- **Spectrum of light from the sun: Fig.1**

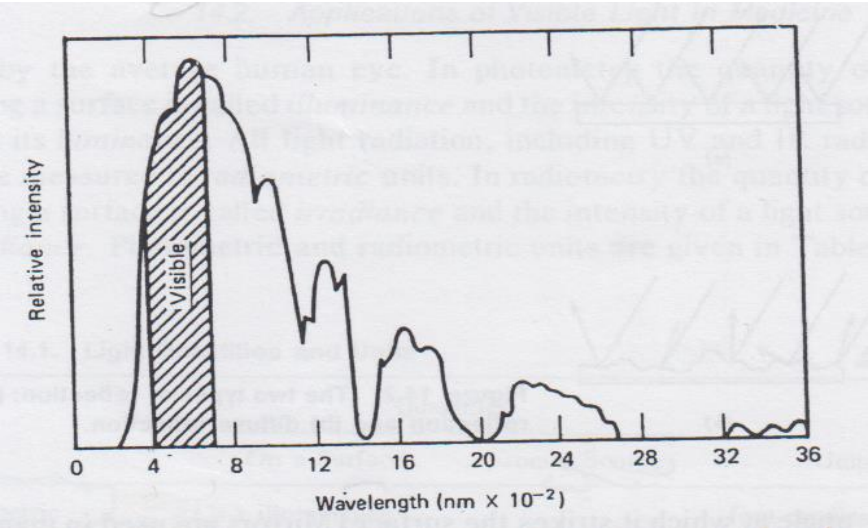

Figure 1. Relative intensity of solar energy of different wavelength at the earth's surface.

- **Properties of light**

1-It consists of bundle of photons, The speed of light changes when it goes from one material into another.The ratio of the speed of light in a vacuum to its speed in a given material is called the *index of refraction*. If a light beam meets a new material at an angle other than perpendicular, it bends, or is refracted.

2- Light behaves both as a wave and as a particle. As a wave, it produces interference and diffraction, which are of minor importance in medicine. As a particle, it can be absorbed by a single molecule. When a light photon is absorbed, its energy is used in various ways. It can cause a chemical change in the molecule that in turn cause an electrical change. This is basically what happens when a light photon is absorbed in one of the sensitive cells of the retina (the light-sensitive part of the eye).

3- When light is absorbed, its energy generally appears as heat. This property is the basis for the use in medicine of IR light to heat tissues. Also, the heat produced by laser beams is used to "weld" a detached retina to the back of the eyeball and to coagulate small blood vessels in the retina.

4- Sometimes when a light photon is absorbed, a lower energy light photon is emitted. This property is known as *fluorescence*; as you may guess, it is the basis of the fluorescent light bulb. Certain materials fluoresce in the presence of UV light, sometimes called "black light" and give off visible light.

The amount of fluorescence and the color of the emitted light depend on the wavelength of the UV light and on the chemical composition of the material that is fluorescing. One fluorescence is used in medicine is in the detection of porphyria, a condition in which the teeth fluoresce red when irradiated with UV light. Another important application is in fluorescent microscopes.

5- Light is **reflected** to some extent from all surfaces. There are two types of reflection. **Diffuse reflection** occurs when rough surfaces scatter the light in many directions. **Specular reflection** is a more useful type of reflection; it is obtained from very smooth shiny surfaces such as mirrors where the light is reflected at an angle that is equal to the angle at which it strikes the surface.

The Energy Carried by Light :

A beam of light is modeled as a stream of photons, each carrying a well-defined energy that is dependent upon the wavelength of the light . The energy of a given photon can be calculated by

Photon energy [$E = hc/\lambda$]

Where E is in joules

h= Plank's constant = 6.6 × 10 -34 J*S

c= Speed of light = 2.998 × 108 m/s

λ= Wavelength of the light in meters

*****For a quantum of green light (500 nm) the energy can be calculated as :

???

Measurement of Light and its Unit

- Ultraviolet (UV) light: λ = 100 ~ 400 nm
  - UV-C: 100 ~ 290 nm.
  - UV-B: 290 ~ 320 nm.
  - UV-A: 320 ~ 400 nm.
- Visible light: λ = 400 ~ 700 nm
- Infrared (IR) light: λ = 700 ~ 10,000 nm
- Photometric unit for visible light (Table:1)
  - Illuminance: quantity of light striking a surface
  - Luminance: intensity of a light source
- Radiometric unit for all lights (Table:1).
  - Irradiance: quantity of light striking a surface.
  - Radiance: intensity of a light source.
- Light has wavelengths much shorter than TV and radio waves but much longer than x-rays and gamma rays. Visible light has energies ranging from2 ~ 4 eV. For comparison, the kinetic energy of a molecule in air at room temperature is about 0.025 eV and the energy of a typical x-ray photon used in medicine is about 50,000 eV, 50 KeV(Fig.2).

	Quantities		
	On a Surface	From a Source	Units[a]
Photometric (visible light only)	illuminance	—	foot-candles or lumina/m² (luces)
	—	luminance	foot-lamberts or watts/m² per sr
Radiometric (UV, visible, and IR light)	irradiance	—	watts/m²
	—	radiance	watts/m² per sr

[a]A steradian (sr) is a unit for a solid angle. A typical ice-cream cone is about 0.2 sr.

Table 1. Light Quantities and units.

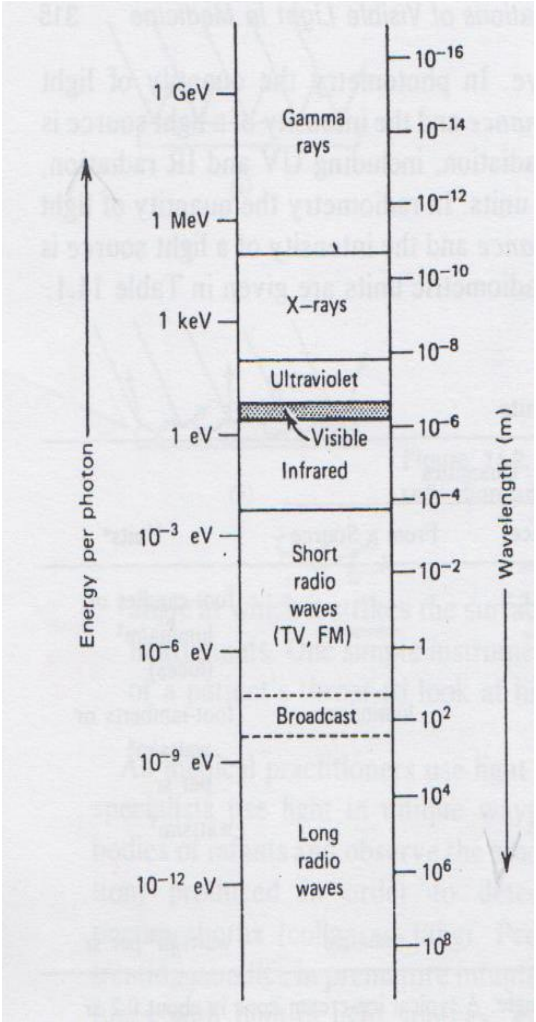

Fig.2. The relationship of light wavelengths to the entire spectrum of electromagnetic radiation

Phototherapy :

Therapeutic uses.

Jaundice (excessive secretion of bilirubin by the liver) in infants ,

Phototherapy using **visible light** (usually blue light ~ 450 nm).

Applications of UV and IR Light in Medicine

- Energy of photon: UV > visible > IR

1- UV light

- < 290 nm: germicidal (kill germs) ⇒ sterilize medical instruments.
- Conversion of molecular products into vitamin D.
- May improve certain skin conditions.
- Affect melanin to cause **tanning** or **sunburn**.
- Solar UV light: major cause of **skin cancer** (light absorption by DNA) ⇒cancer.
- Absorption of UV light in the eye.

2- IR light

- About half of the energy from the sun is in the IR region (Fig: 1). The warmth we feel from the sun is mainly due to the IR component. The rays are not usually hazardous even though they are focused by the cornea and lens of the eye onto the retina. However, looking at the sun through a filter (plastic sunglasses) that removes most of the visible light and allows most of the IR wavelengths through can cause a burn on the retina. Some people have damaged their eyes in this way by looking at the sun during a solar eclipse. Dark glasses absorb varying amounts of the IR and UV rays from the sun.
- Heat lamps that produce a large percentage of IR light with wavelengths of 1000 to 2000 nm are often used for physical therapy purposes. Infrared light penetrates further into the tissues than visible light and thus is better able to heat deep tissues.
- Two types of IR photography are used in medicine: reflective IR photography and emissive IR photography. The latter, which uses the long IR heat waves emitted by the body that give an indication of the body temperature, is usually called *thermography.*
- Reflective IR photography, which uses wavelengths of 700 to 9oo nm to show the patterns of veins just below the skin. Some of these veins are visible to the eye, but many more can be seen on a near-IR photograph of the skin.
- There is considerable variation in the venous patterns of normal individuals. Even in the same individual the venous patterns in the two breasts may be quite different, but these changes can be masked by the normal variations. A layer of fat beneath the skin can reduce the

appearance of the venous pattern. IR photography can be used to follow changes in the venous pattern.
- Near IR penetrates about 3mm below the skin regardless of the color of the skin.
- Infrared can also be used to photograph the pupil of the eye without stimulating the reflex that changes its size.

Lec.4

Lasers in Medicine

- Laser (Light Amplification by Stimulated Emission of Radiation).

Laser Typical characteristic :

- A laser is a unique light source that emits a narrow beam of light of a single wavelength (monochromatic light) in which each wave is in phase with the others near it (coherent light).
- A laser beam can be focused to a spot only a few microns in diameter. When all of the energy of the laser is concentrated in such a small area, the power density becomes very large.

Laser materials: gases, liquids, solids.

- In medicine lasers are used primarily to deliver energy to tissue, the laser wavelength used should be strongly absorbed by tissue (Fig. *).
- This curve varies for different individuals, but the short wavelengths (400-600 nm) are always absorbed better than the long wavelengths (~700 nm).

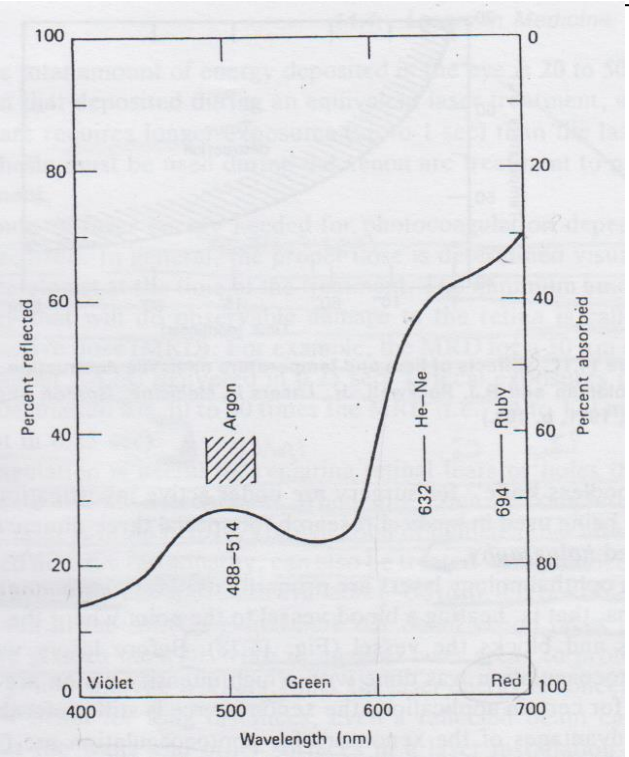

Fig.* The absorbance and reflectance of a white woman's skin.

❍ **Effect of laser**

1- Laser energy directed at human tissue causes a rapid rise in temperature and can destroy the tissue. The amount of damage to living tissue depends on how long the tissue is at the increased temperature.
2- 1064 nm laser ⇒ retina damage without heating.
3- 441.6 nm laser ⇒ photochemical damage.

❍ The laser is routinely used in clinical medicine only in ophthalmology. Its effectiveness in treating certain types of cancer and its usefulness as a "*bloodless knife*" for surgery are under active investigation. Lasers are used in medical research for special three-dimensional imaging called *holography*.

❍ In ophthalmology lasers are primarily used for photocoagulation of the retina, that is, heating a blood vessel to the point where the blood coagulates and blocks the vessel (Fig. 4).

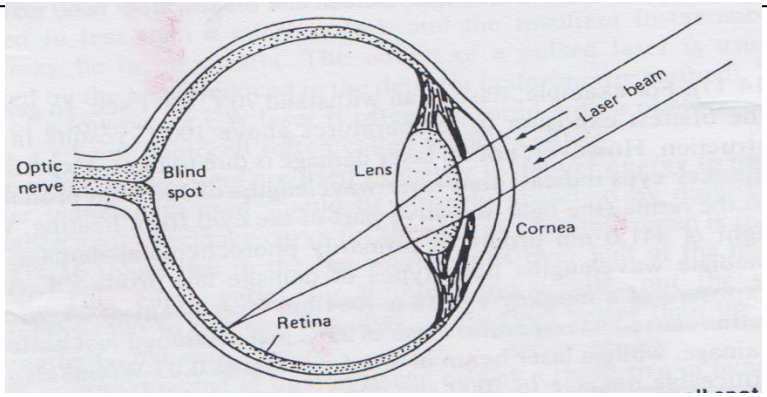

Fig.4. A laser beam is focused by the cornea and lens to a small spot on the retina where it photocoagulates a small blood vessel.

The amount of laser energy needed for photocoagulation depends on the spot s1ze used. In general, the proper dose is determined visually by the ophthalmologist at the time of the treatment. The minimum amount of laser energy that will do observable damage to the retina is called the minimal reactive dose MRD). For example, the MRD for a 50 μm spot in the eye is about 2.4 mJ de1ivered in 0.25 sec. Typical exposures needed for photocoagulation are 10 to *50* times the MRD (i.e., 24 to 120 mJ for a *50*μm spot in 0.25 sec).

Photocoagulation is useful for repairing retinal tears or holes that develop prior to retinal detachment. When the retina is completely detached, the laser is of no help. A complication of diabetes that affects the retina, called diabetic retinopathy, can also be treated with photocoagulation.

❍ Protective glasses must be worn in medical laser areas to protect the eyes of the patient and the workers. The area should have adequate warning signs and a system that prevents outsiders from entering while lasers are in use.

Laser Dental Applications

1- Reshape gum tissue (reduce prominence)
2- Laser aided teeth whiting
3- Laser Drill
   -Preparation for fillings
   - Capable of killing bacteria located in a cavity
   -No vibration