Physical Therapy Procedures -1-(RHS-321)

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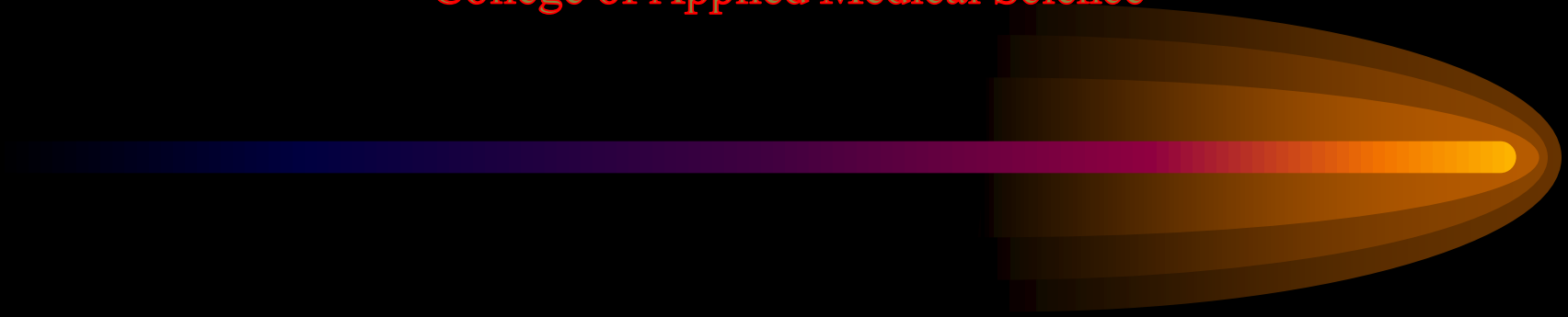

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Objectives of Lecture

Following completion of this lecture the student must be able to;

- Define the electromagnetic spectrum and explain its physical properties.
- Define waveform and frequency and analyze the relation between them.
- Explain how the laws governing the effects of electromagnetic energy apply to different therapeutic modalities..

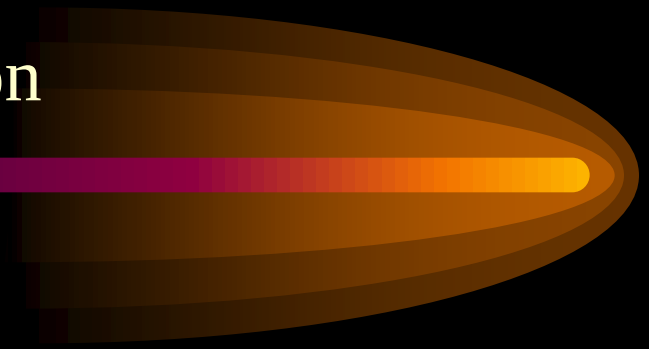
ELECTROMAGNETIC SPECTRUM

Definition

Electromagnetic Radiation Production

Laws of Electromagnetic

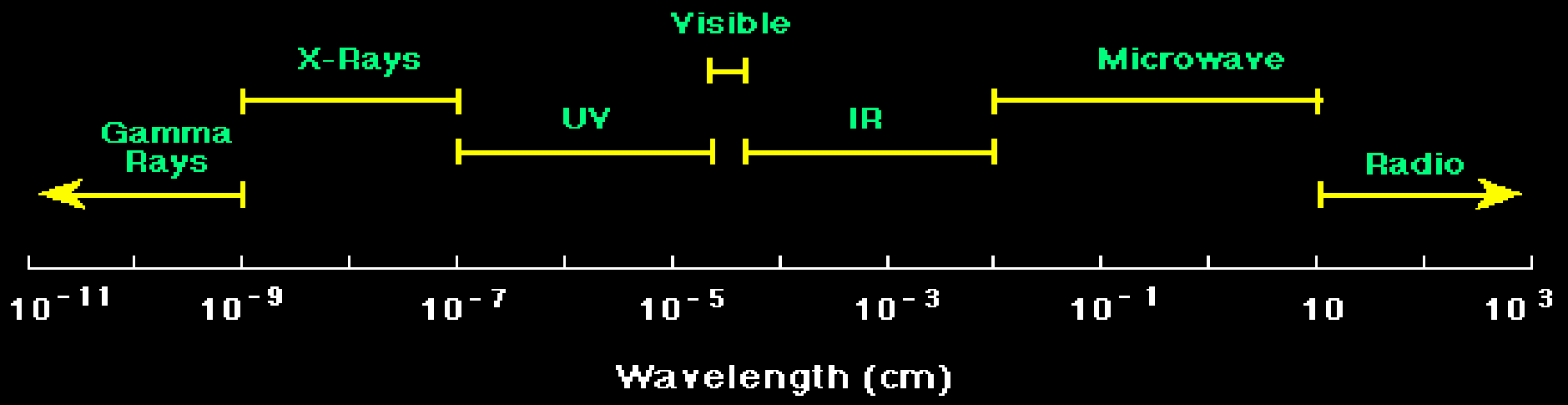
- ✓ Reflection
- ✓ Refraction
- ✓ Absorption
- ✓ Inverse Square law
- ✓ Law of Grotthus-Draper
- ✓ Cosine Law
- ✓ Arndt-Shultz Principle



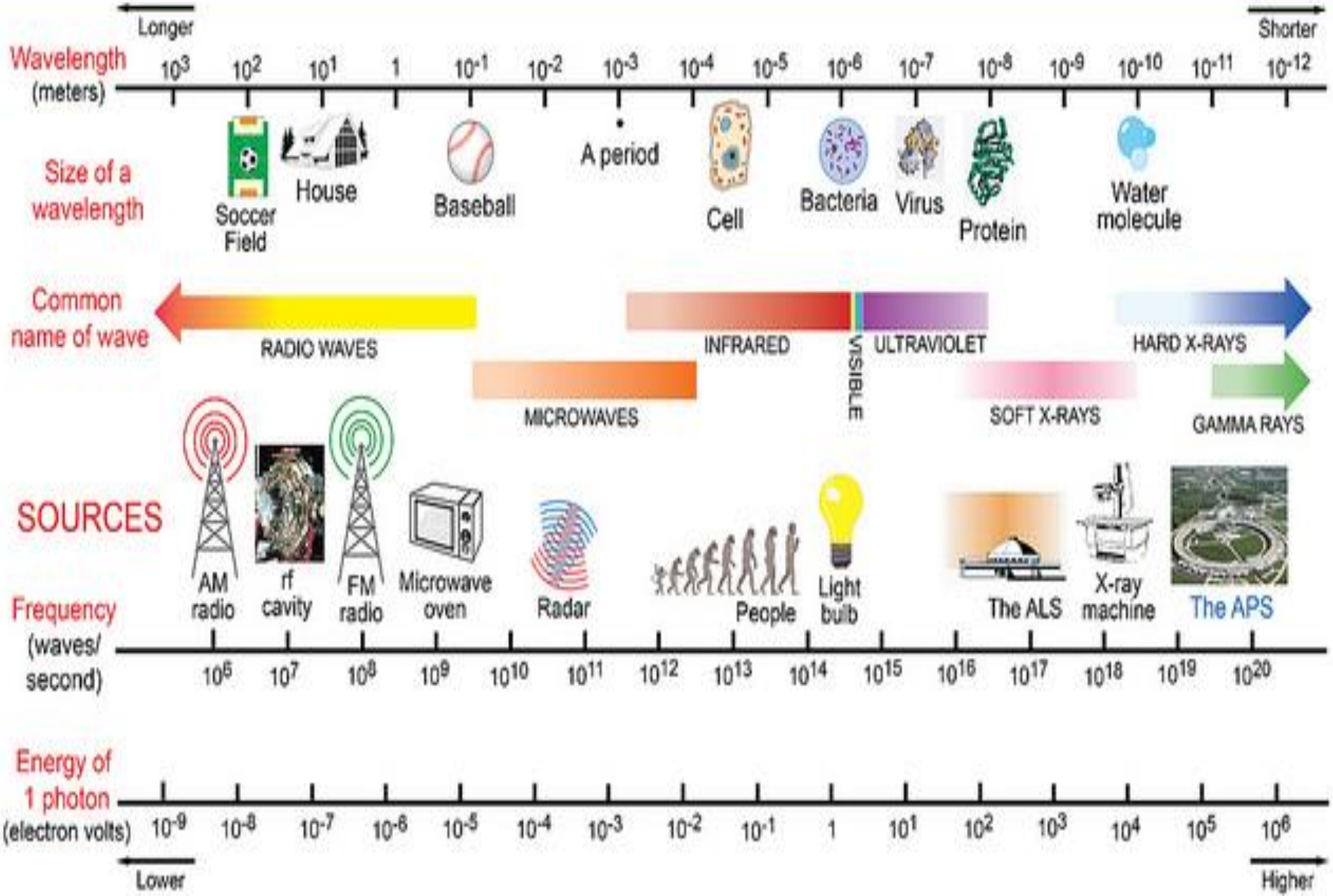
What is Electromagnetic spectrum?

The electromagnetic spectrum is a **continuum line** contains different kinds of **radiations** , which are differentiated by their **wavelengths , frequency and energy.**

Radiation is a process by which electromagnetic energy travels from its source outward through space.



The Electromagnetic Spectrum



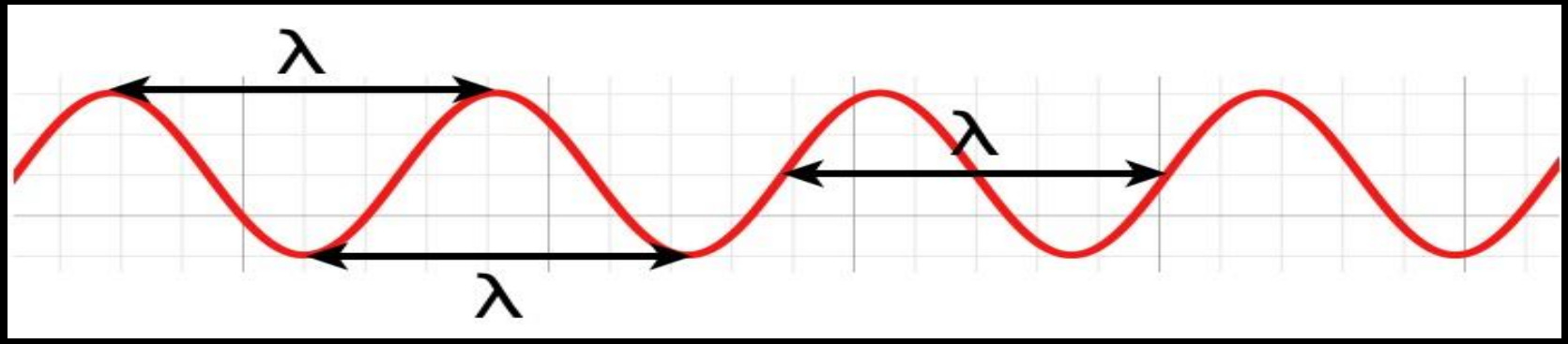
Electromagnetic spectrum

- **Characteristics of Electromagnetic Modalities**
  - Operate at specific wavelengths , frequencies & energy
  - Transmitted without medium for support (vacuum)
  - Travel at speed of light ($3x10^8$ m/sec)
  - Energy travel in a straight line
  - Can be reflected, refracted, absorbed or transmitted

What is Wavelength ?

Wavelength (λ) is the distance between two identical points in a wave. It is typically measured between two easily identifiable points, such as two adjacent crests or troughs

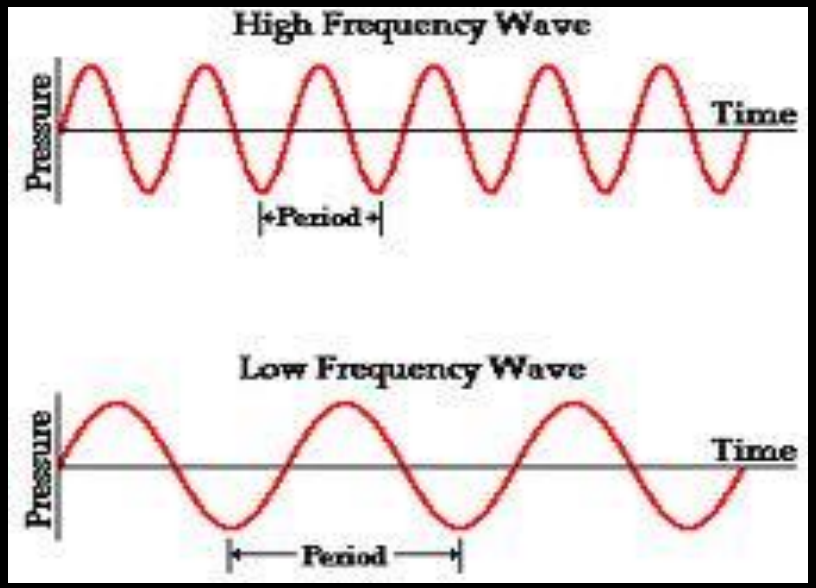
Wavelength is measured in meters, centimeters, millimeters or nanometer.

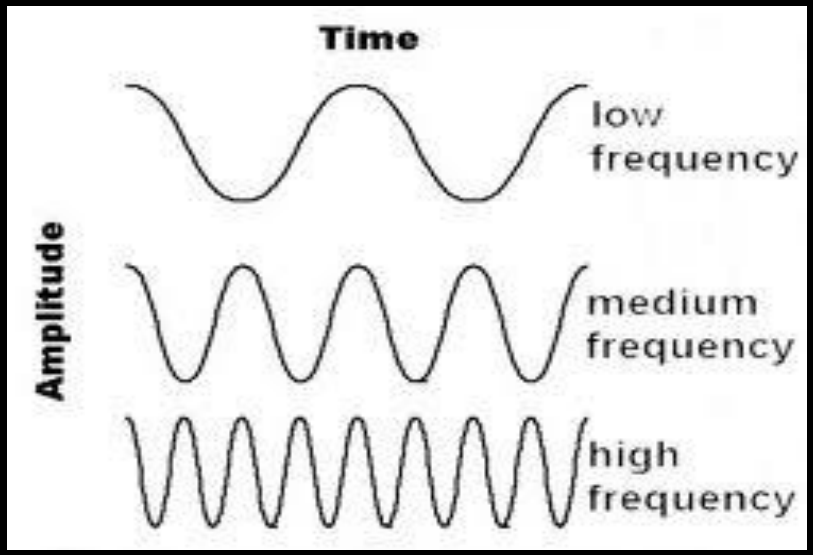


What is Frequency?

Frequency (F) is the number of waves that pass a fixed point in a given amount of time. (cycle /second)

Frequency is expressed in Hertz (Hz). One Hertz is one cycle per second





What is the Velocity?

Velocity (v) is the rate of changes distance in a particular direction. It is the constant for all forms of electromagnetic waves, being $3x10^8$ m/sec {i.e. the speed of light}.

As the velocity is constant for all electromagnetic waves. There is an inverse relationship between wavelength and frequency

Wavelength = Speed of light / Frequency

$$\lambda = V/f$$

Relation between wavelength and frequency

Longest Wavelength

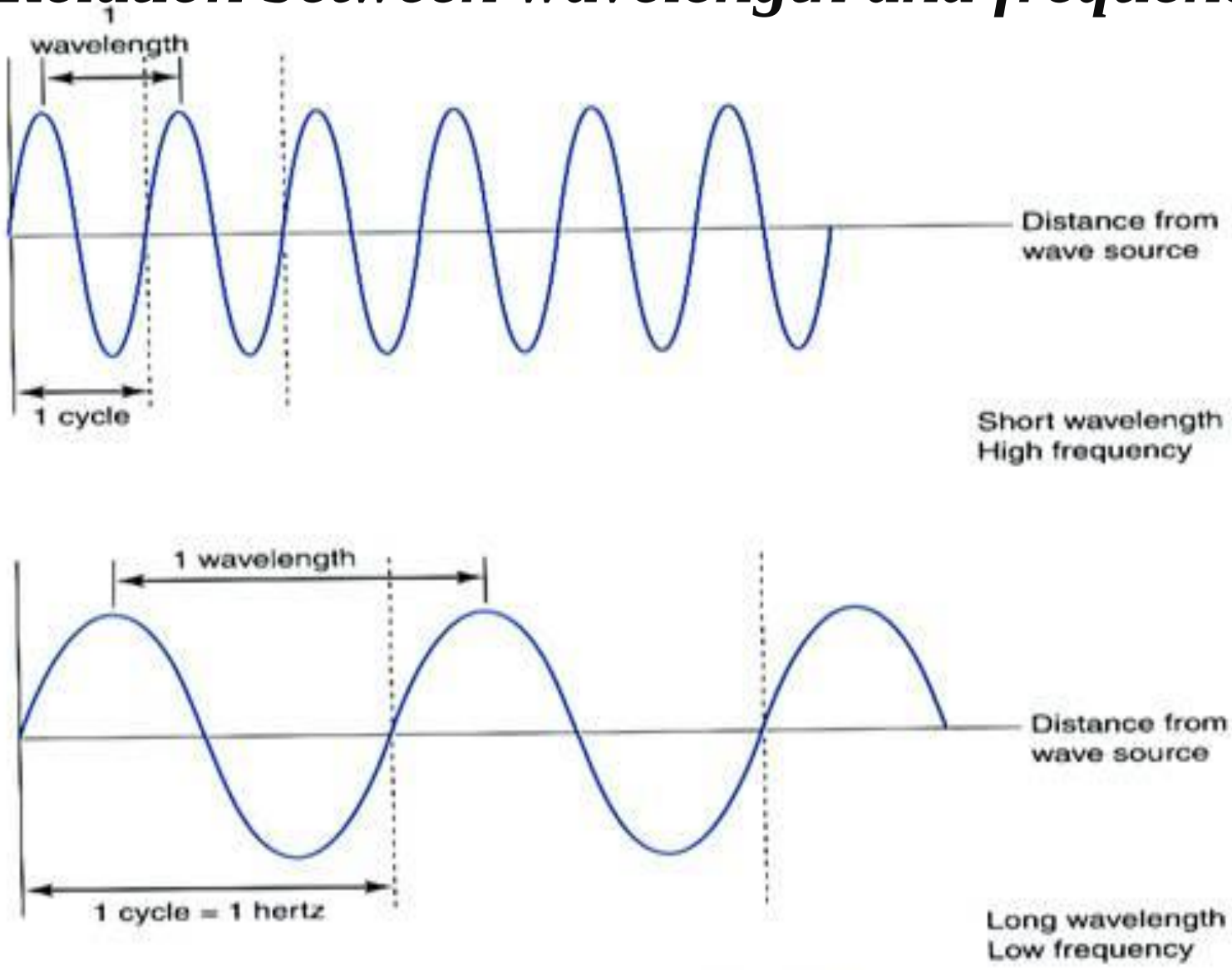
Lowest Frequency Energy

Region	Wavelength (centimeters)	Frequency (Hz)	Energy (eV)
Radio	> 10	$< 3 \times 10^{9}$	$< 10^{-5}$
Microwave	10 - 0.01	3×10^{9} - 3×10^{12}	10^{-5} - 0.01
Infrared	0.01 - 7×10^{-5}	3×10^{12} - 4.3×10^{14}	0.01 - 2
Visible	7×10^{-5} - 4×10^{-5}	4.3×10^{14} - 7.5×10^{14}	2 - 3
Ultraviolet	4×10^{-5} - 10^{-7}	7.5×10^{14} - 3×10^{17}	3 - 10^{3}
X-Rays	10^{-7} - 10^{-9}	3×10^{17} - 3×10^{19}	10^{3} - 10^{5}
Gamma Rays	$< 10^{-9}$	$> 3 \times 10^{19}$	$> 10^{5}$

Shortest Wavelength

Highest Frequency Energy

Relation between wavelength and frequency



The relationship between wavelength and frequency.

What is Non-Ionizing Radiation?

Non-Ionizing radiation includes all kinds of electromagnetic radiations with frequencies < 10^{15} Hz and wavelengths $\lambda=10^{-8}$-10^{4} m.

The Non-Ionizing radiations has enough energy to move atoms in a molecule around or cause them to vibrate, but not enough to remove electrons (cause ionizations in the matter), these Included ;

- Ultraviolet (UV)
- Paraffin Wax (PW)
- Hot packs (HP)
- Infrared Radiation (IR)
- Short waves Diathermy (SWD)
- Microwaves Diathermy (MDT)

What is Ionizing Radiation?

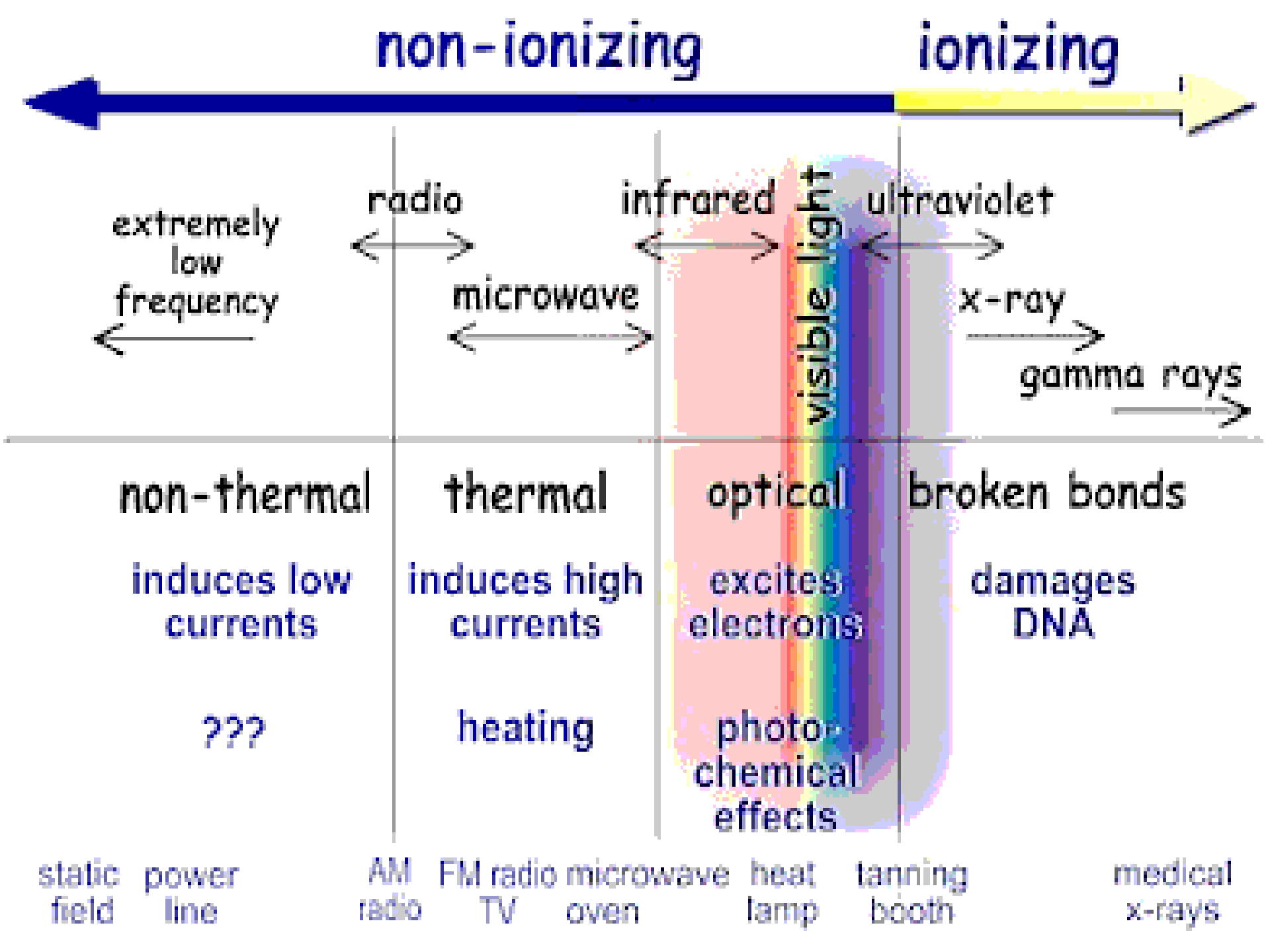
Ionizing Radiation is electromagnetic radiation that has enough energy to cause electrons to be knocked out of their orbital shells in an atom, or to break chemical bonds within a molecule.

- X-ray
- Gamma ray
- Ultraviolet

Ionizing radiation can **inhibit** cell division, therefore, used for

Treatment of cancer &

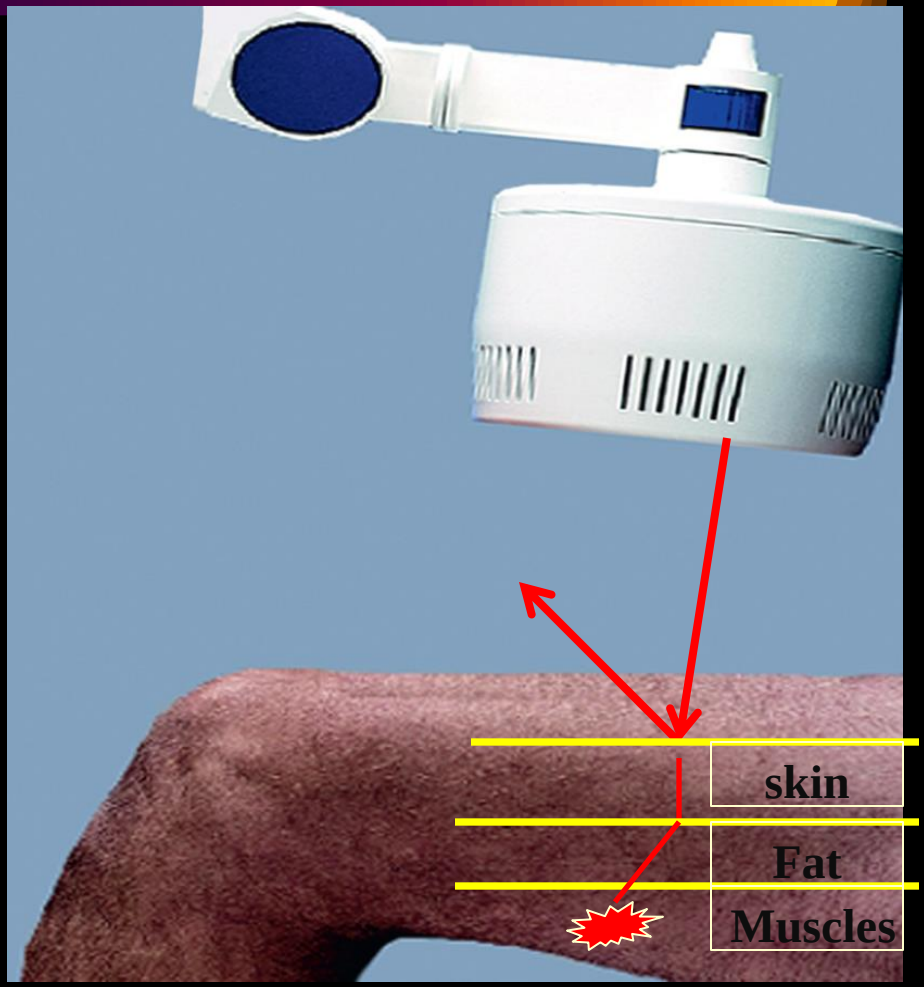
Imaging procedures.


non-ionizing
ionizing
extremely low frequency
radio
microwave
infrared
visible light
ultraviolet
x-ray
gamma rays
non-thermal
thermal
optical
broken bonds
induces low currents
induces high currents
excites electrons
damages DNA
???
heating
photo-chemical effects
static field
power line
AM radio
FM radio TV
microwave oven
heat lamp
tanning booth
medical x-rays

Laws Governing Radiation

All electromagnetic radiations such as Infra-red, visible light, ultra violet, and short waves travel in straight lines until they encounter a different medium, then they may be:

- Refracted
- Reflected
- Transmitted
- Absorbed



Refraction

•Refraction occurs when electromagnetic rays are transmitted from one medium to another with different optical density and an angle of incidence greater than zero.

•Refraction causes the ray to be deflected from its original course by an amount depending on;

- •Media involved
- •Angle of incidence (Snell' law).

- Ray with zero angles of incidence striking the surface at a right angle continue in the same straight line.

Clinical application: using coupling media as in treatment of ultrasound (water coupling media).

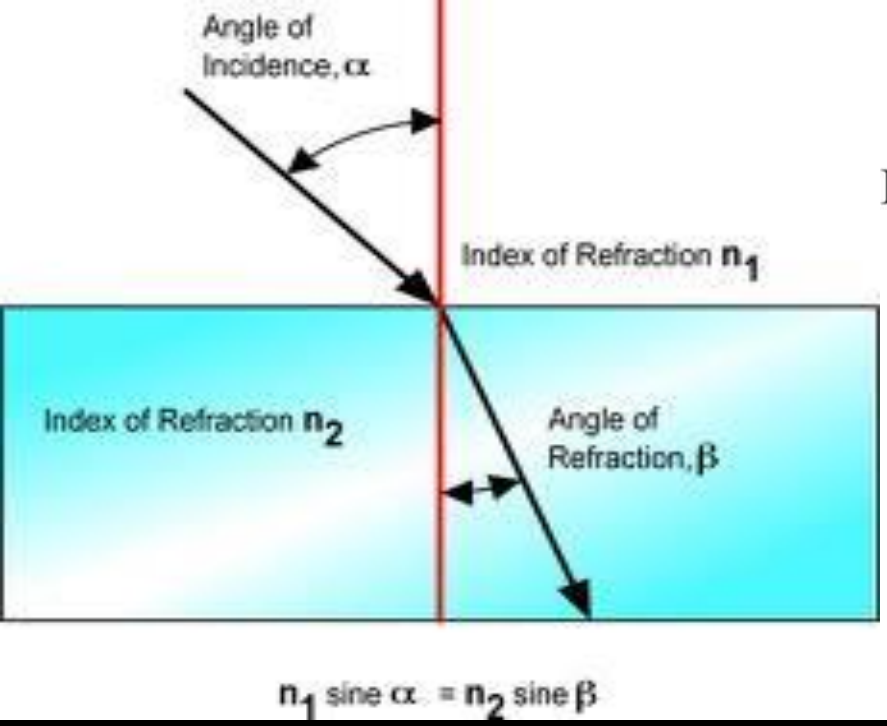
Reflection

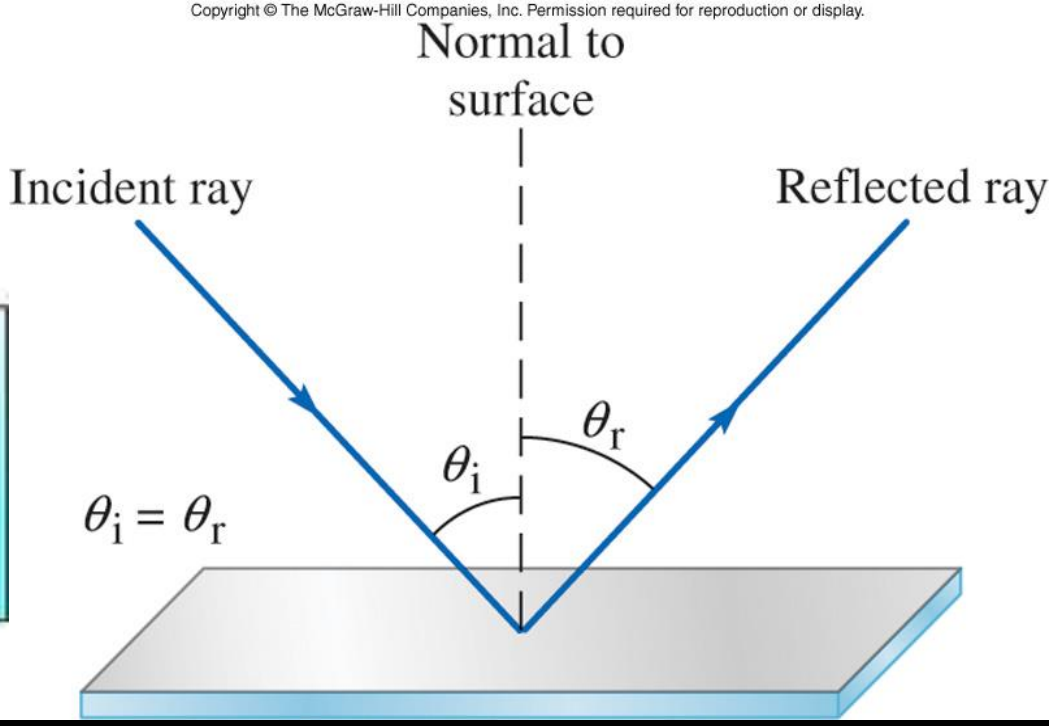
- Reflection occurs when electromagnetic waves encounters a medium which will **not transmit** it. In this case, the ray is **reflected** back into the **same plane** .
- The angle between the incident ray and the normal equals the angle between the reflected ray and the normal.

- If the angle is 0^0(i.e. the radiation strikes the surface at right angles), then the angle of reflection is also $0^{0.}$

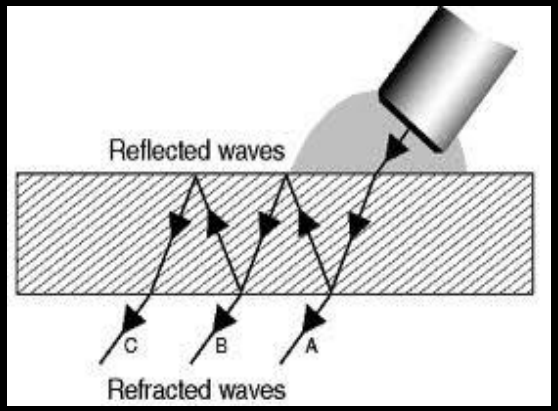
Clinical applications

- 1-In infra-red and ultraviolet, where the re-direction of rays towards an appropriate target is required.
- 2-InUS therapy, {tissue air interface, How?}

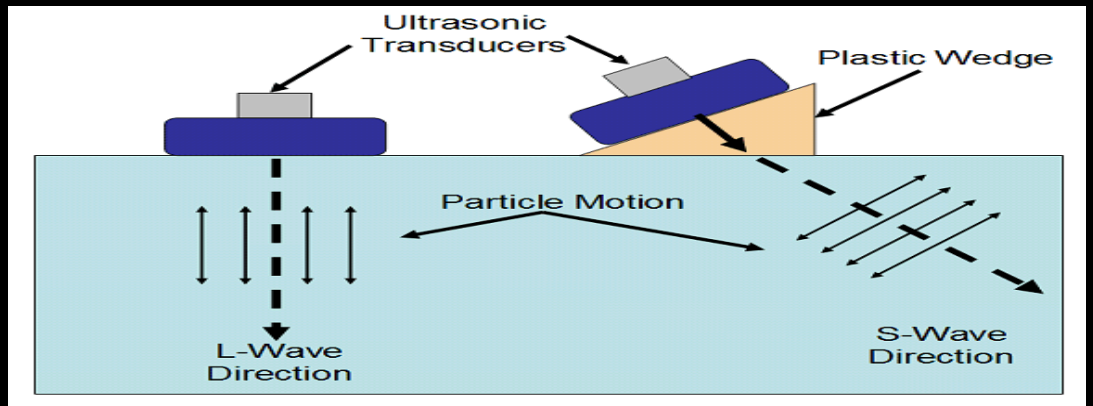




Refraction



Reflection

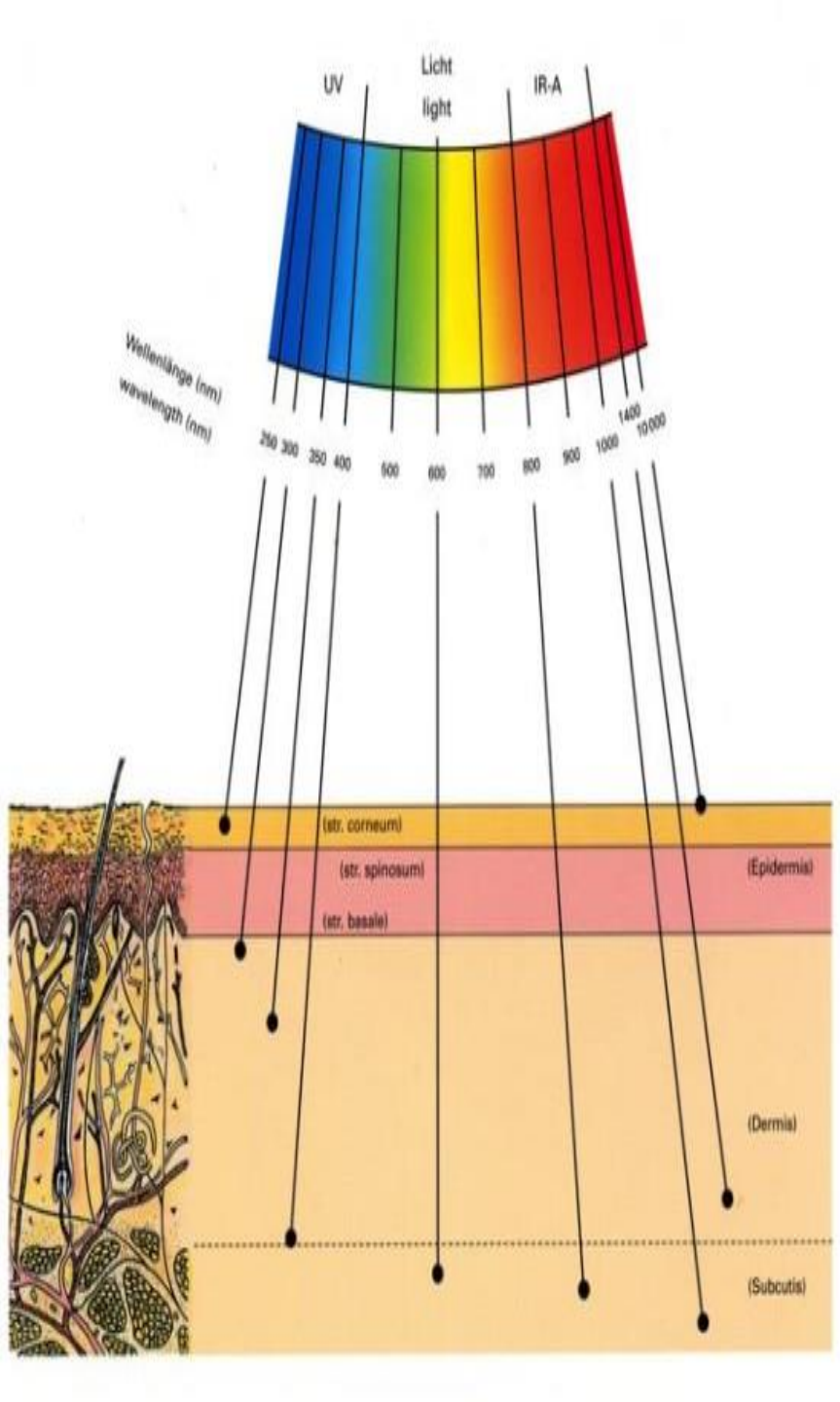


Absorption

When an electromagnetic wave strike a new medium they may be absorbed and thus produce an effect and the amount of rays absorbed depends on:

1. Wavelength & Frequency
2. Angle of incidence
3. Nature of a medium
4. Intensity of radiation.

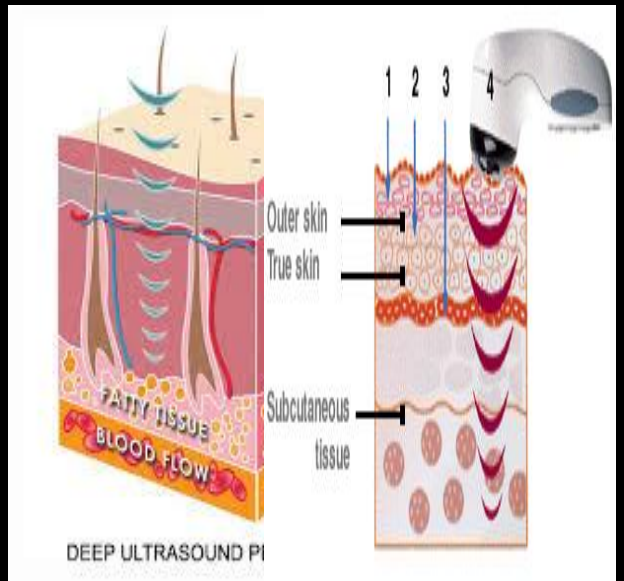
Shorter wavelengths will have higher energy and frequencies and low depth of penetration and greater absorption in superficial tissue.



Law of Grotthus Draper

- The law of Grotthus Draper describes the inverse relationship between the **penetration** and **absorption** of energy. If the energy is not absorbed by the superficial tissues it will penetrate to deeper tissues. So some physiological response will occur

In clinical; using US at a frequency of 1MHz would be more effective than at 3MHz, because less energy would be absorbed superficially at 1MHz and thus more energy penetrate to deeper tissues.

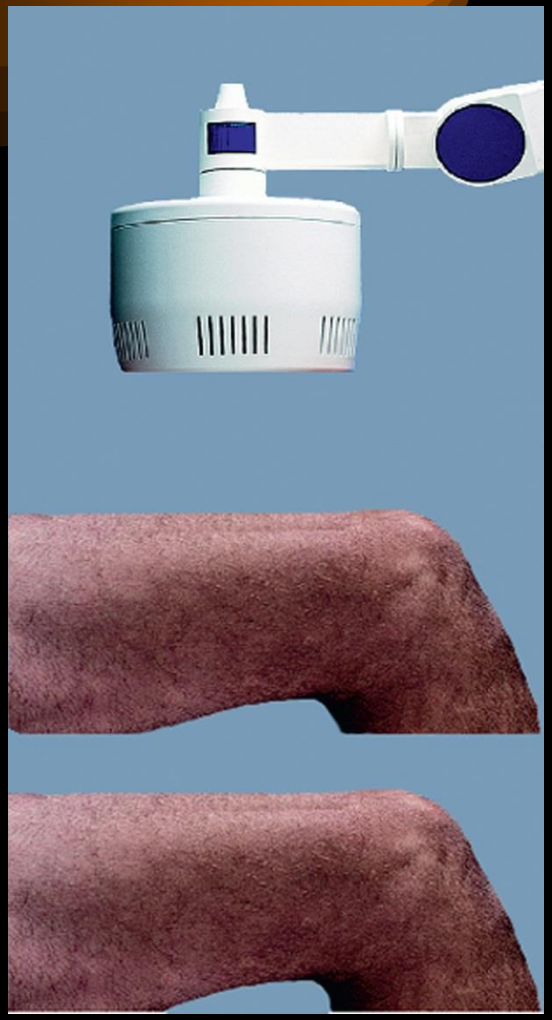


Inverse Square Law

"Intensity of radiation is inversely proportional to the square of the distance" from the source.

- Inverse Square Law $E=E_o/D^2$
  - E= energy received by the tissues
  - E_o= energy produced by the source
  - D^2= Distance Squared
- Inverse square law can be employed in practice;

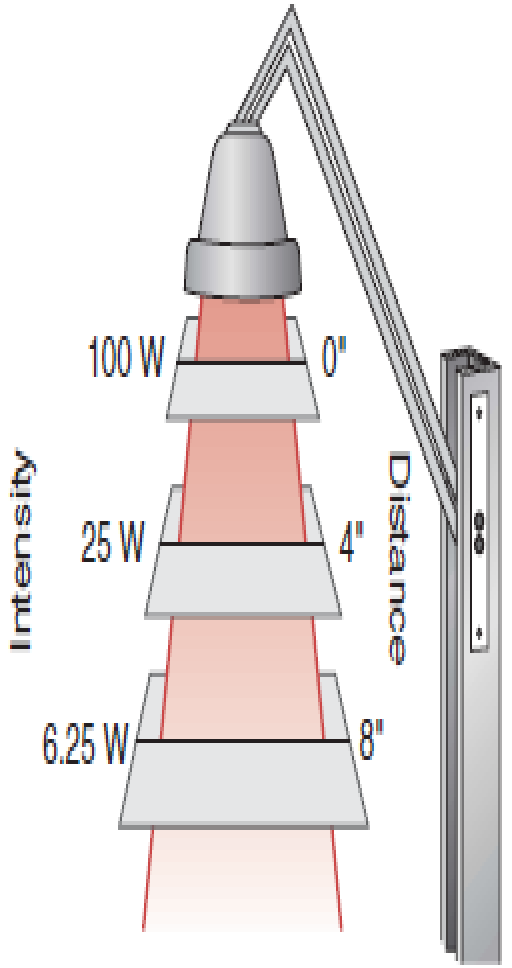
  The closer the source of radiation , the greater the intensity of radiation being received by the skin, the further away, the less the intensity.



Inverse Square Law

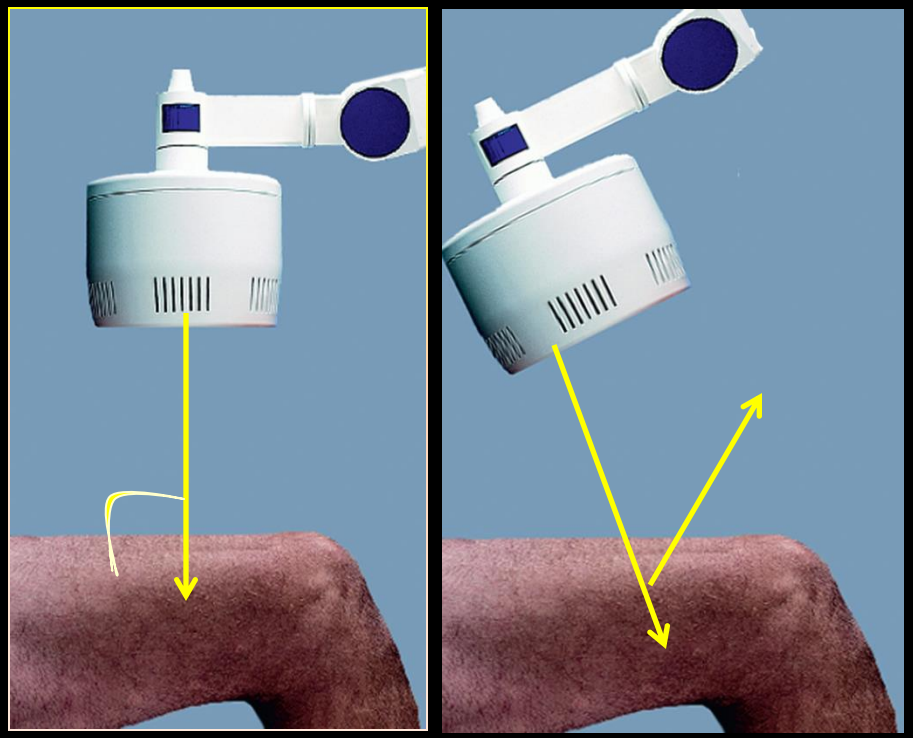
"Intensity of radiation is inversely proportional to the square of the distance" from the source.

When the distance between the energy source and the skin is reduced by half, the heating effect is increased by 4*x* *(the inverse of 1⁄2* equals 2, and 2 equals 4).



Cosine Law

- The smaller the angle between the propagating ray and the right angle, the less the radiation reflected and the greater the absorption. Thus, radiant energy is more easily transmitted to deeper tissues if the source of radiation is at a right angle to the area being radiated.



In clinical; when applying UV, IR, US, great efforts should be made to ensure that the maximum number of radiated energy strike the treatment area at a right angle **(angle of incidence = 0degree).**

- For the most effective absorption of energy. Keep the US head flat on treated body surface **(Why?).**

Arndt-Schultz Principle

- It states that "No reactions or changes can occur in the body tissues if the amount of energy absorbed is insufficient to stimulate the tissues"

In clinical setting

If the amount of energy absorbed is too small, no significant reaction will take place.

If the amount of energy absorbed is adequate, normal function will take place.

If the amount of energy absorbed is too great, disruption and function cannot take place.

Conclusion

Physical modalities, shortwave diathermy (SWD) and microwave diathermy (MWD), the infrared (IR) laser, and ultraviolet (UV) are all classified as portions of the electromagnetic spectrum according to corresponding wavelengths & frequencies associated with each region.

All electromagnetic radiations travel at the same velocity; thus wavelength and frequency are inversely related. Those radiations with the longer wavelengths tend to have the greatest depth of penetration.

Radiations may be reflected, refracted, absorbed, or transmitted in the various tissues.

The purpose of using any therapeutic modality is to stimulate a specific tissue to perform its normal function.

REVIEW QUESTIONS

1. What is the electromagnetic spectrum and radiant energy?
2. What is the relationship between wavelength and frequency?
3. What are the characteristics of electromagnetic energy?
4. According to the Law of Grotthus–Draper, what happens to electromagnetic energy when it comes in contact with and/or penetrates human biologic tissue?
5. Explain the cosine and inverse square laws relative to tissue penetration of electromagnetic energy.

True or False

1. Wavelength is defined as the number of cycles per second.
2. To achieve deeper tissue penetration, the wavelength must be increased.
3-Wavelength is the distance between the peak of one wave and the peak of the next wave

Multiple Choice

1-Which of the following is NOT an electromagnetic energy modality?

a. Ultraviolet light
b. Ultrasound
c. Low-power laser
d. Shortwave diathermy

2. Sound or radiation waves that change direction when passing from one type of tissue to another are said to.

a. Transmit
b. Absorb
c. Reflect
d. Refract

3. The states that if superficial tissue does not absorb energy, it must be transmitted deeper.

a. Law of Grotthus–Draper
b. Cosine law
c. Inverse square law
d. Arndt–Schultz principle

4. According to the cosine law, to minimize reflection and maximize absorption, the energy source must be at a angle to the surface.

a. 45 degree
b. 90 degree
c. 180 degree
d. 0 degree