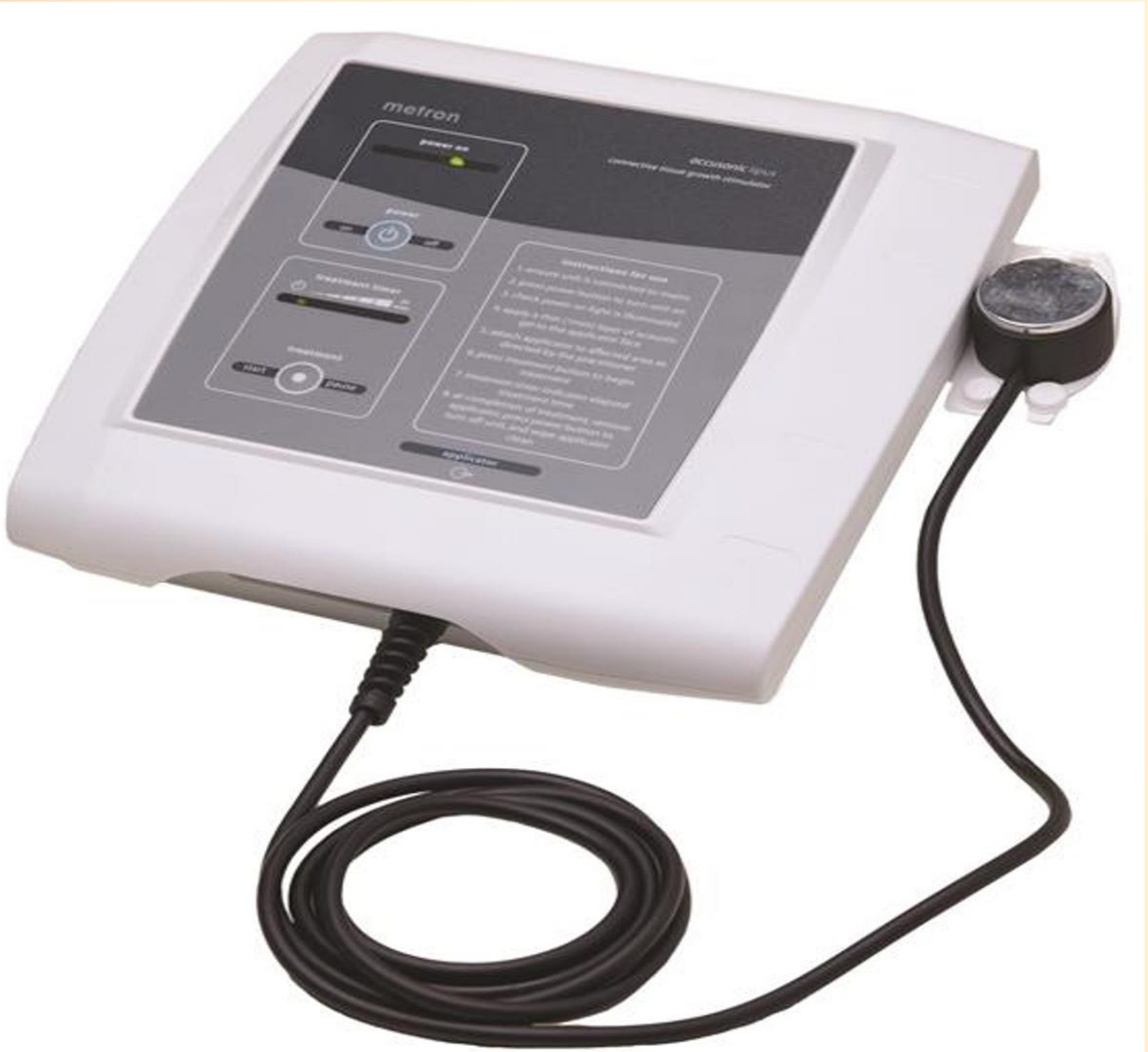
Characteristics		CUS	LIPUS	NCLFUS
Frequency	Low (LF) Mid (MF) High (HF)	MF/HF 1–3 MHz	MF 1.5 MHz	LF 40 kHz
Intensity	Low (LI) High (HI)	LI/HI 0–3 W/cm^2	LI 0.03 W/cm^2	LI 0.5 W/cm^2
Delivery mode	Continuous (C) Pulsed (P)	C/P	P	P
Application technique	Stationary (S) Dynamic (D)	D	S	D
Application method	Contact (C) Noncontact (NC)	C/NC	C	NC
Coupling agent	Gel (G) Water (W)	G/W	G	W
Effect	Mechanical (M) Thermal (T)	M/T	M	M
Indication		Muscle, tendon, and ligament disorders	Bone fracture	Dermal wounds

CUS, conventional ultrasound; LIPUS, low-intensity pulsed ultrasound; NCLFUS, noncontact low-frequency ultrasound.

Typical conventional ultrasound device (**A**) with soundhead applicators of various sizes

Aquasonic gel

gel pad



Low-intensity pulsed ultrasound device.

Noncontact low-frequency ultrasound device

Biophysical Characteristics of Therapeutic Ultrasound

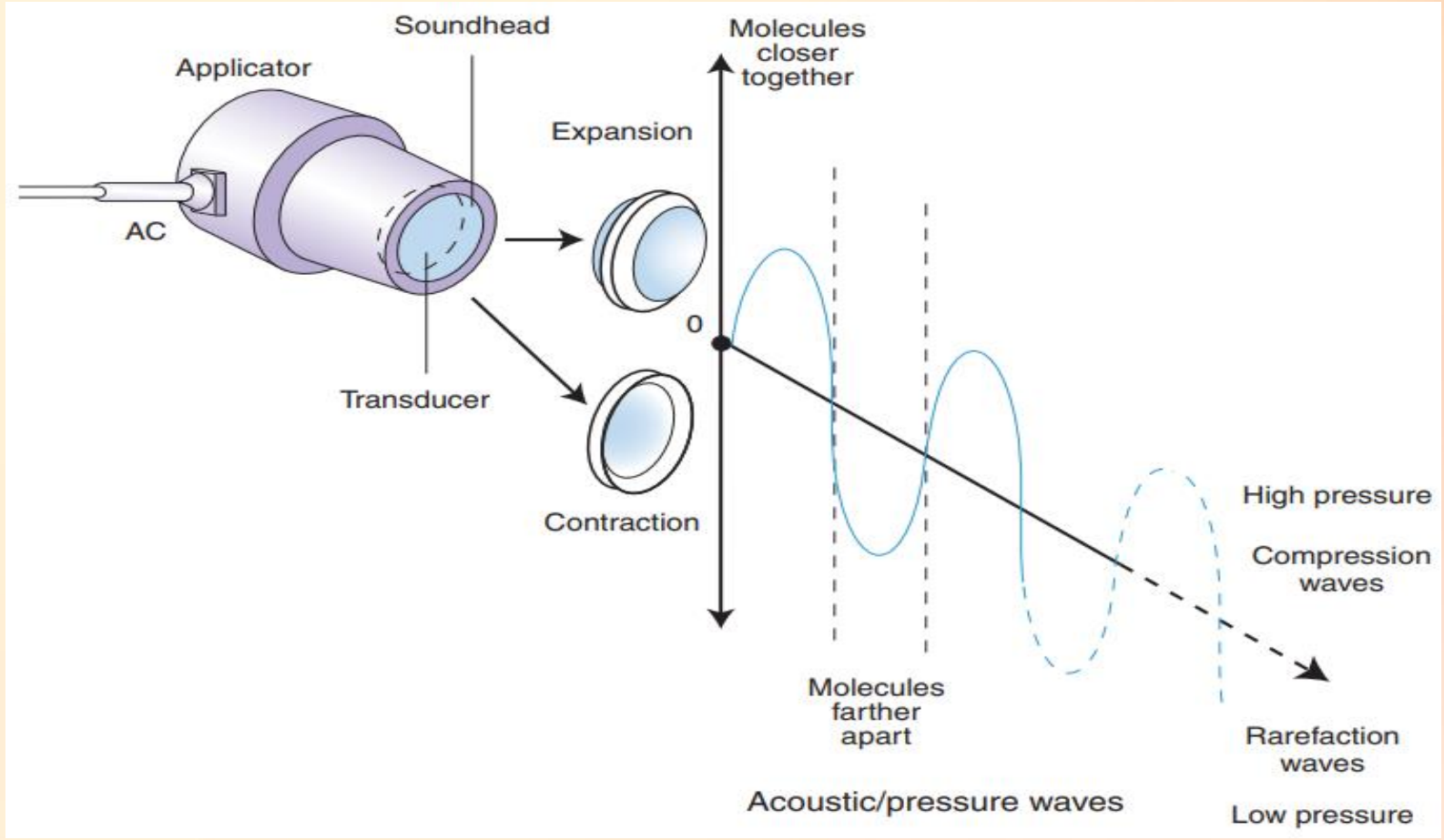
-Ultrasonic Wave Form:

*The formation of sound, or mechanical waves, is based on the reverse piezoelectric effect, which states that when a high-frequency, alternating electrical current (AC) is applied to the surface of a piezoelectric material, called a transducer, mechanical deformations of this transducer follow in the form of oscillations, or cycles of expansion and contraction.

*The repeated high-frequency cycles of micro expansion and micro-contraction of the transducer create an **ultrasonic** beam of energy described as acoustic, mechanical, or pressure waves having a sinusoidal shape and traveling in time in the medium.

*During the **expansion phase** of the transducer, high pressure develops in the soft tissues, bringing molecules closer together. During the **contraction phase**, however, low pressure develops, which sends molecules farther apart.

***Ultrasound waves** are longitudinal waves because the motion of the molecules in the medium is parallel to the direction of the wave propagation.

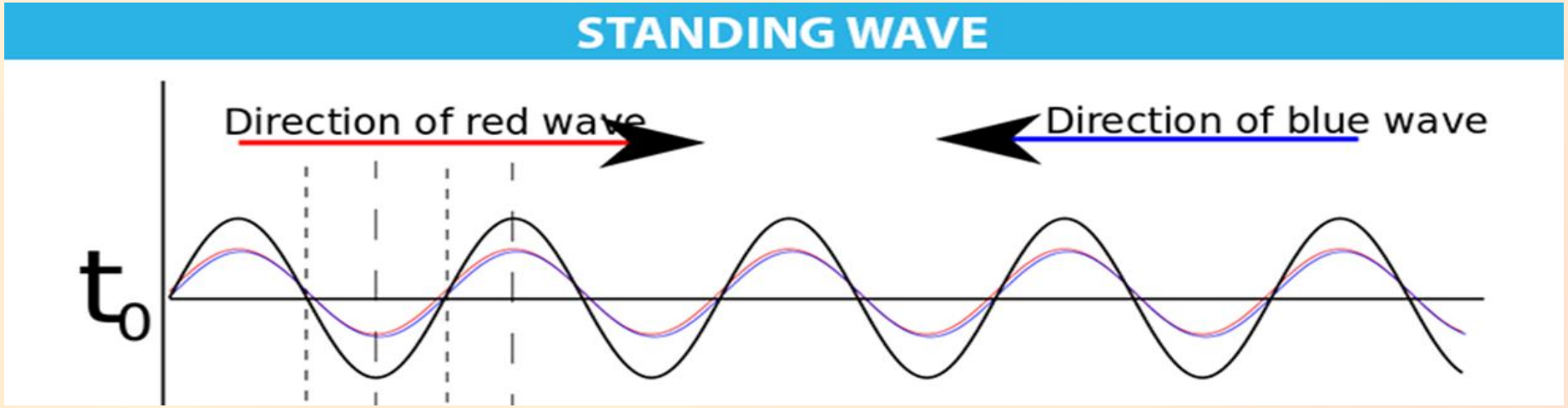


*When **acoustic waves** reach a point of change in tissue density, waves can be **reflected**, **refracted**, or **absorbed**.

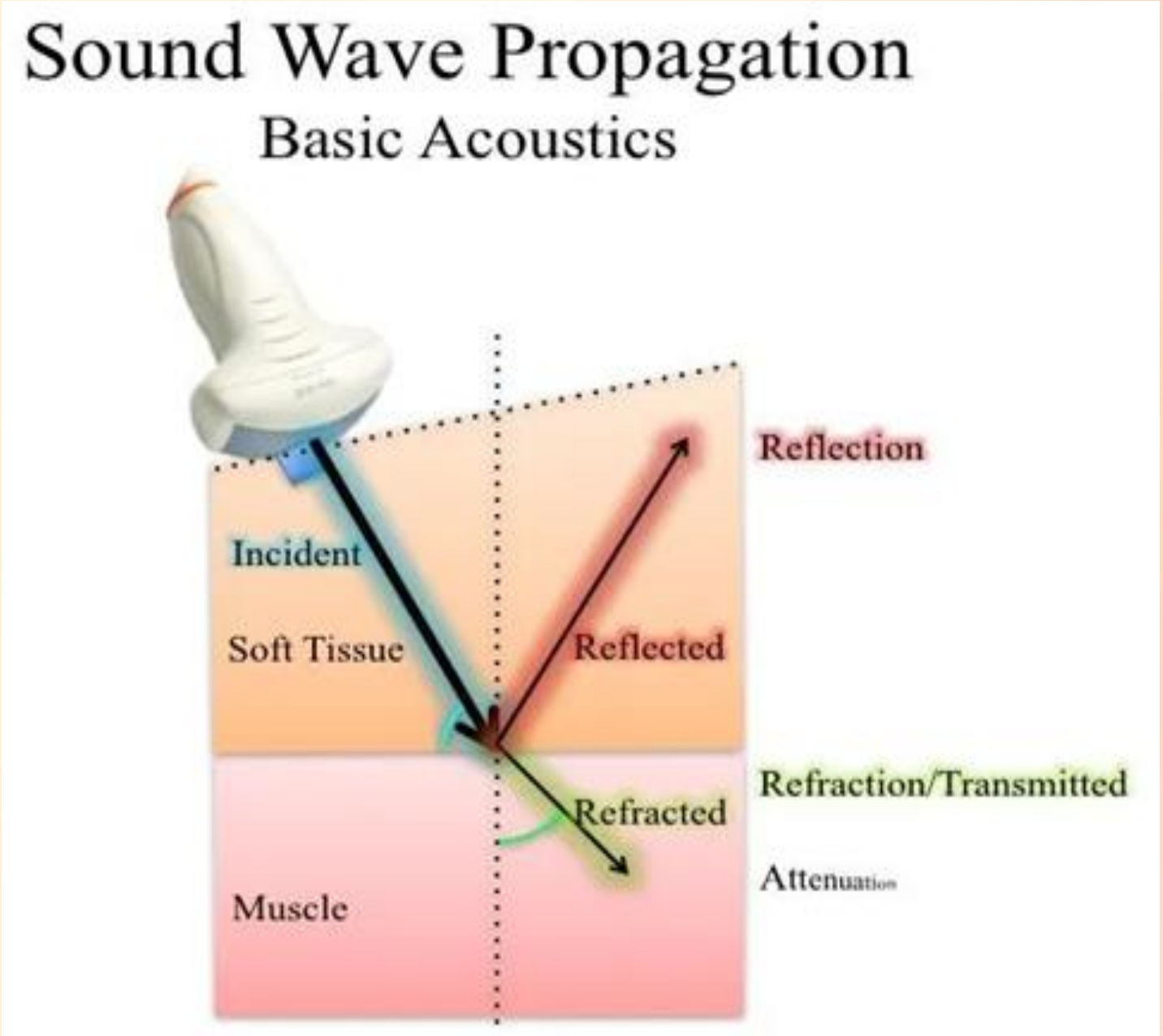
*When the wave is absorbed, the kinetic energy of movement is transformed into thermal energy.

*Those **waves** that pass through the denser tissue will be refracted and will no longer follow their original path.

***Reflected waves** can interact with the incident waves by enhancing the wave intensity forming a **standing wave**.



*Most body tissues behave as liquids of varying densities. **Bone** is an exception, as it acts as a solid. Thus, although longitudinal waves predominate in most tissues, **both longitudinal and transverse transmission** of **ultrasonic waves** occur in **bone**.



*The two main components of the US device are the **generator** and the **applicator**.

*The **US applicator** consists of two main components: the **piezoelectric crystal** and the **sound head**.

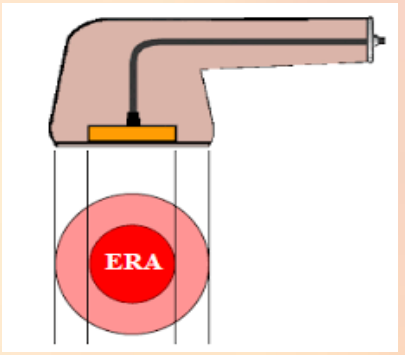
*The **piezoelectric crystal** is a thin sheet (2 to 3 mm thick) made of lead zirconate or titanate ceramic.

*An **alternating electrical current** is sent through the **crystal**, causing it to undergo compression and expansion.

*When **no current** is applied, the **crystal** maintains its normal shape.

*The **acoustic wave** is transmitted through the **sound head** connected to the **piezoelectric crystal**.

*The **crystal's** structure and size produce a collimated **beam** of **acoustic waves**.



*The **beam** is slightly **smaller** than the **crystal's size** because the crystal's ends do not expand or contract much.

*The **effective radiating area (ERA),** which is approximately 10% smaller than the surface area of the applicator head, represents the crystal's portion that contributes to acoustic waves.

*Also, the **sound head** of the **US device** is often aluminum, stainless steel, or ceramic. It covers the **piezoelectric crystal**.

*The stainless-steel **sound head** is preferred for its durability.

***Acoustic energy** from the **crystal** is conducted to the **sound head** and then through a **conductive gel** into the skin.

CHARACTERISTICS OF THE ULTRASOUND WAVE AND TREATMENT PARAMETERS

1)Frequency:

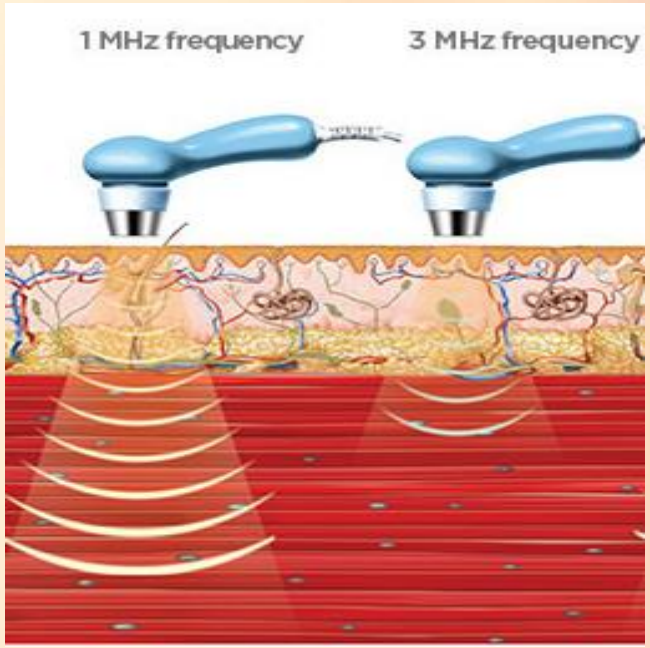
*__Frequency__ in ultrasound (US) refers to the number of waves delivered per second.

*Most therapeutic US units offer **dual-frequency applicators** with options like **1 MHz** and **3.3 MHz.**

*__Frequencies__ typically range from 0.75 to 3.3 MHz (millions of cycles per second).

*__Depth__ is **inversely proportional** to the US **frequency**, **Higher frequencies** (e.g., **3 MHz**) are effective up to 2.5 cm deep, while **lower frequencies** (e.g., **1 MHz**) can penetrate up to 6 cm deep.

*Increasing the **intensity** of ultrasonic energy doesn't necessarily result in deeper penetration; it's the **frequency** that primarily affects penetration depth.



*Tissues absorb **3-MHz US** three times faster than **1-MHz US**, leading to faster tissue heating.

N.B.

*The rate of tissue heating is related to the rate of absorption, making **3 MHz US** suitable for **more superficial structures** (e.g., **tendons**), while **1 MHz** is used for **deeper structures** (e.g., **muscles**).

2)Intensity:

*__Intensity__ is defined as the amount of acoustic power, measured in watts, per unit area of the transducer ERA, measured in square centimeters.

*__Spatial Peak Intensity (ISP)__ refers to the maximum intensity delivered during the continuous delivery of US energy.

*__Spatial average intensity (ISA)__ refers to the mean or average, intensity delivered during pulsed delivery of US energy.

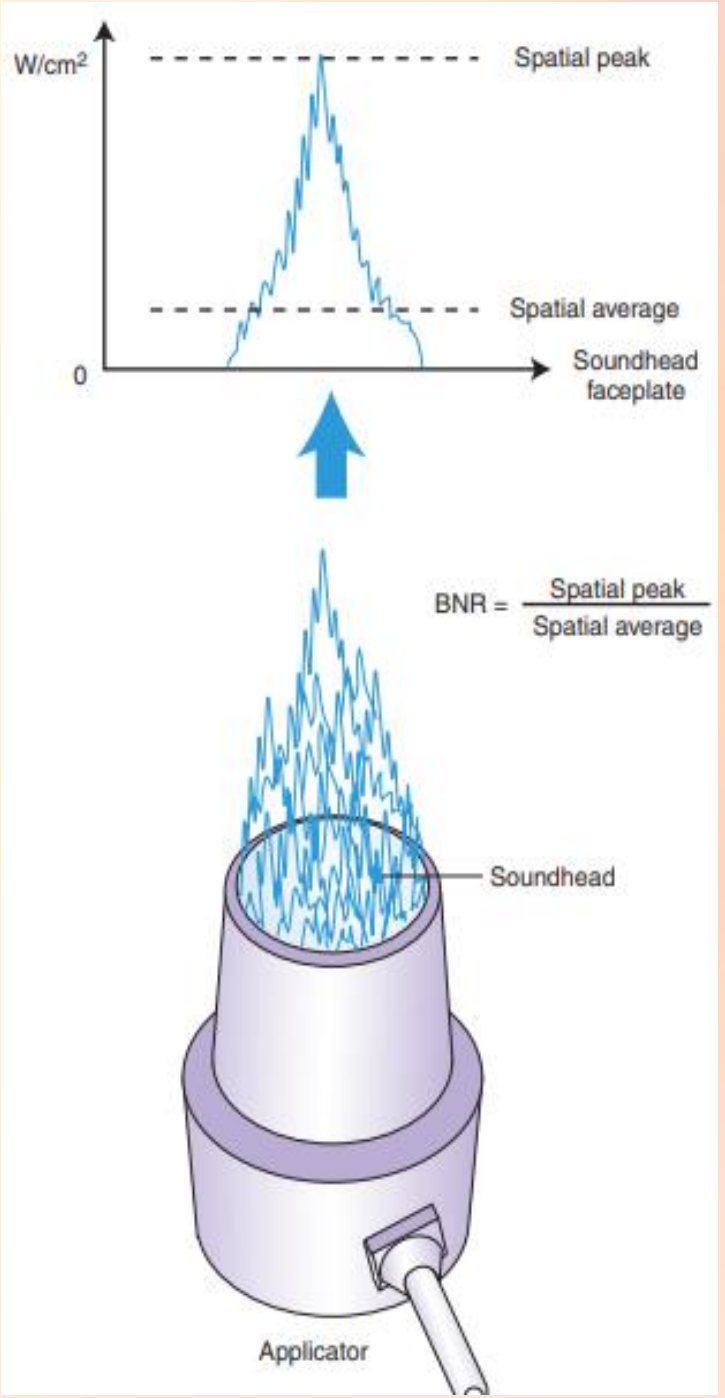
*The **nonuniformity** of an **ultrasonic beam** of energy is represented by its **beam nonuniformity ratio (BNR)**.

*A transducer **BNR** is calculated as the **ratio** of its **spatial peak intensity** (ISP) to its **spatial average intensity** (ISA).

*Many US units have BNRs between 5 and 6, although **better** units have BNRs of about 2 to 3.

*The areas of peak intensity can form "**hot spots**", which can easily cause tissue damage or discomfort if an area is sonicated for too long.

*To equally distribute these **hot spots** around the treatment area and avoid burns or discomfort, the **US head** must be continuously moved in a pattern over the treatment area throughout the period of application.



Tissue State	Intensity required at the lesion (W/cm2)
Acute	0.1 - 0.5 W/cm2
Subacute	0.5 – 1 W/cm2
Chronic	1 - 1.5 W/cm2

3)Mode of Delivery:

*Therapeutic CUS is delivered using the continuous and pulsed modes.

*Continuous mode refers to the uninterrupted flow of acoustic energy during the entire treatment duration.

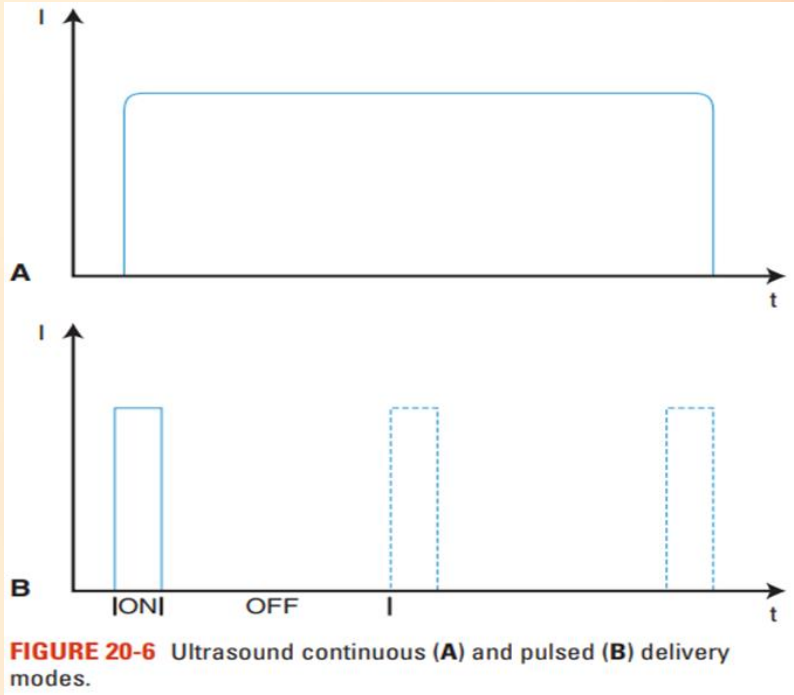


FIGURE 20-6 Ultrasound continuous (A) and pulsed (B) delivery modes.

*Pulsed mode refers to periodic interruption of acoustic energy characterized by ON (flow) and OFF (no flow).

4)Duty cycle (DC):

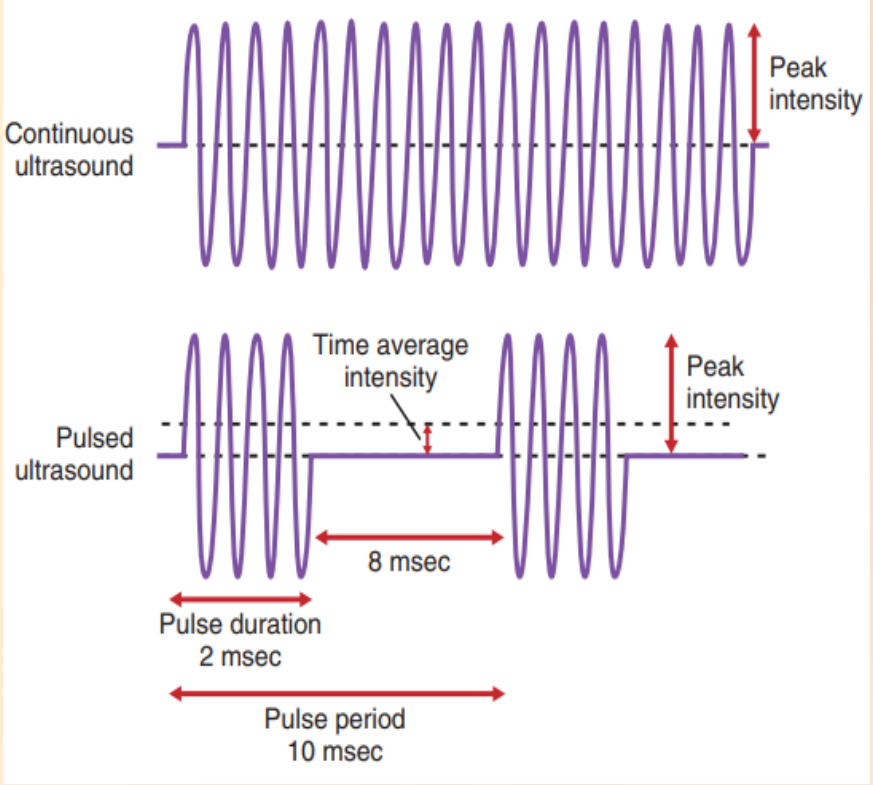
*It refers to the **duration**, measured as a **percentage** (%), during which acoustic energy is delivered and is calculated using this formula: **DC (%) = (ON/(ON + OFF)) × 100**.

*The **duty cycle** related to the **continuous mode** is always 100% because there is no (zero) OFF time.

***Duty cycle** related to the **pulsed mode** equals 20%:

20% = (2 ms / (2 ms + 8 ms)) × 100.

*This **duty cycle** means that ultrasonic energy is delivered for a period equivalent to 20% of the total treatment duration.



5)Treatment Duration:

*The **duration of US treatment** is dependent on different aspects like the surface area of the treated area, the US mode, and the specific status of the treated area.

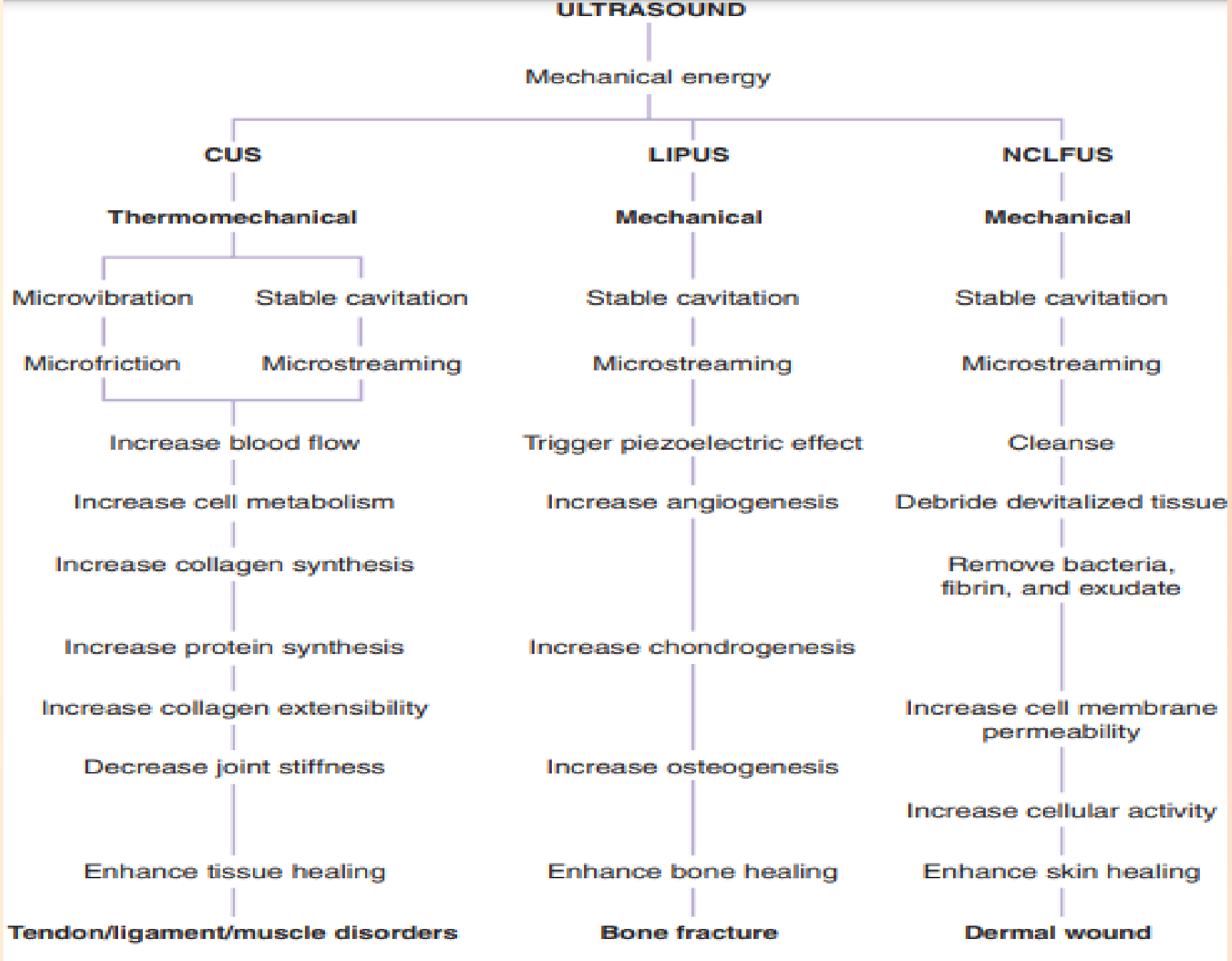
*Generally, **US** can be applied between 5-10 minutes per session.

*For **Continuous US**, **Don not** cover an area of more than 2-3 times the ERA of the applicator head **per 5 minutes** of treatment.

*For **Pulsed US**, use the **rule of 1 minute**; 1 min. × [1:2 Duty cycle, represents pulse factor of 3 **or** 1:4, represents pulse factor of 5)] × numbers of square areas will be covered by the US head.

***Move the applicator head slowly** (1.5 inches per second) in overlapping circles or longitudinal strokes.

Physiological Effects of Therapeutic Ultrasound



Therapeutic Effects and Indications of CUS

1)Thermal Effect:

*When acoustic energy penetrates soft tissues, molecules in the acoustic field vibrate at high frequencies, experiencing compression and rarefaction waves.

***Higher intensity** of the ultrasonic beam and **continuous emission of** acoustic waves lead to **more vigorous molecular micro-vibration** and **micro-friction** between sonated molecules.

*The increase of 1°C→ Increase metabolic rate, 2-3°C→ Reduce muscle spasm, and 3-5°C→ Increase tissue extensibility.

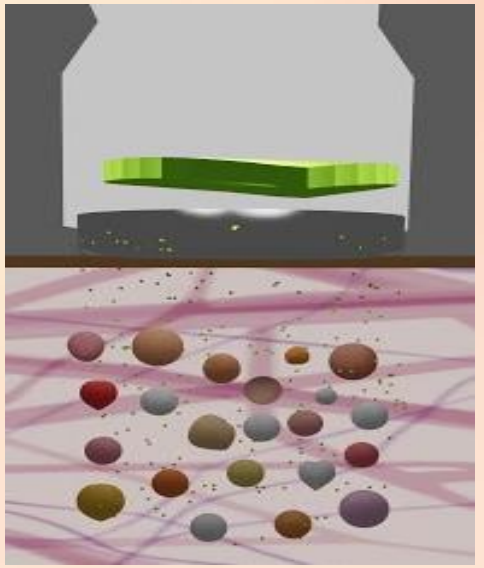
*This heightened **micro-friction** effect generates more intense cellular kinetic energy, producing **frictional heat** in the tissue.

2)Mechanical Effect:

*It is triggered by the absorption of ultrasonic energy.

*Delivery of ultrasonic energy to soft tissues induces **two mechanical effects:** stable cavitation and microstreaming.

*__Cavitation__, from the Latin word "cavus" meaning "hollow," involves the formation of empty spaces or cavities, such as **microbubbles**.

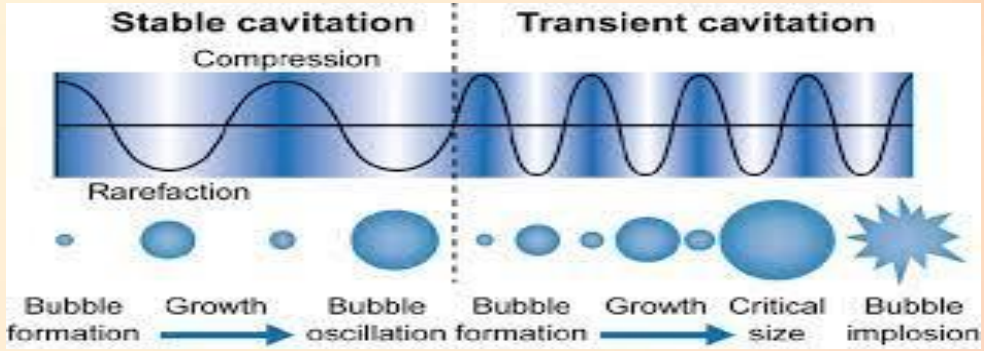


*Under the influence of acoustic radiation, these **bubbles** pulsate or oscillate at the same frequency as the acoustic waves.

*Depending on **frequency** and **intensity**, two types of **cavitation** can occur stable and unstable.

*__Stable cavitation__ involves bubbles pulsating during high and low-pressure waves, causing molecular movement known as **microstreaming**.

*__Microstreaming__ is the creation of localized high-velocity fluid streams by ultrasonic energy in a liquid.



*The movement and transfer of fluids induced by **microstreaming** contribute to the **therapeutic effects** of ultrasonic treatment in soft tissues.

*__Unstable cavitation__, which poses **no therapeutic concern**, occurs when the bubbles, subjected to **strong** cycles of compression and expansion, their collapse, releasing very high temperature and pressure changes in their vicinity in the fluid.

3)Targeted Tissues:

*For **thermomechanical effects** to occur, **ultrasonic energy** must be absorbed by soft tissues. **Attenuation** reflects on the weakening of sound energy as it propagates through a medium such as soft tissues. It reflects the absorption.

*The **larger the attenuation** coefficient of a tissue, the **greater** its **capacity to absorb** ultrasonic energy.

*More dense connective tissues, such as ligaments and tendons, **absorb US better** than less dense tissues such as muscle and fat.

*Although **cartilage** & **bone** have the highest protein (**Collagen**) content, the problems associated with wave **reflection** mean that **most US energy** striking their surfaces is likely to be reflected.

*There is an **inverse** relationship between absorption and penetration.

***Attenuation** means that the amplitude and intensity of **US waves** decrease as they travel through tissue.

TABLE 4–1. Attenuation of a 1-MHz Ultrasound Beam in Various Tissues

Tissue	Attenuation (%/cm)
Blood	3
Fat	13
Muscle	24
Blood vessel	32
Skin	39
Tendon	59
Cartilage	68
Bone	96

AMOUNT OF ULTRASONIC REFLECTION	
Interface	**Energy Reflected**
Water – Soft tissue	**2%**
Soft tissue – Fat	**1%**
Bone	**15 – 40%**
Air	**99.9%**

Research-Based Indications of CUS

1- Painful conditions such as Myofascial trigger points and Back pain (Strong evidence).
2- Non-specific shoulder disorders (Moderate evidence).
3- Carpal tunnel syndrome (Strong evidence).
4- Improving dermal wound healing (Strong evidence).
5- Calcific tendinitis (Moderate evidence).
6- Arthritis (Moderate to Strong evidence).
7- Bursitis (Moderate evidence).
8- Improving tissue extensibility (Strong evidence).

Instructions for CUS Application

1-Check for any contraindications.

2-Consider any precautions or risks.

3-Ensure comfortable body positioning and inform the patient that a sensation of heat may be present during treatment.

4-Prepare the treated area: Cleanse the skin overlying the targeted area with **rubbing alcohol**. Shave or clip excess hair over treatment area because air bubbles tend to cling to them, thus reducing ultrasound transmission.

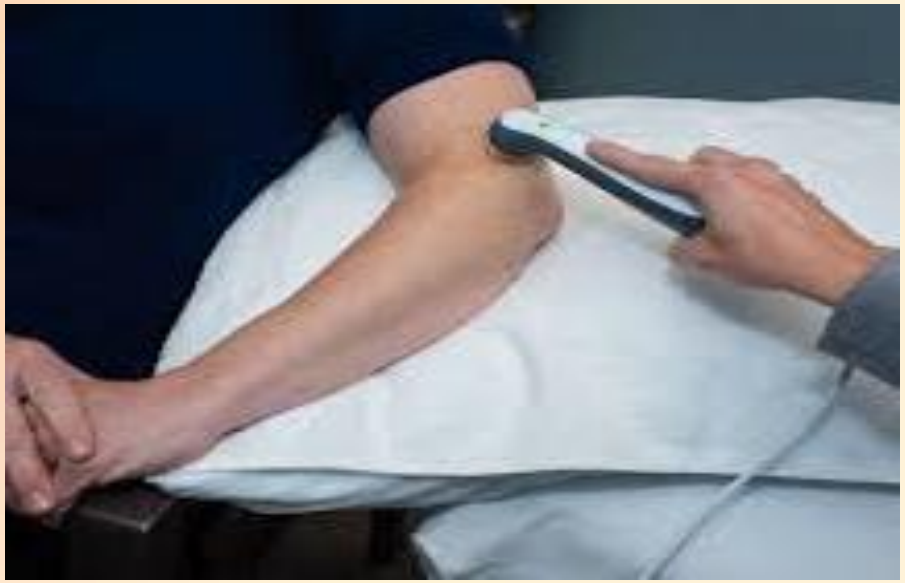
5-Choose between contact and noncontact methods. Noncontact is recommended when the treated surface area is too irregular or too painful for contact by the applicator.

6-For **contact method**:

*Use commercial ultrasonic gel for optimal ultrasonic transmissivity.

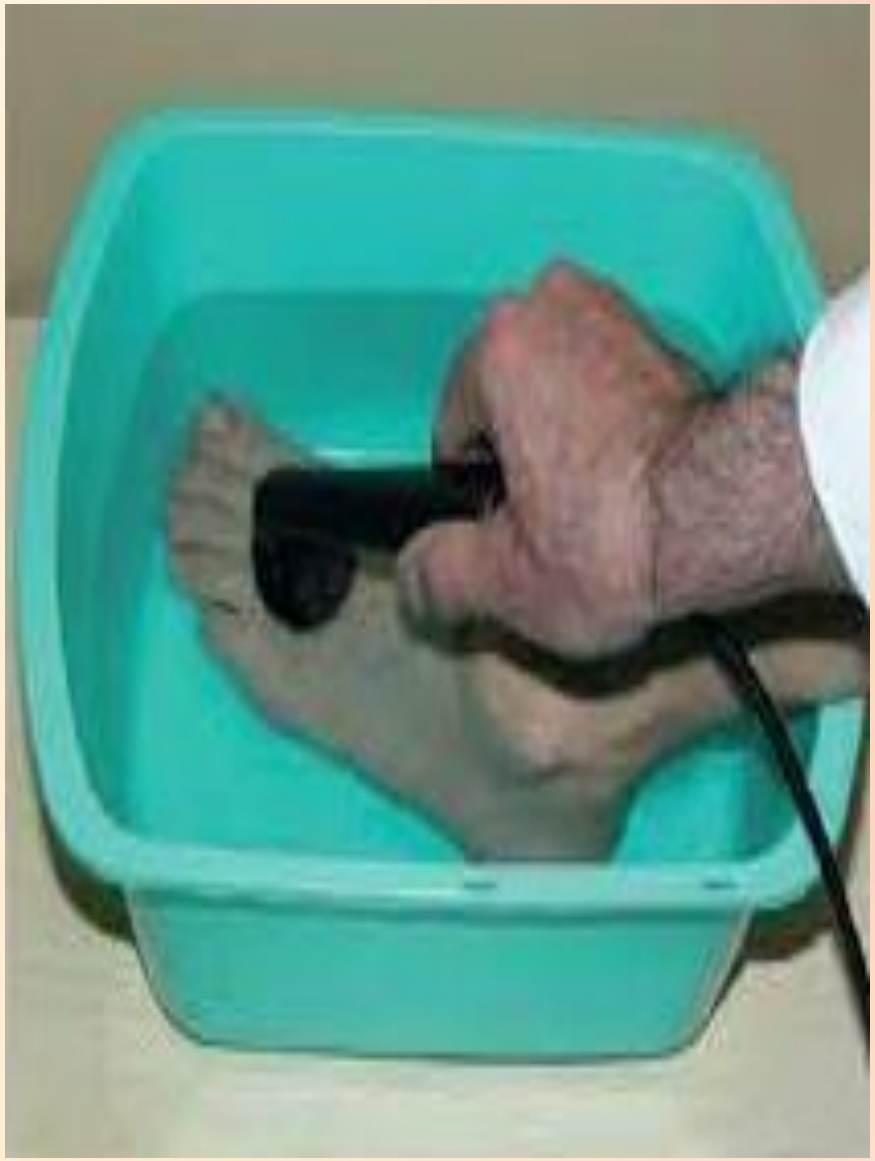
*Use thinner gel pads to optimize transmissivity. Keep ultrasonic coupling media at room temperature for optimal thermal effect.

7-For **noncontact method**: Immerse both body segment and applicator in a plastic bath or tub filled with tap water. Keep the soundhead faceplate at a distance of **2–3 cm** for the skin overlying affected tissue, because the farther away it is, the less the temperature elevation in the tissues. To compensate for thermal energy loss to water, increase the dosage with the distance while keeping at least 1 cm between the applicator and treated body part.



Direct Contact method

Indirect Gel Pad Contact method



Noncontact method (Immersion Technique)

8-Keep **ultrasound devices** at least **5 m** (15 ft) away from functioning shortwave diathermy devices to prevent electromagnetic interference.

9-Plug line-powered devices into a **ground-fault circuit interrupter** (GFCI) to eliminate the risk of electrical macro-shocks.

10-Make sure that the ultrasound device is properly calibrated and that its **beam nonuniformity ratio** (BNR) value is between 2 and a maximum 8.

11-Estimate the depth of the lesion (in centimeters) from the skin surface as well as its **surface area** (in square centimeters). Information about tissue depth will guide the selection of **frequency**.

12-Choose between **1** and **3 MHz**. The deeper the lesion, the shorter the frequency.

13-Choose between the **continuous** and **pulsed modes**. Theoretically, the **continuous mode** will always provide more thermal effects, than the pulsed mode.

14-Keep the **applicator faceplate perpendicular** to the treatment surface to minimize reflection and use the appropriate **coupling medium**.

15-Apply the soundhead faceplate over the treatment surface and turn the device **ON**.

16-After ending the US session, Wipe off excess ultrasonic gel or water. Inspect the exposed skin area and record any adverse reaction.

17-Clean and **disinfect** the **applicator faceplate** to ensure optimal hygiene and prevent cross-contamination between patients.

Contraindications for CUS:

1- Pregnancy—over the abdomen, low back
2- Active bone growth at the epiphysis
3- Cancer—over a known or suspected area of malignancy
4- Tuberculosis infection—infected tissue, particularly that under tension (swelling/abscesses)
5- Hemorrhagic conditions—over an area of active bleeding; **N.B.** can be used for areas of hematoma and hemophilia.
6- Thermal-sensitive reproductive organs like testes.
7- Eyes
8- Anterior neck—particularly over the carotid sinus.

Precautions for CUS:

1- Plastic or cemented implants—moderate evidence for damage to these.

2- Spinal cord and superficial or regenerating nerves— poor evidence for this but still considered a precaution.

3- Implanted cardiac pacemaker or other implanted electronics—unsure if damage to the device could occur because of either heating or vibration.

4- Impaired sensation—nerve damage, so no sensory feedback about excessive warmth or burning.

5- Impaired cognition—no feedback about excessive warmth.

*__Phonophoresis__ is the application of the US to enhance the absorption of topical agents through the skin.

*__Topical Drugs__ can be absorbed with continuous or pulsed US, however, __pulsed US__ with a __20% duty cycle__ and under __0.5-0.75 W/cm2__ is the recommended parameter for phonophoresis.

*The effects of US to enhance the entry through the skin of a topical agent have been attributed to both physical "__pushing__" of the agent through the skin and the increase in tissue permeability.

*Also, the most likely cause is the thermal effect of the US.

*Most commonly, hydrocortisone and analgesics (such as salicylates and lidocaine) are administered in a __gel formula__ __rather than__ creams as a coupling medium with __phonophoresis__.


Thank
you!


سُبْحانك
اللّهُمّ وبحمدك
أشهدُ أنْ لا إله إلاّ أنتَ
أستغفرُك وأتوبُ إليك


قال ﷺ: "من سلك طريقاً يلتمسُ فيه علماً،
سهل اللّه له به طريقاً إلى الجنة"


وَقُل رَّبِّ زِدْنِي عِلْمًا
طه ١١٤
Islamiyatsb

ELECTROTHERAPY

EXTRACORPOREAL SHOCKWAVE THERAPY

By:

Dr. Mohamed Gamal AbouElYazeed Ali

Lecturer of Physical Therapy

South Valley University

Extracorporeal Shockwave Therapy

*Extracorporeal shockwave therapy, commonly designated under the acronym (ESWT), is the application of pressure mechanical waves outside of the body (extracorporeal) that violently impact (shock) biologic tissues for therapeutic purposes (Gleitz, 2011).

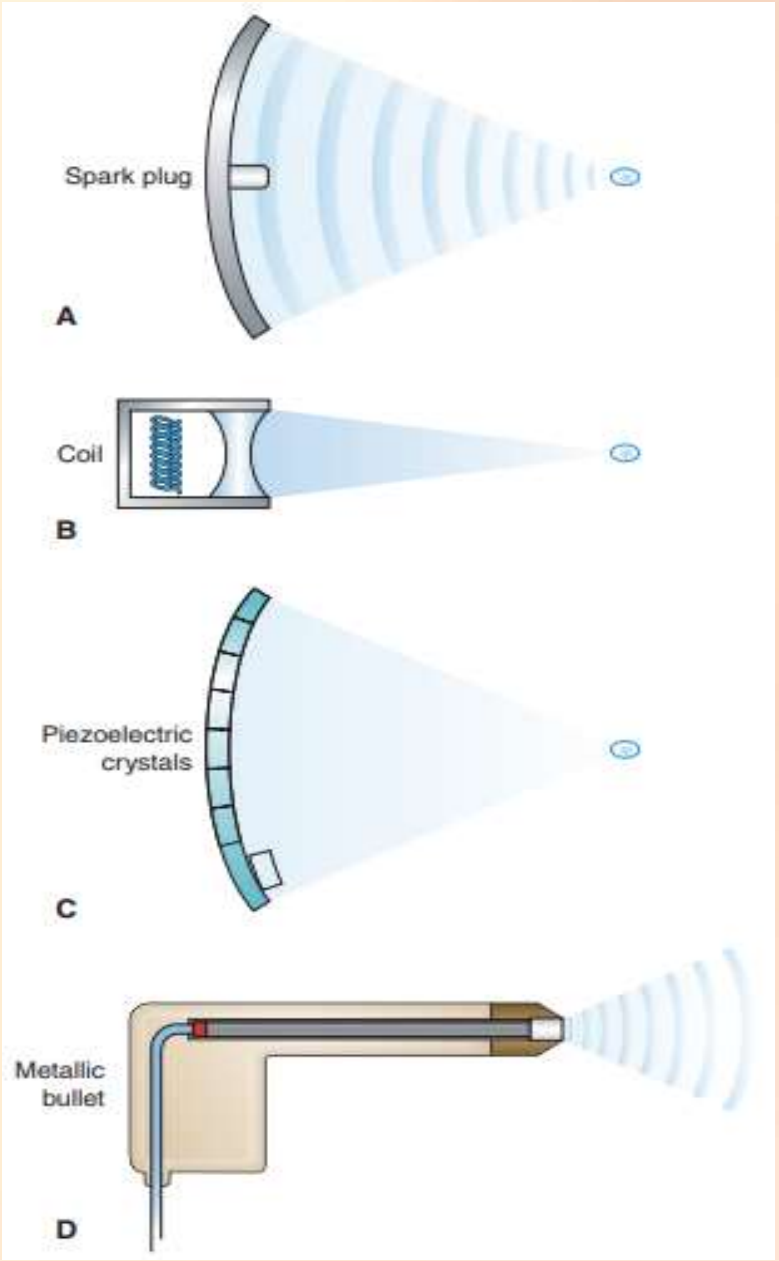
*Shockwave is defined as a low- to large-amplitude wave formed by the sudden mechanical compression of the medium through which the wave moves.

*Based on their propagation pattern, shock waves are divided into Focused and Unfocused (Radial).

*Focused shockwaves are produced using **electrohydraulic**, **electromagnetic**, and **piezoelectric** systems.

*Radial shockwaves, on the other hand, are produced **pneumatically** using compressed air to accelerate a projectile onto a solid applicator that is in contact with the skin surface overlying the affected tissue.

*The repetitive delivery of **shockwaves** causes mechanical energy that is absorbed by soft tissues and leads to physiologic and therapeutic effects.



*ESWT was founded on the principles of **lithotripsy**, a technology employing acoustic sound waves to fragment kidney stones.

*Typical **ESWT** devices include those that deliver high-energy focused ESWT (**f-ESWT**), those that deliver low-energy radial ESWT (**r-ESWT**), and **dual or combined-type** units.

*The **f-ESWT** device is mounted with an **integrated image-guiding system** that can be adjusted along its axis to allow precise localization for therapy.

*The **r-ESWT** device consists of a pneumatic system connected to a **handheld pistol-like applicator** via a cable. Its divergent wave eliminates the need for an image-guiding system.


3000
110.0
8.5
1.5


R-SW 1
R-SW 2
V-ACTOR
VACU-A
4.0
400
15
0
Orthopaedics
Patients
Thigh
Knee
Lower leg
Foot
Settings
Info
Visible Body
STORZ MEDICAL
MP200
MASTERPULS

TABLE 21-1 COMPARISON BETWEEN FOCUSED AND RADIAL EXTRACORPOREAL SHOCKWAVE THERAPY

Parameters	f-ESWT	r-ESWT
Generator	Electrohydraulic Electromagnetic Piezoelectric	Ballistic
Propagation	Focused (convergent)	Radial (divergent)
Penetration depth	Deep at focal point >5 cm	Superficial on skin surface <5 cm
Localization method	Image guided	Clinical focusing/palpation
Compressive pressure* (P+)	Up to 120 MPa Up to 1,200 bar	Up to 0.5 MPa Up to 5 bar
Tensile pressure (P–)	–1/10 of P+	–1/10 of P+
Rise time (RT)	<0.1 μs	<10 μs
Pulse duration (PD)	<0.5 μs	<500 μs
Energy flux density (EFD)	Up to 2.0 mJ/mm^2	Up to 0.5 mJ/mm^2
Coupling medium	Fluid (water or gas)-filled balloon	Thin layer of aquasonic gel
Applicator	Bulkier and more difficult to manipulate	Smaller and easier to manipulate
Local analgesia	Often required to prevent pain during treatment	Not required
Indication	For smaller, more focused, and deeper area	For larger, less focused, and more superficial area

f-ESWT, focused extracorporeal shockwave therapy; r-ESWT, radial extracorporeal shockwave therapy.
*1 MPa = 10 bar.

Biophysical Characteristics of ESWT

-Wave Form and Parameters:

*Both waveforms are characterized by a compressive phase followed by a tensile phase.

***Radial shockwaves**, compared to **focused shockwaves**, present much lower compressive and tensile pressures and longer time courses.

***Compressive Versus Tensile Pressure:**

-Positive peak pressure (Pp+) is defined as the difference between the maximum positive peak pressure of the shockwave and ambient pressure (baseline). P+ represents the pressure exerted during the positive compressive phase of the shock wave.

-**Negative peak pressure** (**P–**), on the other hand, relates to the maximum negative peak pressure exerted during the tensile phase of the shock wave and gas bubbles (**Cavitation**) occur.

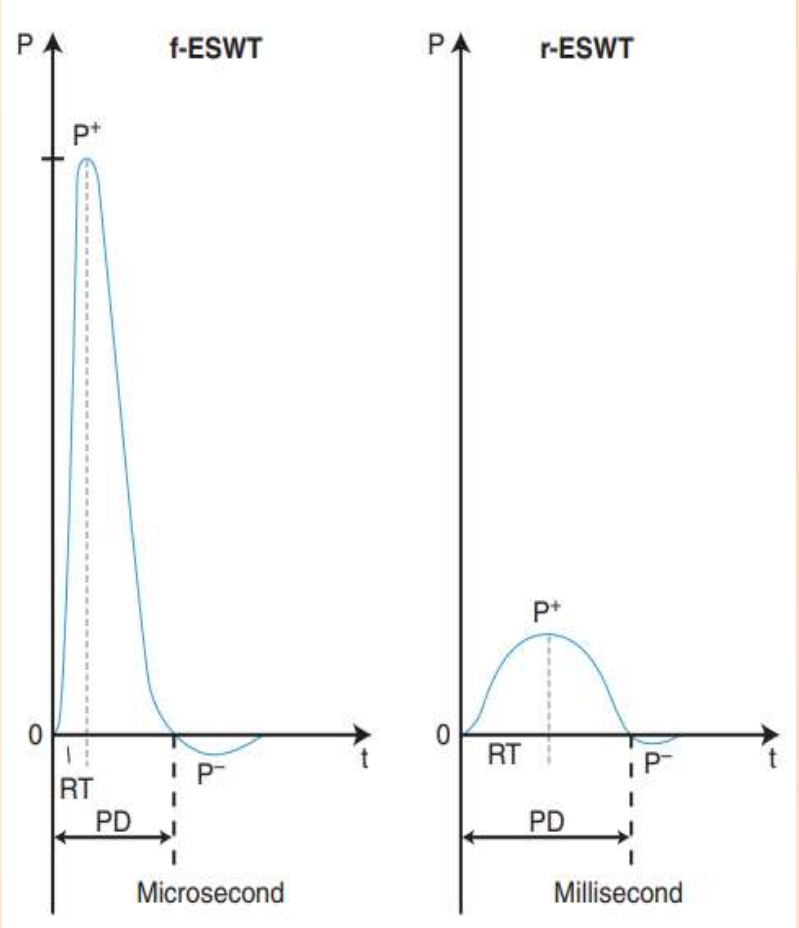
-**Pressure** is commonly measured in units of megapascal (Mpa) or bar, where 10 bar is equivalent to 1 MPa.

-**Tensile pressure** amplitudes are equivalent to approximately **10%** of P+.

*__Rise Time and Pulse Duration:__

-**Rise time** is the time interval during which P+ rises from baseline to peak value.

-**Pulse duration** is the interval between the beginning and ending of compressive phase.



*In comparison to ultrasound waves, the **shockwave peak pressure** is approximately **1000 times greater** than the **peak pressure of an ultrasound** wave.

***Energy and Energy Flux Density:**

-The mechanical or **acoustic energy** contained in a **shockwave** is expressed in **millijoules (mJ)**.

-A measure of **shockwave energy density** is obtained by calculating the **energy flux density (EFD)**, which is defined as the amount of mechanical acoustic energy per unit area (A) per shock. **EFD** is measured in **millijoules per square millimeter (mJ/mm2)**.

-The **EFD** level may be classified as **low**, **medium**, **or high**.

*It is more accurate for **r-ESWT** devices to use **bars** rather than **mJ/mm2** when representing the pressure level (**EFD**).

***Classification of Shockwave Intensity (EFD):**

-**Low Energy Shockwave** is below 0.08 mJ/mm2.

-**Medium Energy Shockwave** is between 0.08 - 0.28 mJ/mm2.

-**High Energy Shockwave** is above 0.28 mJ/mm2.

***Intensity of Radial Shockwave:**

-**Less than 1.5 bar** for activation of tissue healing.

-**Between 1.5 - 2 bars** for pain, chronic inflammation, muscle spasm, trigger points, and edema reduction.

-**Above 2.5 bars** for elimination or reabsorption of calcifications.

***Coupling Medium:**

-Delivering shockwave acoustic energy to soft tissues, as with ultrasonic acoustic energy, requires the use of a coupling medium to optimize energy transmission to soft tissues.

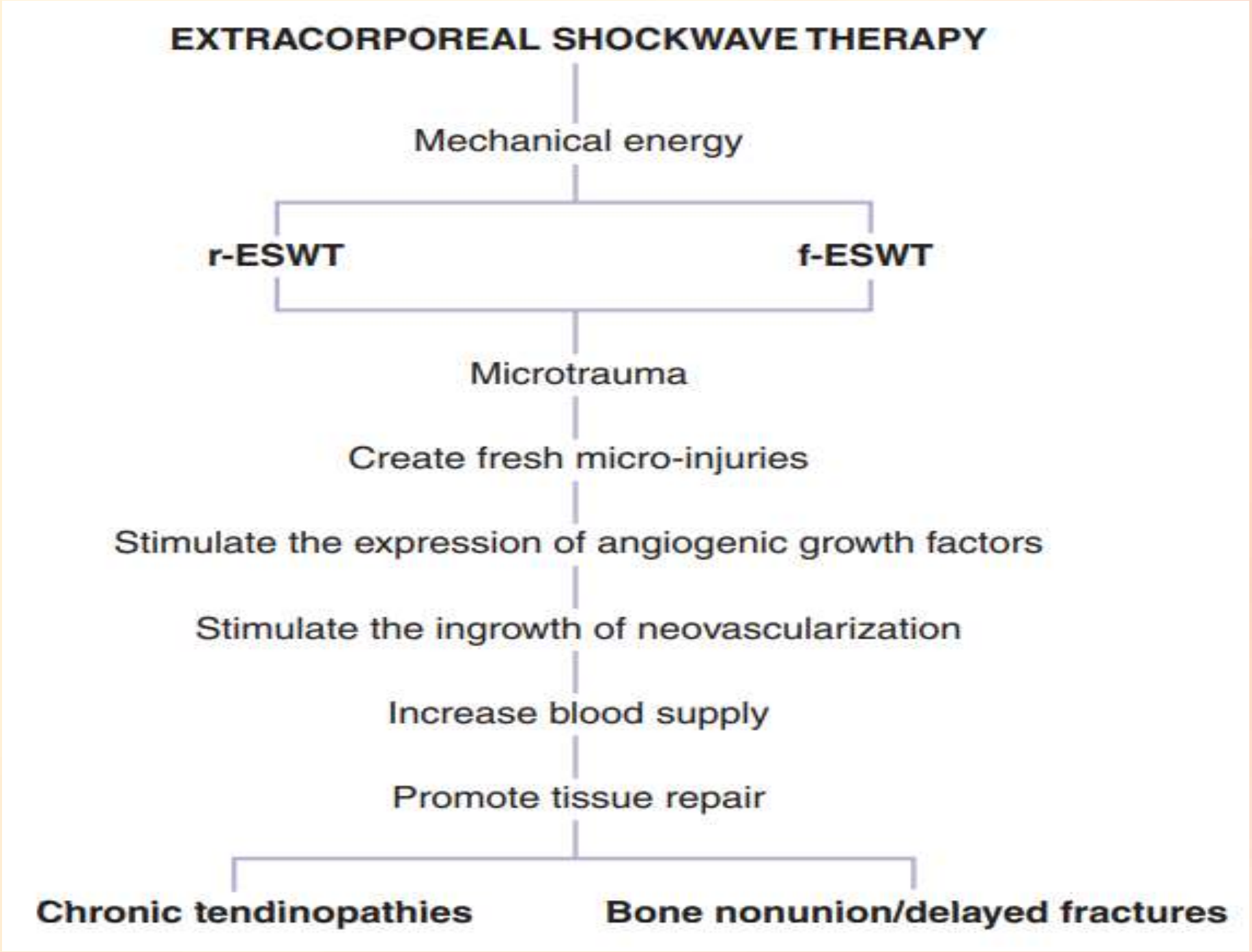
-An **acoustic fluid-filled adapter** is used at the applicator–skin interface to deliver **f-ESWT**.

-To deliver **R-ESWT**, a thin layer of **acoustic gel** is applied over the applicator contact surface.

*The **r-ESWT applicators** (headpieces or handpieces) are smaller and easier to manipulate than those used for **f-EWST**.

*Because the application of high-energy **f-ESWT** can be painful. **Lidocaine cream** is applied before therapy over the target area.

Physiological and Therapeutic Effects of ESWT



Therapeutic Effects and Indications of ESWT

1) Microtrauma:

*The delivery of mechanical or acoustic energy contained in shock waves causes **microtrauma**, which creates fresh micro-injuries within the targeted soft tissue. These micro-injuries are presumed to stimulate the expression of angiogenic growth factors [Nitric oxide (NO), and Vascular Endothelial Growth Factor (VEGF)] and the ingrowth of **neovascularization**.

*Together, these biological effects are presumed to increase the blood supply, which **promotes soft-tissue repair** (stimulates collagen synthesis) in cases of **chronic** **tendinopathies** and **delayed bone fractures**.

Research-Based Indications of ESWT

1- Shoulder, Elbow, Achilles, and Patellar chronic tendinopathies.

2- Chronic plantar fasciitis and Calcaneal Spurs.

3- Calcific tendonitis of the rotator cuff in the shoulder.

4- Chronic foot ulcers, either diabetic or nondiabetic.

5- Osteoarthritis of the knees.

6- Nonunion and delayed-union bone fracture.

7- Avascular Necrosis of the femoral head.

* Overall conditions, the strength of evidence is moderate.

Instructions for r-ESWT Application

1-Check for any contraindications.

2- Consider the risks: Pain, swelling, ecchymosis, and bruising—repetitive pressure impacts cause local tissue microvascular damages that may trigger one or many of these risks.

3-Ensure comfortable body positioning and inform the patient to minimize movement of the treated body segment during therapy. Inform the patient that he or she may feel light to uncomfortable pain and vibration during treatment.

4-Prepare the treated area: Cleanse the skin with **rubbing alcohol**.

5-Select device type and delivery mode:
Select **radial** mode. All **r-ESWT** devices are ballistic-type (pneumatic) devices. r-ESWT is used when the objective is to deliver divergent (radial) **low** to **medium energy levels** (less than 0.28 mJ/mm2). **shockwaves** to **larger** and **more superficial (less than 5 cm** for the skin surface) soft-tissue areas.

6-Select application mode: **r-ESWT** requires no image-guiding system. Instead, **clinical focusing** that is, the patient's own localization of the painful area is used. **No need for sedation** or **local analgesia**.

7- Select applicator: All applicators have a **pistol-like shape** (handpiece). Select the one that best matches the geometry of the treated area.

8-Prepare r-ESWT device: Connect the handheld applicator, via its cable, to the device. Power the device ON.

9-Apply coupling medium and position the applicator: Localize the treatment area (most painful area) by **palpation** based on the patient's feedback (**clinical focusing**). Mark the skin over the treatment area. Apply aquasonic gel over the area to be treated. Manually apply and hold the applicator surface against the skin overlying the painful area.

10-Set dosimetry: -There is an **inverse relationship** between **frequency** and the **depth of penetration**.

-Patients report **higher frequencies (14-20 Hz)** as more comfortable, while **lower frequencies (8-12 Hz)** are often perceived as more painful.

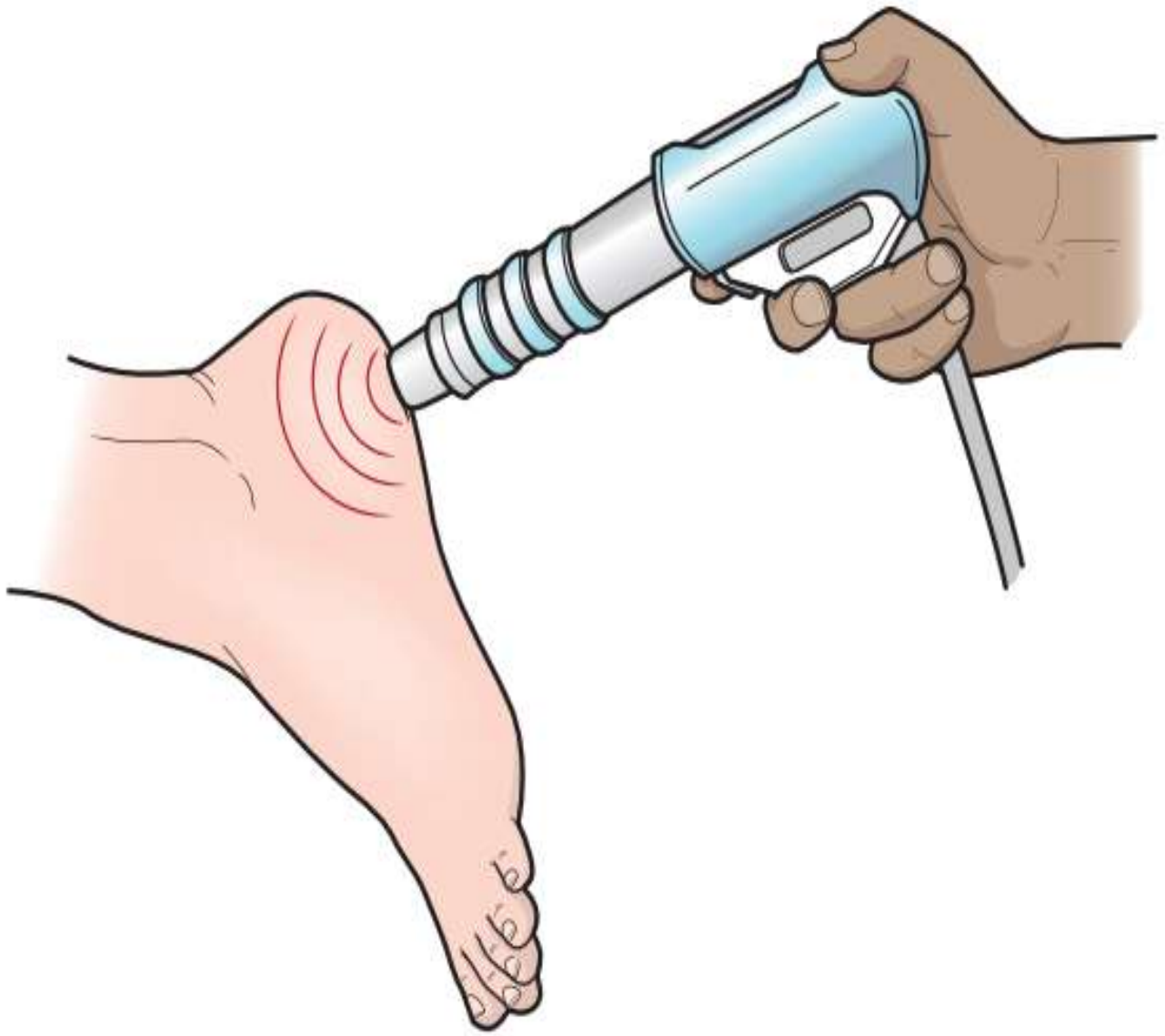


Fig 16 ■ 7 Extracorporeal shock wave therapy applied to the heel for plantarfasciitis.

-It is recommended to start with higher frequencies and gradually decrease it during treatment.
-For instance, a treatment plan may involve 200 shocks at 16 Hz, followed by 200 at 14 Hz, and then 200 at 12 Hz, ultimately aiming for a target **frequency** of 10 Hz with a total of 2000 shocks.
-**Shock number** usually between 1500 and 2000 in a treatment session.
-Most clinical research has used between **3 – 5 sessions** at low energy levels, suggesting **up to 7** may be needed in the more refractory lesions.
-Treatment sessions are mostly delivered at **1 x weekly** intervals.

11-Apply treatment: Ensure adequate monitoring.
12-Conduct post-treatment inspection: Inspect the treated skin area for any **light bruising** or **swelling**. Reassure the patient that these are **normal side effects** that will disappear within a few hours or days.

Contraindications for ESWT:

1- Bleeding conditions—severe bleeding.
2- Pacemakers.
3- Medications that prolong blood clotting.
4- Over major blood vessels and nerves, and Joint replacements.
5- Pregnancy: over uterus—disrupts fetal development.
6- Acute injuries—increase the inflammatory process.
7- Active bone growth at the epiphysis—alters normal growth.
8- Cancer—over a known or suspected area of malignancy.
9- Over gas-filled tissues such as lungs and intestine—severe tissue damage.

Precautions While Using ESWT:

*Some **side effects** can occur after treatment, including transient pain, hematoma, petechiae, and local soft tissue swelling.

***Avoid** the use of **anti-inflammatory drugs** **immediately after** **ESWT** sessions because it may disturb the desired effect of **ESWT**, the conversion of chronic inflammation into acute one.

*It is allowed to use **some painkillers** that have **no** anti-inflammatory effects like **Paracetamol** to relieve the transient pain after **ESWT**.

*Key Points Regarding ESWT:

-**Lithotripsy** is a procedure that uses **high-energy focused shockwaves** to break up or fragment stones in **kidneys** (**Kidney Stones** are composed of Calcium oxalates 60-70%, Calcium phosphates 10-20%, Uric acid, Cystine, and Cholesterol).

-When speaking about the **Radial Medium Intensity Shockwave** or **Focused Medium Intensity Shockwave** (which are commercially available) and their effect on the fragmentation of bone spurs or osteophytes (**Spurs or osteophytes** are **bony extensions** that have osteoblasts, osteocytes, bone matrix, calcium, and collagen fibers. so, **spurs are different from stones**), this will not be a scientific claim.

-**Calcific deposits** are **not like** **bone spurs** or **osteophytes**.

-**Shockwave** improves plantar fasciitis with or without calcaneal spur providing relief in symptoms **rather than** eliminating the spur itself.

-**Shockwave Therapy** may be **an important part** of the Physical Therapy session rather than to be **the whole** treatment program.

-In **Dermatology**, Shockwave can be used for **hypertrophic scars** because scar tissue is very rich in collagen, and as Ultrasonic these waves are highly absorbed by **collagen-rich tissues** like ligaments, tendons, fascia, and skin.

-In **Cardiology**, Research regarding **Neoangiogenesis** in rats with **induced myocardial infarction** provides promising results in the treatment of acute myocardial infarction.

-In **Neurology**, there is **strong evidence** that both **radial and focused Shockwaves** reduce post-stroke spasticity and improve function with radial parameters (2000 shocks per session, 2 bar intensity, 1-8 HZ frequency with 6-8 sessions).

-In **Gynecology**, there are promising results for **Medium-intensity Shockwaves** on the reduction of size and stiffness of Uterine Fibroids in rats, which may be a positive step in research phases towards human application.

-**Shockwaves** **haven't bactericidal effect** because there were no changes in activation of resting macrophages type 1(M1 are a pro-inflammatory type for phagocytosis) but there was a transformation of macrophages type 1 to macrophages type 2 (M2 inhibits inflammation and increases protein production as collagen so, **Shockwaves** have **anti-inflammatory properties**).

-**Shockwave Therapy** **stimulator head** should be held perpendicular to the target tissue to enhance its absorption and reduce its reflection.

-**Shockwave** is **contraindicated** when applied directly to the spinous process, however, it can be applied with caution to **paraspinal muscles**.


Thank you!


سُبْحانك
اللّهُمّ وبحمدك
أشهدُ أنْ لا إله إلاّ أنت
أستغفرُك وأتوبُ إليك


قال ﷺ: "من سلك طريقاً يلتمسُ فيه علماً،
سهل اللّه له به طريقاً إلى الجنة"


وَقُل رَّبِّ زِدْنِي عِلْمًا
طه ١١٤
Islamiyatsb

ELECTROTHERAPY

LASER THERAPY

IN

PHYSICAL THERAPY

By:

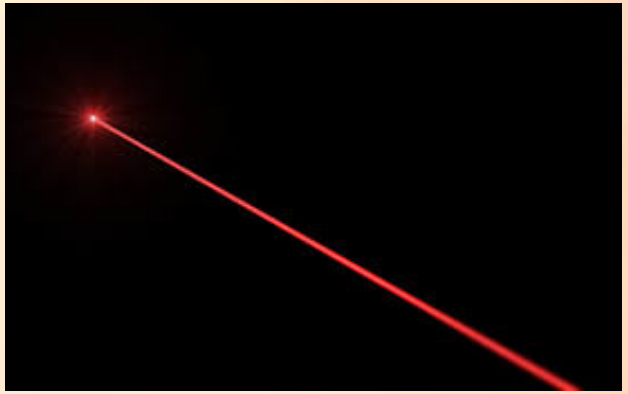
Dr. Mohamed Gamal AbouElYazeed Ali

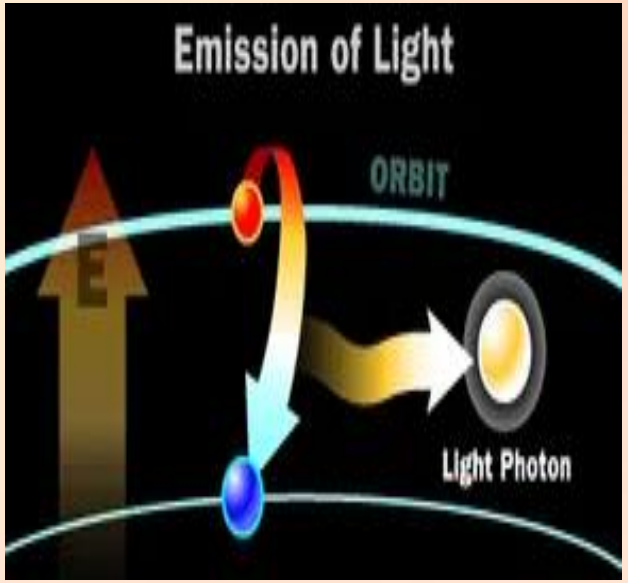
Lecturer of Physical Therapy

South Valley University

Introduction of LASER Therapy

*LASER is the acronym for light amplification by stimulated emission of radiation, in the visible red and near-infrared bands of the electromagnetic spectrum, for the purpose of photoactivation cellular mechanisms leading to enhanced soft-tissue repair and pain modulation.





*Light is the emission of electromagnetic waves, made of photons, traveling in space.

*If **electrons** jump to an outer orbital, they use energy. But if they jump to an inner orbital, they give up energy. This energy is released as a tiny packet of **light** or a **photon**.

***Lasers** are classified into four major hazard classes (I, II, IIIa/IIIb, and IV) based on the power outputs.

*Class I, II, and IIIa lasers have single-diode power outputs of less than 5 megawatts (mW) and are **not** used for therapeutic purposes.

*Class IIIb lasers have power outputs ranging between 5 and 500 mW and are used for therapeutic purposes.

*Class IV lasers have power outputs of more than 500mW

TABLE 11-1 COMPARISON OF LASER TYPES USED IN HEALTH CARE

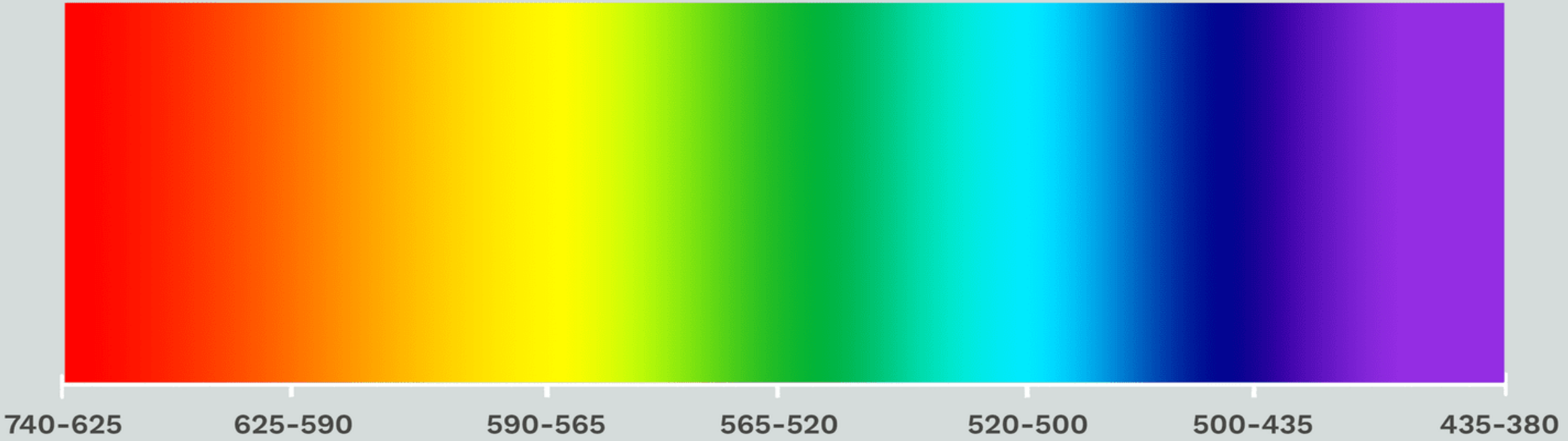
	LLLT	HLLS
OSHA classification	IIIb	IV
Single diode power	≤500 mW	>500 mW
Use	Therapy	Surgical therapy
Physiologic effect	Photobiomodulation	Photothermal
Therapeutic effect	Enhance cellular function	Cellular destruction

LLLT, low-level laser therapy; HLLS, high-level laser surgery; OSHA, Occupational Safety and Health Administration.

*Laser light will behave according to the basic laws of light; in that it travels in straight lines at a constant velocity in space. It can be **transmitted, reflected, refracted,** and **absorbed**. It can be placed within the **electromagnetic spectrum** according to its **wavelength/frequency** which will vary according to the particular generator under consideration.

The Visible Light Spectrum

The visible light spectrum is the section of the electromagnetic radiation spectrum that is visible to the human eye.



Biophysical Characteristics of LASER (LLLT)

A-Fundamental Elements:

Properties of Light:

*Laser light differs from all other lights based on the following three properties: monochromaticity, coherence, and collimation.

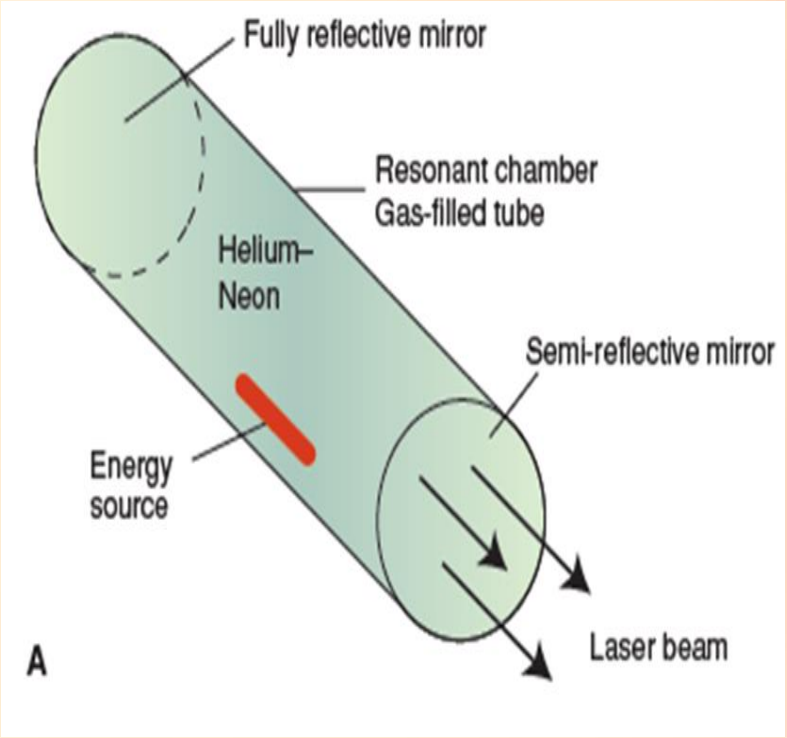
-**Monochromaticity:** implies that all photons accounting for the laser light have a single wavelength, and thus a single color.

-**Coherence:** refers to the fact that the photons that make up a laser light travel in phase, in both time (temporal) and space (spatial), with each other (in the same direction at the same time).

-**Collimation:** refers to the ability of a beam of laser light not to diverge, or spread, significantly with distance.

Components of a Laser Device:

-**Active Medium:** Material emitting laser light, **gaseous** (e.g., helium-neon (**HeNe**)), **diodes – semiconductors-** (e.g., gallium-aluminum-arsenide (**GaAlAs**)), and **solid-state lasers** (e.g., neodymium: yttrium aluminum garnet (**Nd: Yag**) as in **HLLT**.



-**Resonance Chamber:** Cavity containing the active medium, where lasing occurs.

-**Power Source:** Electrical current common to **HeNe** and **GaAlAs** types, passing through the resonance chamber to stimulate the active medium.

Process of Laser Light Emission:

*The sequential biophysical steps leading to the emission of laser light, regardless of their type, are:

a. **The First Step:** Pumping of Active Medium:

(the process of moving atoms, and therefore their electrons, from their resting ground state to their excited state).

b. **The Second Step:** Population Inversion:

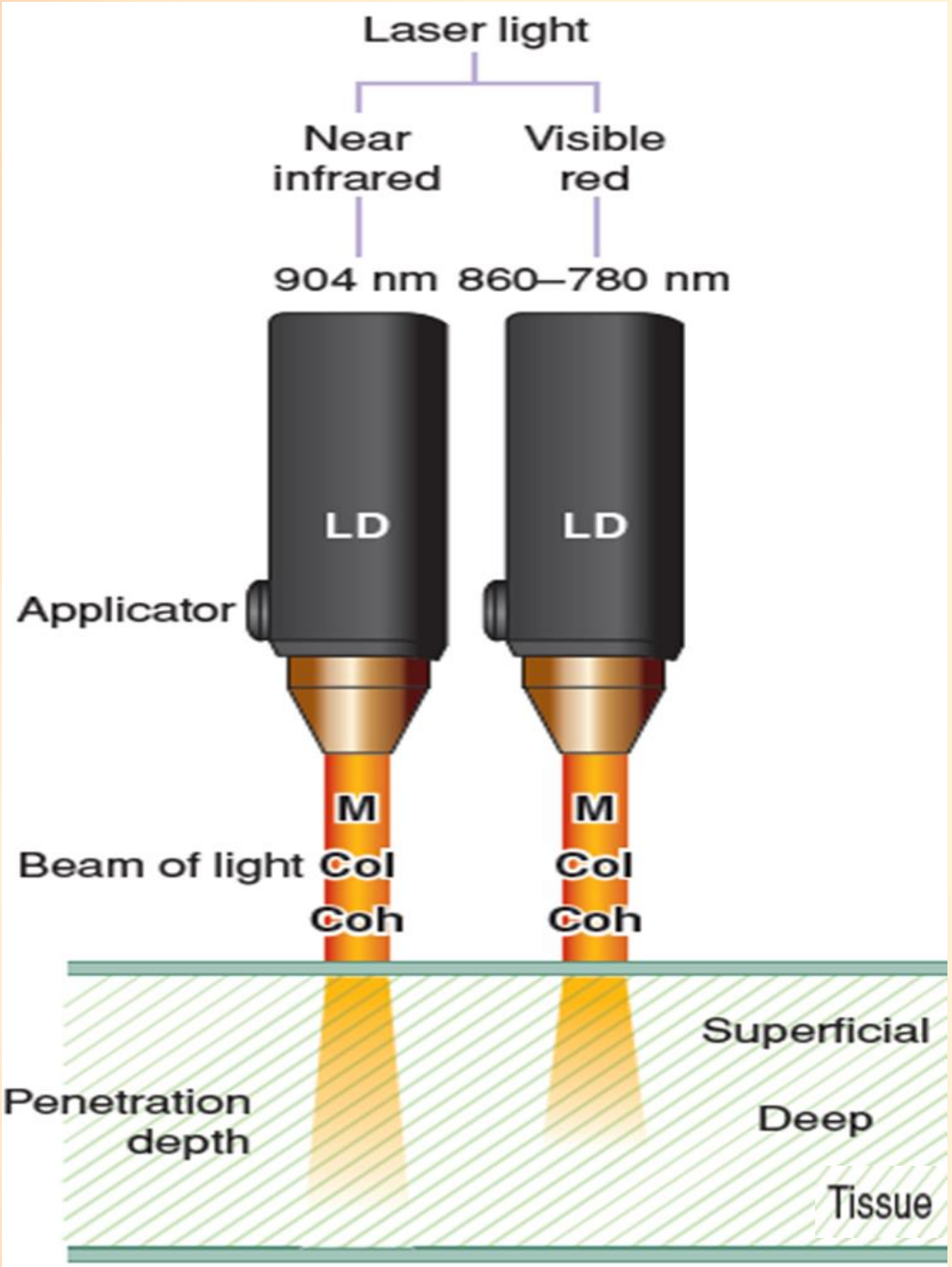
(when most atoms are in their excited state).

c. **The Third Step:** Spontaneous Emission:

d. **The Fourth Step:** Stimulated Emission:

e. **The fifth and Final Step:** Amplification:

(the back-and-forth movements of the newly emitted photons).



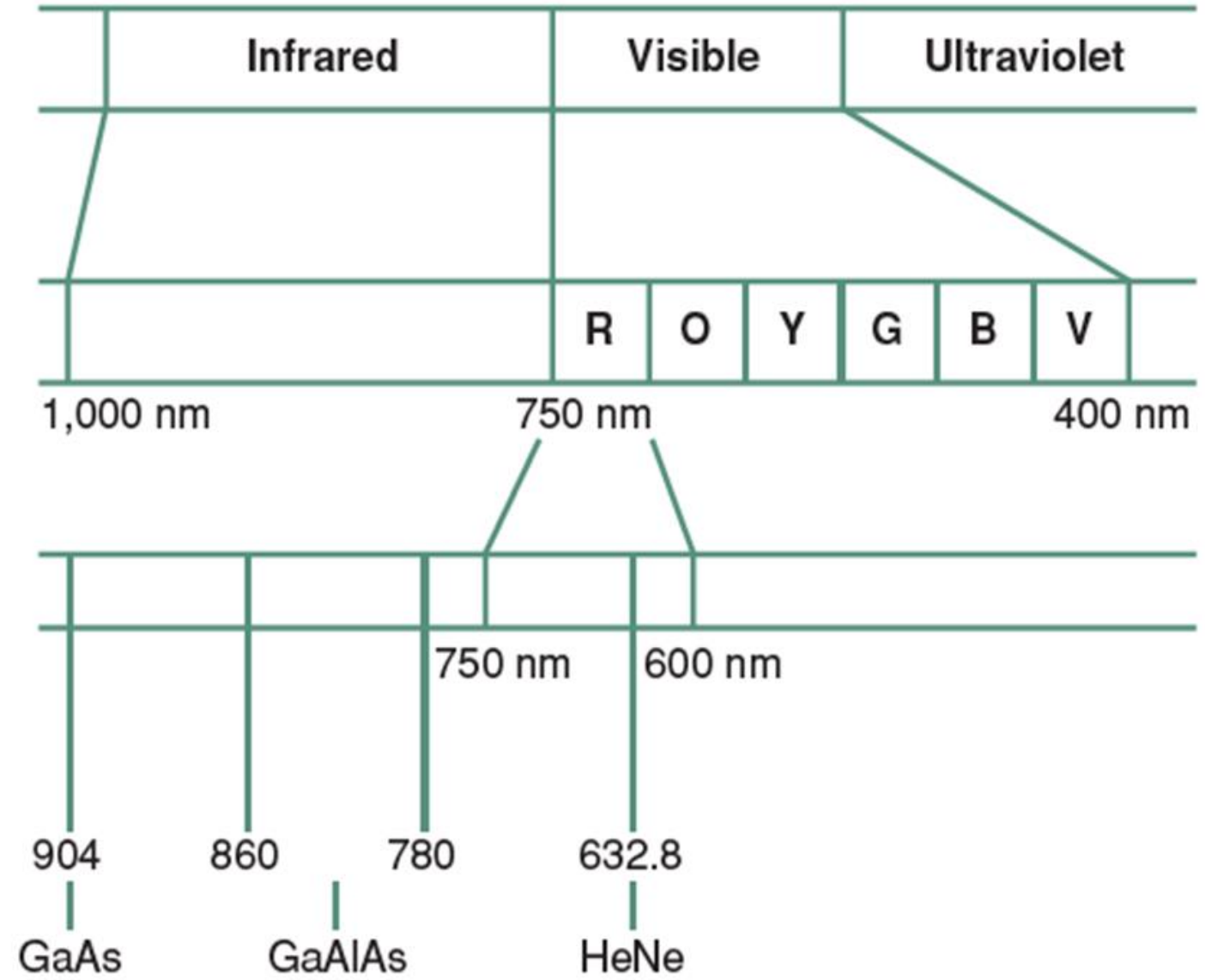


FIGURE 11-5 Low-level laser therapy radiation spectrum. GaAs, gallium arsenide; GaAlAs, gallium-aluminum-arsenide; HeNe, helium–neon. (R, red; O, orange; Y, yellow; G, green; B, blue; V, violet)

B- Red and Infrared Lasers:

*Lasers used for **Low-Level Laser Therapy** (**LLLT**) are commonly categorized as **red** and **infrared** lasers.

-**Gaseous HeNe laser** emits **red light** at 632.8 nm (visible spectrum).

-**Diode-type lasers, such as GaAlAs and GaAs**, emit light in the **infrared range** (860 to 780 nm and 904 nm, respectively).

-The **HeNe laser's** red light is visible to the human eye as it falls within the red band of the visible spectrum.

-**Diode-type lasers** emit infrared light, which is invisible. The red beam visible at the tip of an infrared laser applicator comes from embedded LEDs for **safety** and **visual guiding purposes**.

TABLE 11-4 LOW-LEVEL LASER PENETRATION DEPTH

Parameter	Formula	GaAlAs and GaAs	
Light		Red	Infrared
Wavelength (λ)		600–780 nm	780–904 nm
Absorption (A)		++	+
Scattering (S)	$S = 1/\lambda$	++	+
Penetration (P)	$P = 1/A$	+	++
Penetration (P)	$P = 1/S$	+	++
Penetration depth		~1.0 cm	~5.0 cm

GaAlAs, gallium-aluminum-arsenide; GaAs, gallium arsenide; +, less; ++, more.

*It is important to keep in mind that the **useful life of a laser** is predetermined and specified by the manufacturer.

*This is because the **laser's active medium** has a **finite number of hours**, which may vary between **5,000 and 20,000 hours**, during which it can be optimally stimulated or lased.

*The application of **LLLT** is also governed by the same four laws of electromagnetic energy that are, Arndt-Shultz (**dosage**), Grotthuss-Draper (**absorption**), inverse square (**divergence**), and Lambert's cosine (**reflection**).

*The **inverse square law** does not apply to **laser light (diodes)** application because its beam is **collimated**, thus showing no divergence with distance from the skin.

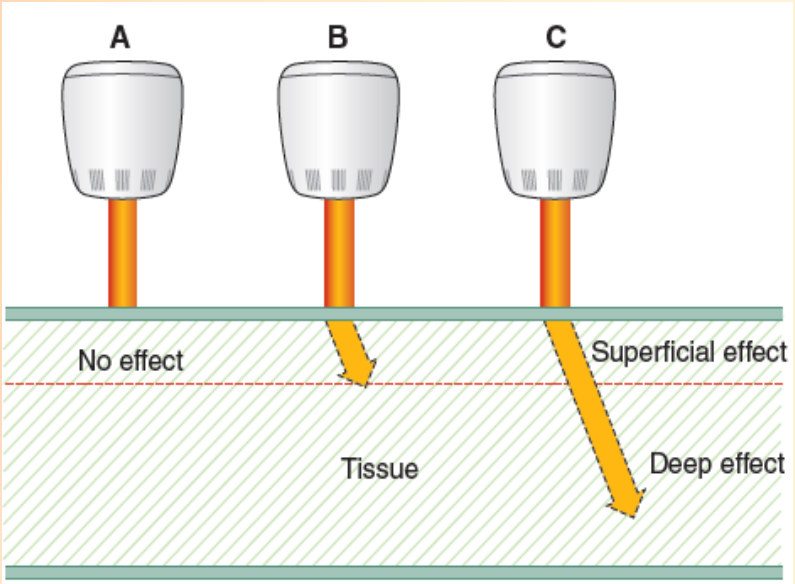


FIGURE 10-8 Grotthuss-Draper law.

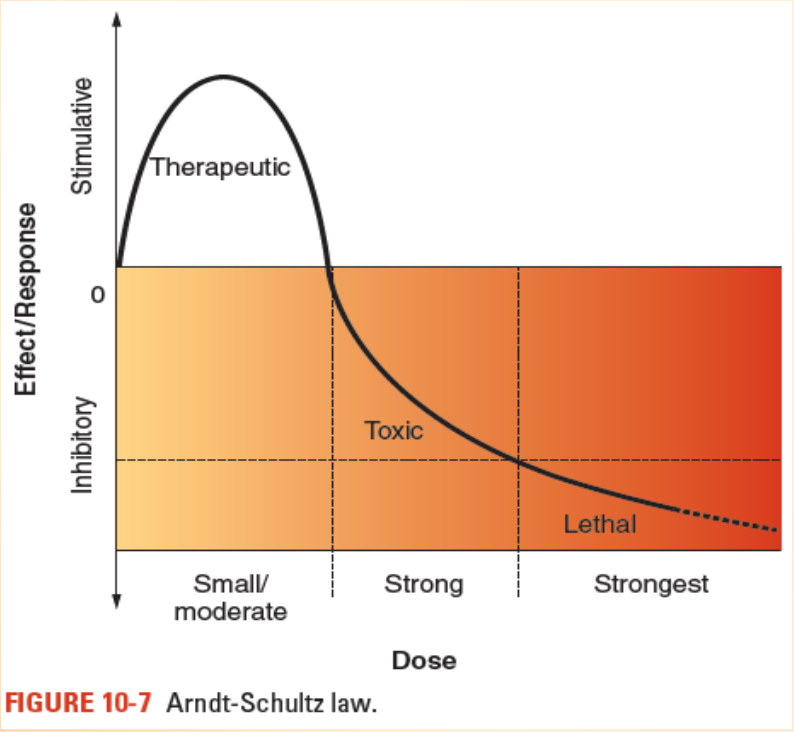


FIGURE 10-7 Arndt-Schultz law.

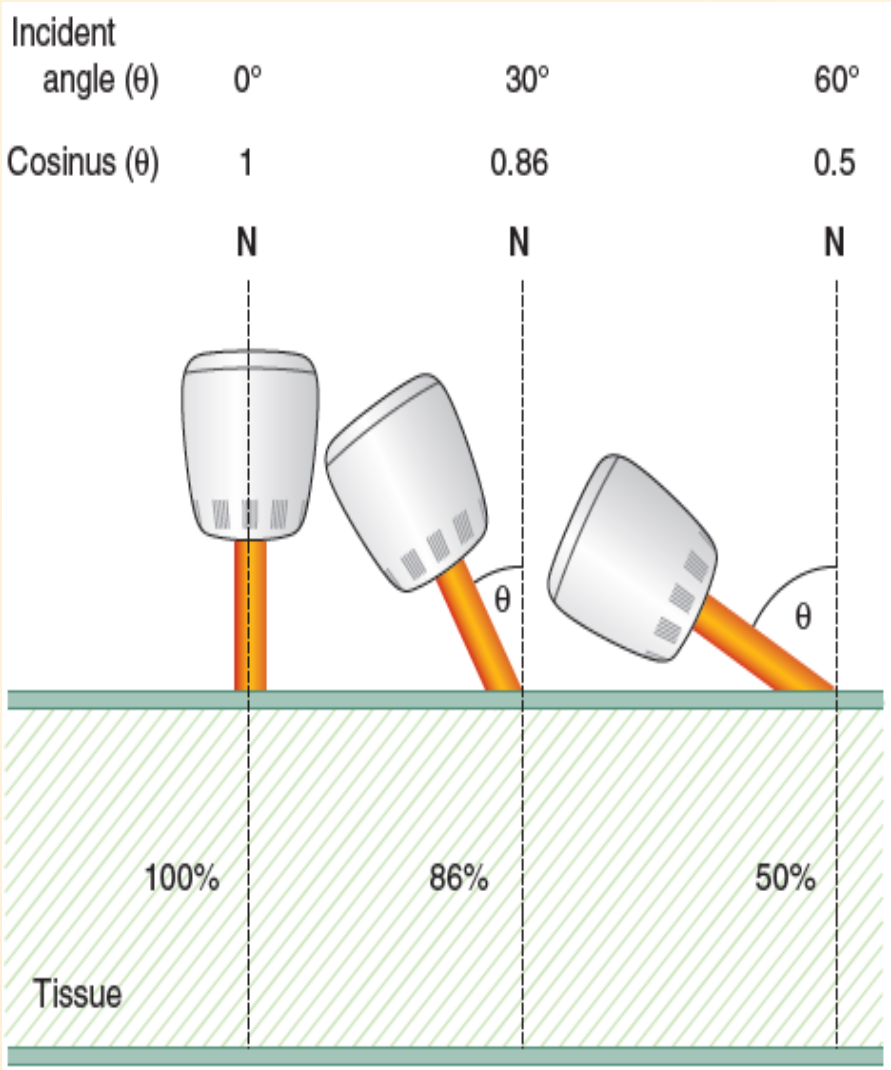


FIGURE 10-10 Lambert's cosine law.

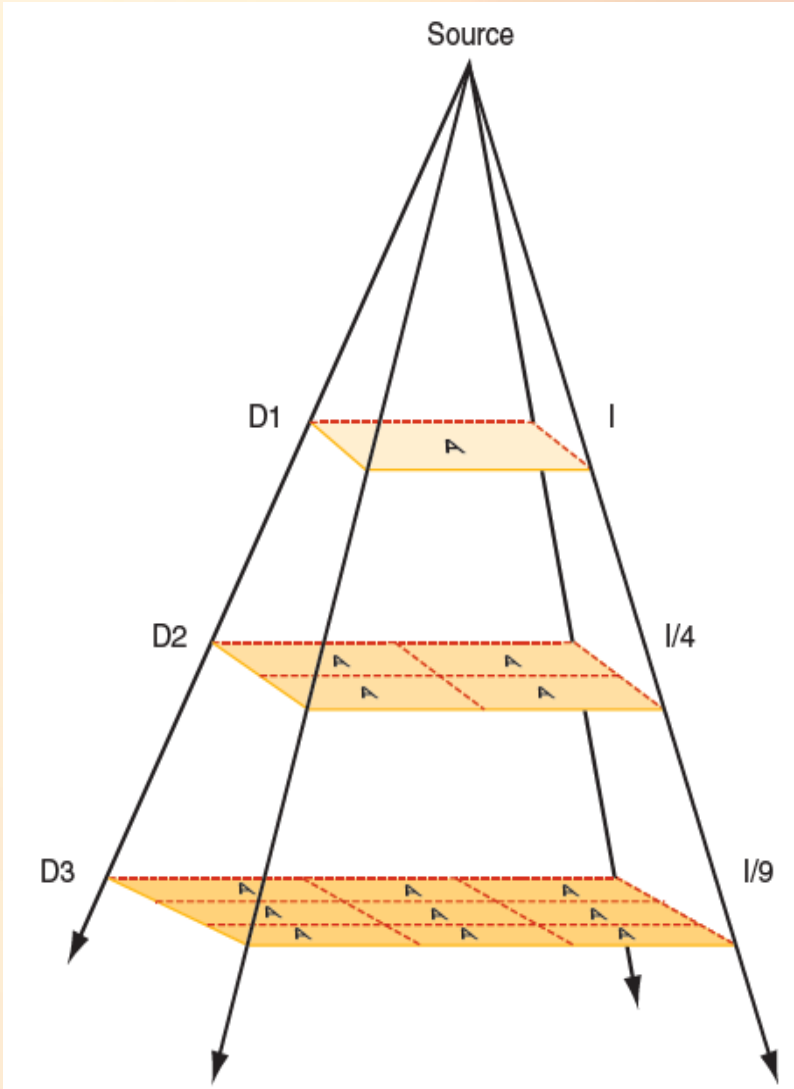
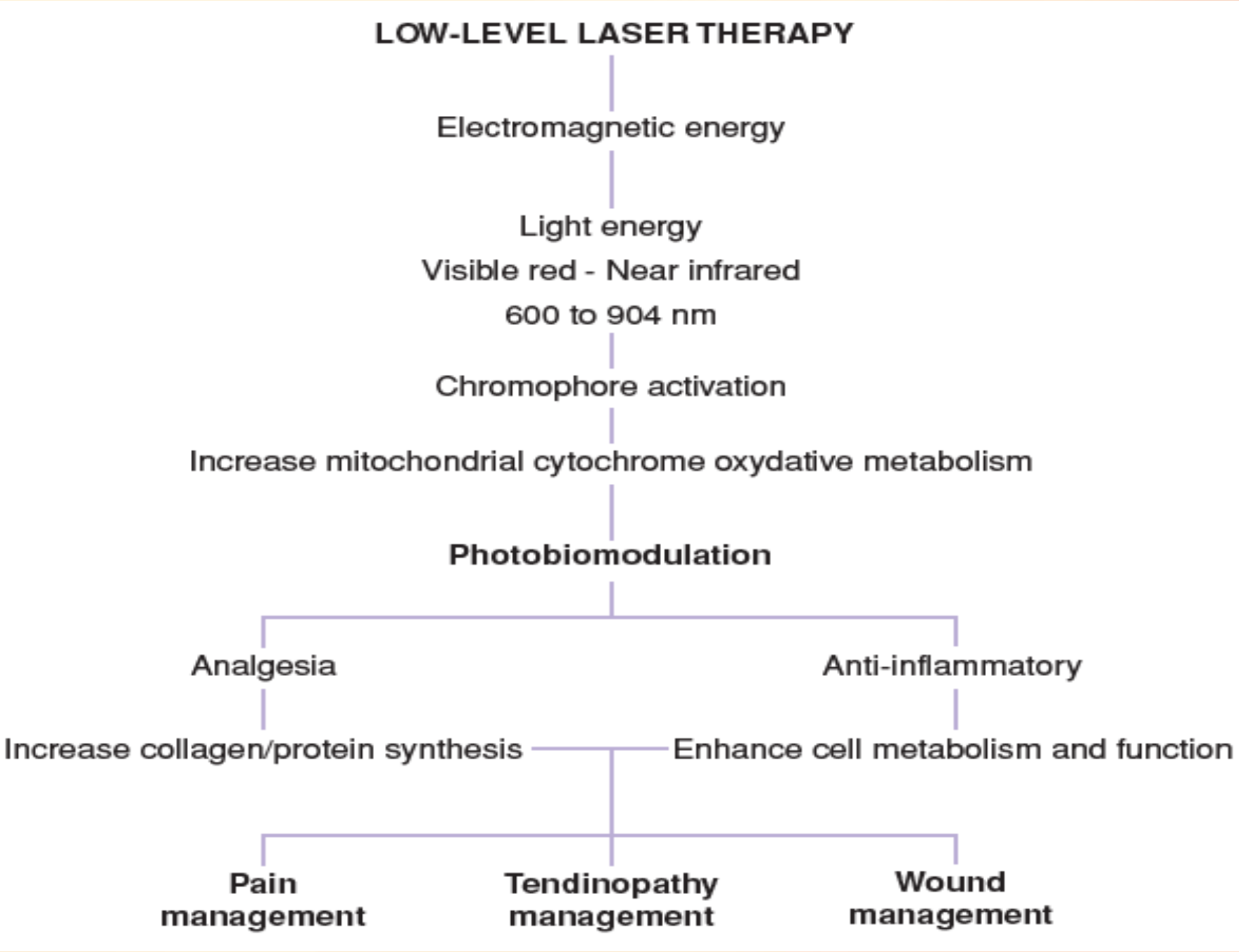


FIGURE 10-9 Inverse square law.

Physiological Effect of Low-Level Laser Therapy (LLLT)



Therapeutic Effects and Indications of LLLT

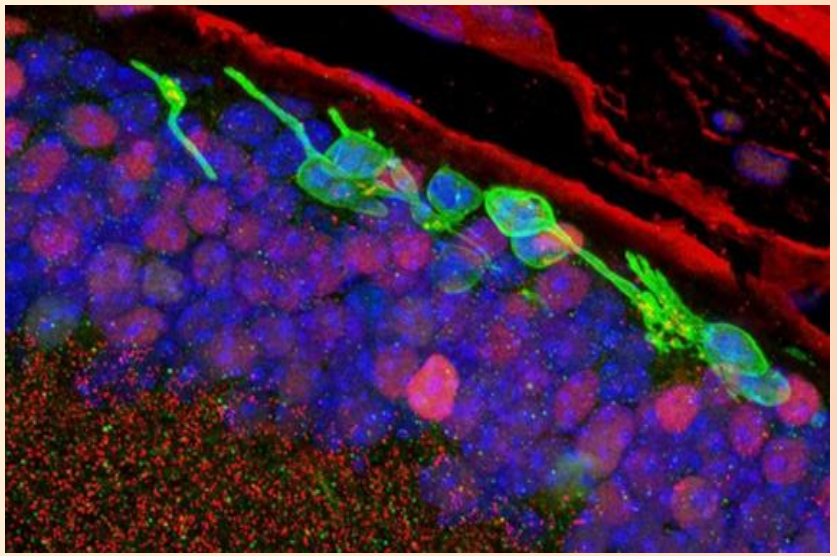
1) Photobiomodulation:

*The exact physiologic and therapeutic effects of **LLLT** on human soft tissues are, unfortunately, far from well-established or understood.

***LLLT** induces **photobiomodulation** effects through photochemical interactions between photons and healthy cells within and surrounding the soft-tissue pathology.

***Low-level laser** electromagnetic energy within the visible red and near-infrared bands causes **chromophore activation**, which then triggers **photobiostimulation effects** in soft tissues.

*A **chromophore** is a light-absorbing part of a molecule that gives its color. **Melanin** (skin darkening), and **hemoglobin** (red blood), are among the best-known chromophores, or pigments, found in human tissues.



***LLLT's** cellular effects are based on the absorption of monochromatic visible (greater than 600 nm) and near-infrared (less than 1000 nm) light by **photoreceptor molecules** in biological tissues.

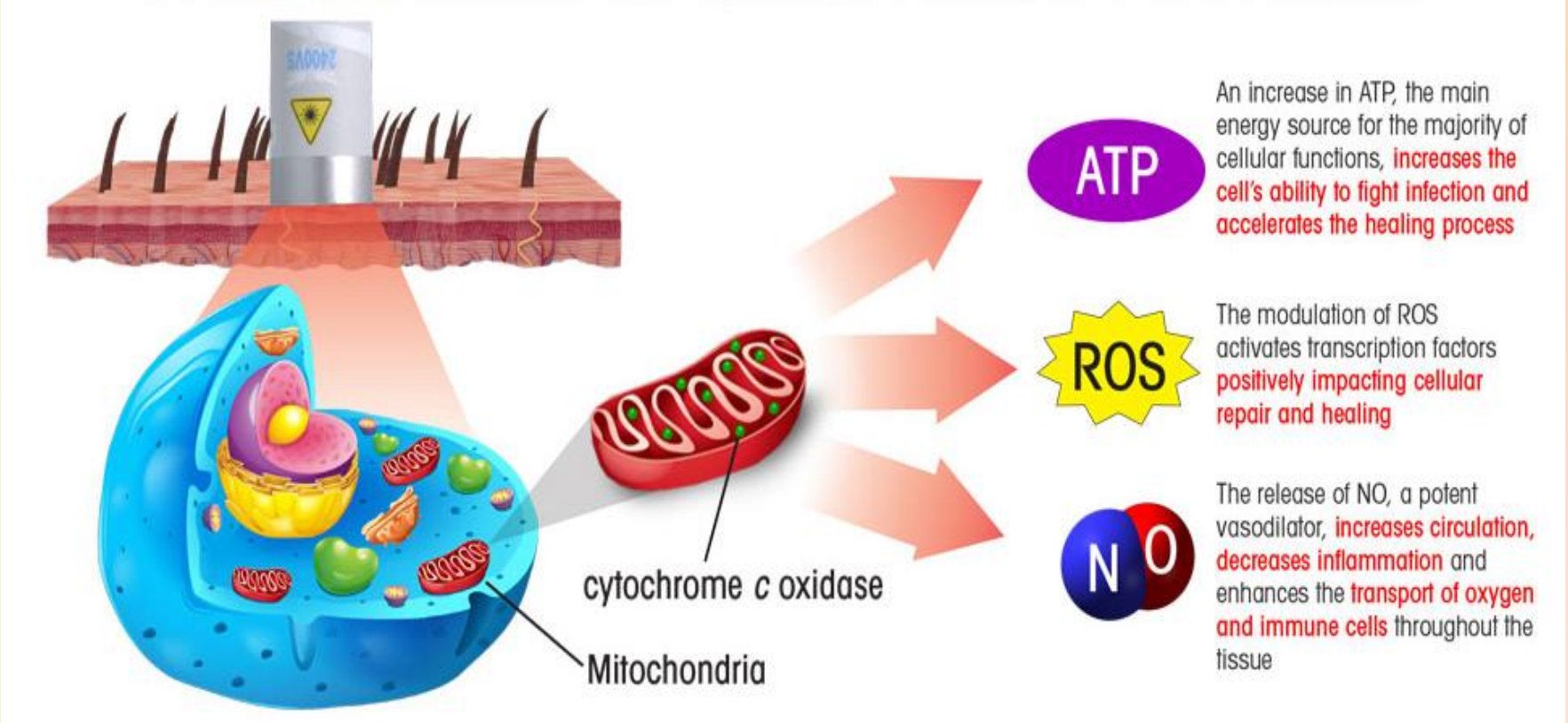
*Evidence suggests that **LLLT** photobiomodulates soft tissues by increasing oxidative metabolism in mitochondria through the electronic excitation of respiratory chain components.

*Mitochondrial chromophores, absorb light energy, presumed to trigger **photobiomodulation**.

*Photobiomodulation effects include **analgesia**, **anti-inflammation**, and **increased protein and collagen synthesis**.

*Enhanced cellular metabolism and function are proposed, promoting soft-tissue healing.

*LLLT has been primarily used for managing wounds, tendinopathies, and pain.



Research-Based Indications of LLLT

1- Dermal wounds.
2- Tendinopathies.
3- Myofascial/trigger point pain.
4- Rheumatoid arthritis.
5- Mixed painful musculoskeletal conditions.
6- Osteoarthritis.
7- Herpes/postherpetic pain.
8- Neck/lower back pain.
9- Temporomandibular disorders.
10- Carpal tunnel syndrome.

Parameters of LLLT

1. Wavelength:

-**Helium-neon** laser 632 nm for superficial penetration (0.5-2 cm)

-**Gallium arsenide** laser 905 nm for deep penetration (2-10 cm)

2. Frequency:

- 200 Hz to 10,000 Hz.
- For healing less than 1000HZ and for pain relief more than 1000HZ.

3. Power output:

-The power output of the machine is expressed usually in **milliwatts**.

-Power is from 2 mw to 500 mw to vary the energy.

4. Total Energy:

- This is given in **joules** (J)
- It is expressed the energy of irradiation for the total treatment

J = 1 W× sec

Ex: a 30 mW device applied for 1 min.

0.03×60 = 1.8 J

5. Energy density:

- It’s the best method of specifying dosage and is given in **joules per unit area (J/cm2)**.

***N.B.**

- ENERGY DENSITY per TREATMENT SESSION should generally fall in the **range of 0.1 - 12.0 J/cm2** though there are some recommendations that go **up to 30 J/cm2**.

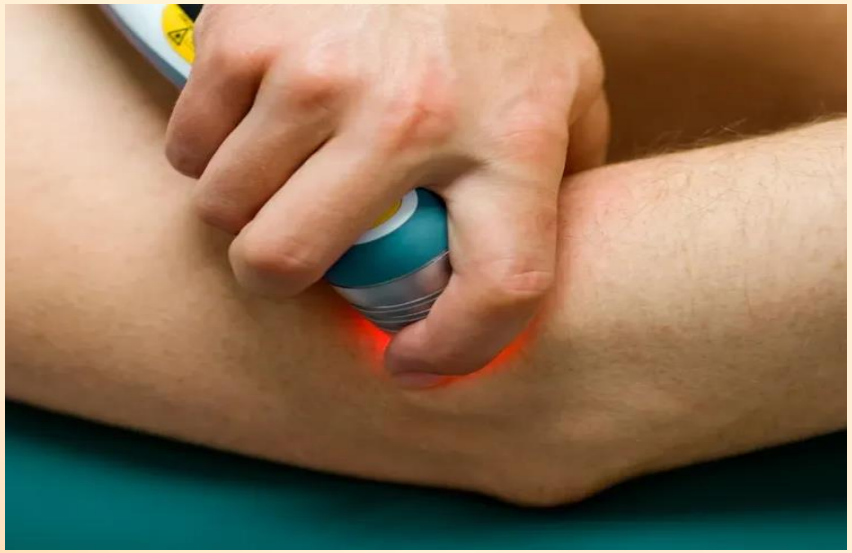
6 -10 J/cm2	Wound infection
2-5 J/cm2	Wound healing
10 J/cm2	Hypertrophic scar
2-3 J/cm2	Acute muscle strain and ligament sprain
4-6 J/cm2	Chronic muscle strain and ligament sprain
2- 6 J/cm2	Pain
2-4 J/cm2	inflammation
2-5 J/cm2	Osteoarthritis
2-5 J/cm2	Open nerve regeneration
2 J/cm2	Closed nerve regeneration
2-6 J/cm2	Fracture

6. Mode:

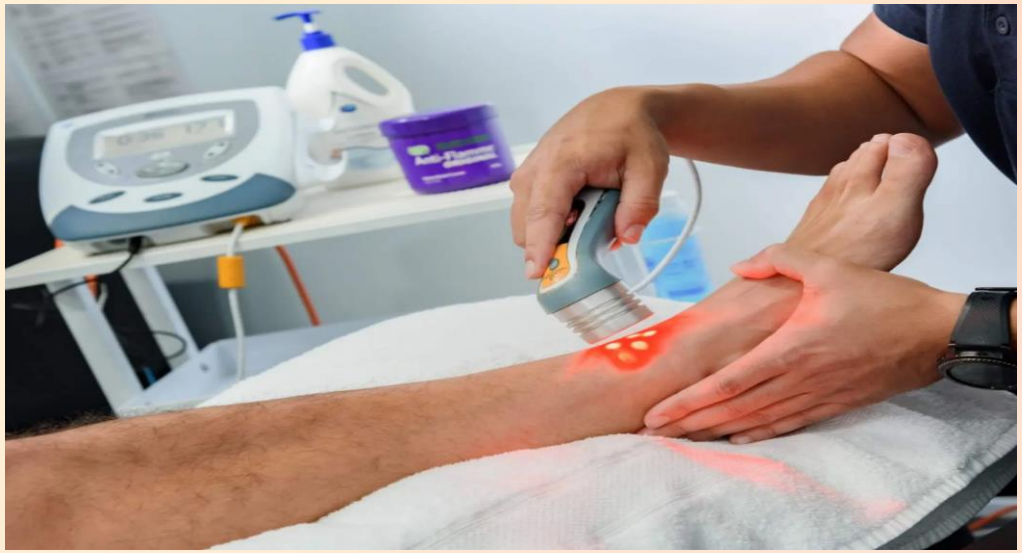
- **Pulsed** in acute conditions and **continuous** in chronic.
- Pulse ratio is 10%, 20% up to 100%.
- **Helium-neon lasers** are usually in continuous mode.
- **Gallium arsenide lasers** are usually in pulsed mode.

*Delivery technique:

I- Contact technique.



II- Non-contact technique.



Instructions for LLLT Application

1-Check for any contraindications.

2-Consider any precautions or risks.

3-Ensure comfortable body positioning and inform the patient that he or she may feel nothing during treatment.

4-Prepare treatment area:

- **Normal skin:** Cleanse the exposed skin with rubbing alcohol to remove impurities. Shave excessive hair if necessary.
- **Wounded skin:** Wash and debride the wound. Wear protective gears like goggles, mask, gown, and gloves to prevent contamination.

5-Estimate **location**, **depth**, and **surface area of lesion**:
Locate the pathologic soft-tissue lesion, estimate its depth (in centimeters) from the skin surface, and measure its surface area (in square centimeters). Information about tissue depth will guide the selection of laser. Measurement of lesion's surface area will guide the selection of applicator's size.

6-Select device type: **Diode-type lasers** have replaced the **gaseous type** because they are much less expensive to manufacture. Consequently, the remaining elements of this protocol relate only on the application of **diode-type lasers** (**GaAlAS** and **GaAs**). Plug line-powered devices into ground-fault circuit to prevent macroshock.

7-Select light range: the deeper tissue, the infrared light should be used.

- **Red light:** Select diodes emitting within the 600–750 nm range.
- **Infrared light:** Select diodes emitting within the 750–1000 nm range.

8-Select applicator type and size: Choose between the wand, cluster, or array pad applicators. Select the wand probe for small, cluster probe for medium, and array pad for larger treatment areas.

9-Select application technique:

- **Stationary with contact:** The applicator makes contact with the skin and is kept in place for the entire irradiating duration or treatment. This method eliminates photonic reflection off the skin surface and minimizes beam divergence because of the probe's proximity to the treated area.
- **Stationary with noncontact:** The applicator makes no contact with the skin and is kept in place for the entire irradiating duration or treatment. The applicator-irradiating surface is maintained at a few millimeters (less than 1 cm) for the skin surface. This method is recommended when patients cannot tolerate the pressure exerted by the applicator on the treated surface.

• **Gridding:** This technique, also called point-by-point, consists in making a grid by mapping the entire treatment surface area with 1-cm2 squares to guide the point-by-point application.
Each square centimeter corresponds to one point, thus the related term point-by-point technique. The grid can be made either visually or with a plastic sheet and a pen. Gridding is used with the wand probe, because its tip or irradiating area is often less than 1 cm2.

• **Scanning:** The entire treatment surface area is scanned (noncontact) using wand- and cluster type probes. This scanning action may be done by manipulating the wand probe (up-and down and side-to-side movements). It can also be done automatically by means of robotic displacements of the diodes within the cluster probe positioned over the treatment area.

10-Set dosimetry: Choose between the continuous or pulsed mode of delivery. Determine the dose (J) of energy that you want to deliver to the tissues per application.

15- Position the applicator: Apply the following two laws in application:

- **Lambert's cosine law:** Keep the laser beam as perpendicular as possible to the exposed treated surface area to minimize light reflection.
- **Inverse square law:** If noncontact is used, keeps the distance separating the applicator and the exposed skin surface as small as possible, and constant from one application to the next.

16-Put on protective laser goggles:

Both patients and practitioners must wear protective glasses, which filter the wavelength range emitted by the laser device during therapy.

17-Conduct post treatment procedures: Inspect the exposed treatment area and record any adverse reaction.

Contraindications for LLLT:

1- Over the eye—damage to the retina.

2- Over a malignant lesion—further spread of lesion.

3- Over the abdominal and pelvic area of a pregnant woman—interference with normal development and growth of the fetus.

4- Over a hemorrhagic area—exacerbating the condition by laser-induced vasodilation.

5- Over the thyroid gland—interfering with normal function of the thyroid gland.

6- In patients with epilepsy—inducing an epileptic seizure.

N.B. **Metal and plastic implants**, as well as **pacemakers**, are **not contraindicated** and can be used safely.

Precautions for LLLT:

1- Over bruised muscle—the risk of enhancing bruising.

2- Over testicular region—risk of affecting fertility.

3- Over sympathetic ganglia, vagus nerve, and cardiac region in patients with heart disease—risk of adverse heart effects.

4- Over the bone epiphyseal region of growing children—the risk of affecting bone growth.

5- Over an infected area—the risk of stimulating or inhibiting bacterial activity.

*Before treatment with **LLLT**, **both** patients and practitioners must **wear protective glasses or goggles**, which filter the wavelength range emitted by the laser device during therapy.


Thank
you!


سُبْحانك
اللّهُمّ وبحمدك
أشهدُ أنْ لا إله إلاّ أنتَ
أستغفرُك وأتوبُ إليك