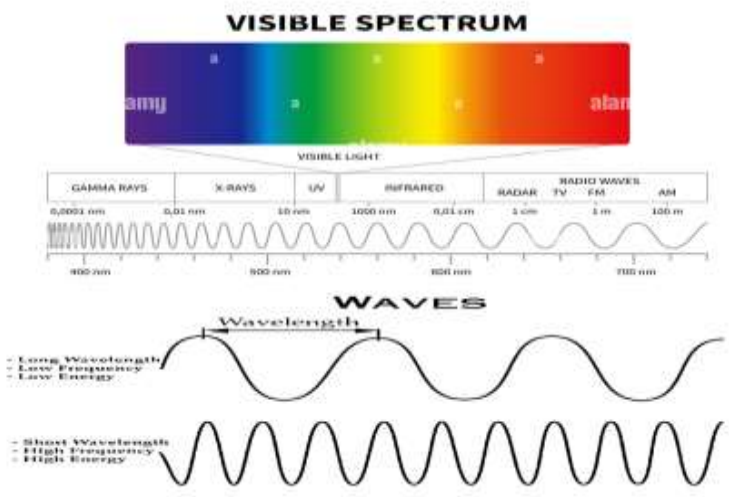
Light in Medicine

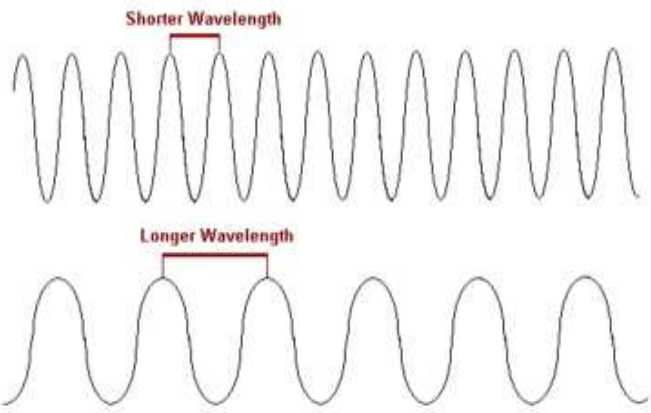
Light is part of the electromagnetic spectrum; the electromagnetic spectrum can be divided into several bands based on the wavelength (which ranges from radio waves to gamma rays).

1. Travel at the speed of light

2. Have no electric charge

We will study light in three categories (visible & ultraviolet & infrared).





Properties of light

Light has some interesting properties, many of which are used in medicine: -

1. The speed of light changes when it goes from 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. This property permits light to be focused and is the reason we can read and see objects clearly.

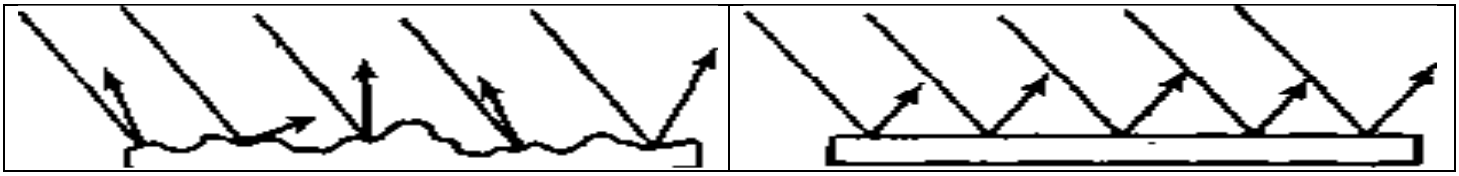
2. Light behaves both as a wave and as a particle. As a wave it produces interference and diffraction, which are of minor importance in medicine. As a particle it can be absorbed by a single molecule. When a light photon is absorbed its energy is used in various ways. It can cause a chemical change in the molecule that in turn can 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). The chemical change in a particular point of the retina triggers an electrical signal to the brain to inform it that a light photon has been absorbed at that point.

3. When light is absorbed, its energy generally appears as heat. This property is the basic 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 photon is absorbed, a lower energy light photon is emitted. This property is known as fluorescence, 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-way 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 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. Mirrors are used in many medical instruments.



Measurement of light and its units

The three general categories of light UV, visible, and IR **(Infrared)** are defined in terms of their wavelengths. Wavelengths of light used to be measured in **microns ($1\mu=10^{-6}m$)** or in **angstroms ($1Å=10^{-10}m$)**, but at present the recommended unit is the **nanometer ($1nm=10^{-9}m$).**

1-Ultraviolet light has wavelengths from about 100 to 400 nm.

2-Visible light extends from about 400 to 700 nm.

3-IR light (Infrared) extents from about 700 to over 10^4nm.

Energy of photon: UV > visible > IR

Applications of visible Light in medicine

A- Curved Surfaces

Curved lenses (concave, convex & cylindrical) lenses

Curved mirrors which are used in:

a. ophthalmoscope for the eye.

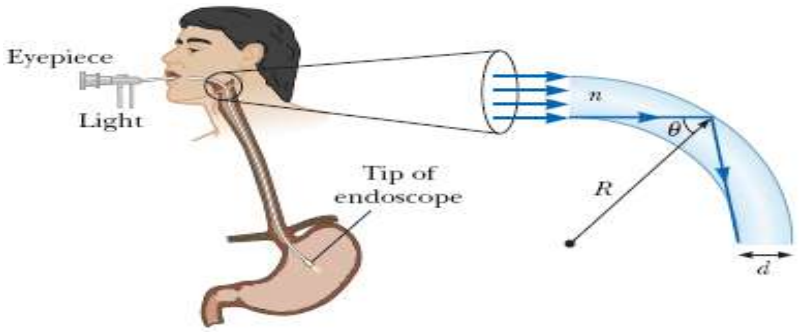
b. otoscope for the ear.

Ophthalmoscope

Otoscope

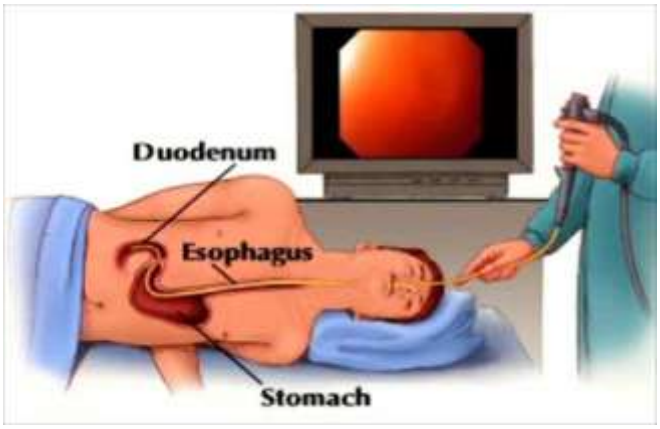
B- Endoscopy

is a tube with built-in light sources, an instrument used to examine the interior of a cavity of the body.



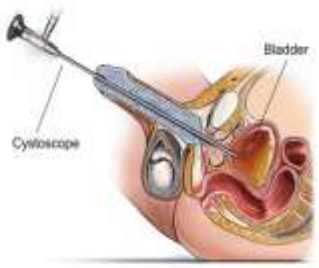
How do endoscopes work?

An endoscope is a thin, flexible tube with a light and a tiny camera on the end. The doctor inserts it into the mouth, down the throat, and into the esophagus. The doctor views the images on a screen to look for tumors or other health problems



Types of Endoscope

Cystoscopes are used to examine the bladder.
Proctoscopes are used for examining the rectum.
Enteroscopy used to examine small intestine.
Colonoscopy used to examine large intestine.
Hysteroscopy used to examine the uterus.
Bronchoscopes are used for examining the air passages into the lungs.
Arthroscope used to examine (joints)
Laparoscope used to examine (abdomen or pelvis).



Some endoscopes are rigid tubes with a light source to illuminate the area of interest. Many of them are equipped with optical attachments to magnify the tissues being studied.

Flexible endoscopes that are made of fiber optics can be used to obtain information from regions of the body that cannot be examined with rigid endoscopes, such as the small intestine and much of the large intestine. Flexible endoscopes usually have an opening or channel that permits the physician to take samples of the tissues **(biopsies)** for later microscopic examination.

C- Transillumination

It is the transmission of light through the tissue of the body.

It used clinically in the detection of:

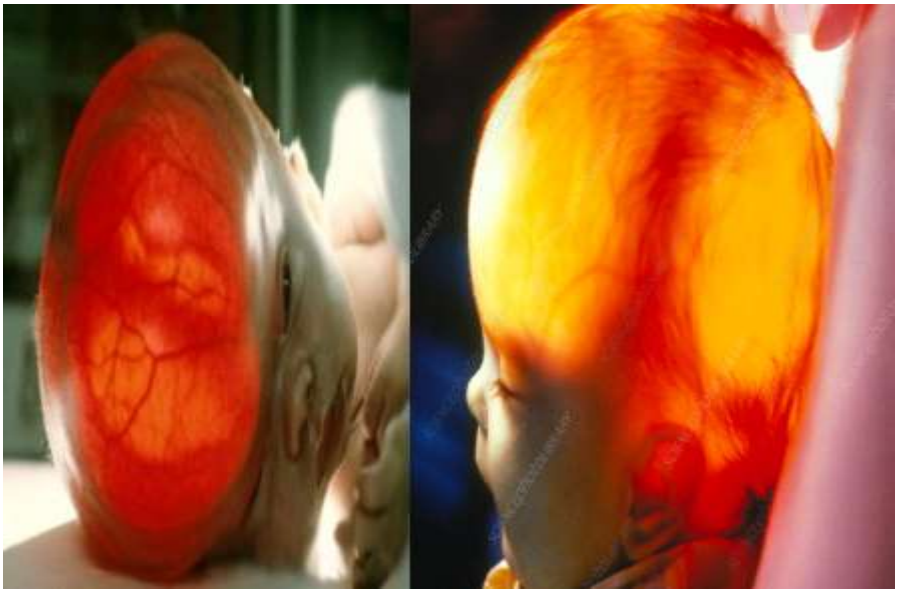
1. hydrocephalus (water head) in infant.
2. pneumothorax (collapsed lungs) in infant.
3. (phototherapy).

1-The detection of hydrocephalus

Since the skull of young infants is not fully calcified, light is able to penetrate to the inside of the skull; if there is an excess of relatively clear cerebrospinal fluid (CSF) in the skull, light is scattered to different parts of the skull producing patterns characteristic of hydrocephalus (water-head).

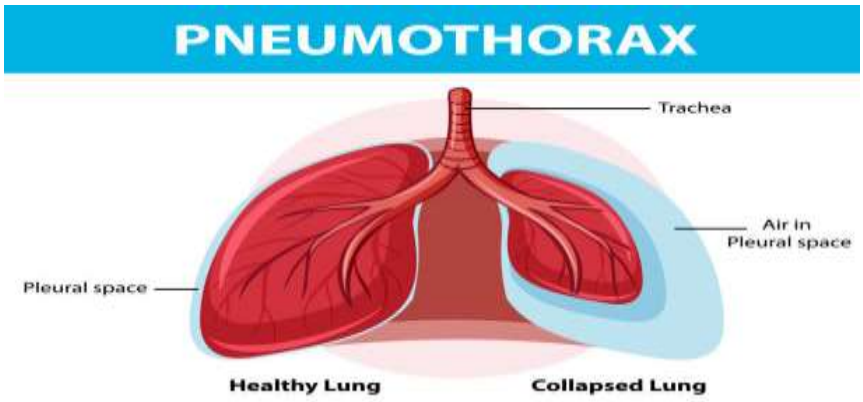
The infant is taken into a dark room for the study. The physician then point the barrel at the part of the head to be studied with an intense white light used for the study. Infrared absorbing glass in the beam removes almost all the IR radiation so that the light striking the infant is primarily visible light.

The room lights are dimmed or turned off so that the area of the body may be seen more easily. A bright light is then pointed at that are



2-Detection of pneumothorax

The bright light penetrates the thin front chest wall of an infant and reflects off the back chest wall to indicate the degree of pneumothorax (collapsed lung). The physician can then insert a needle attached to a syringe into the area of collapse to remove the air between the lung and chest wall, causing the lung to reinflation.



3- Recovering from jaundice

Many premature infants have jaundice, premature infant recover from jaundice when they exposed to visible light. A premature infant is a baby born before 37 completed weeks of gestation a condition in which an excess of bilirubin is excreted by the liver into the blood. Most premature infants recover from jaundice if their bodies are exposed to visible light **(phototherapy).**

Applications of ultraviolet light in medicine:

UV photons have energies greater than visible and IR light. Because of their higher energies, UV photons are more useful than IR photons.

* < 290: germicidal (kill germs) , sterilize medical instruments.

* One of the major beneficial effect of UV light from the sun is the conversion of molecular products in the skin into vitamin D.

* UV light from the sun effects the melanin in the skin to cause tanning and can produce sunburn as well as tan the skin at wavelengths around 300nm.

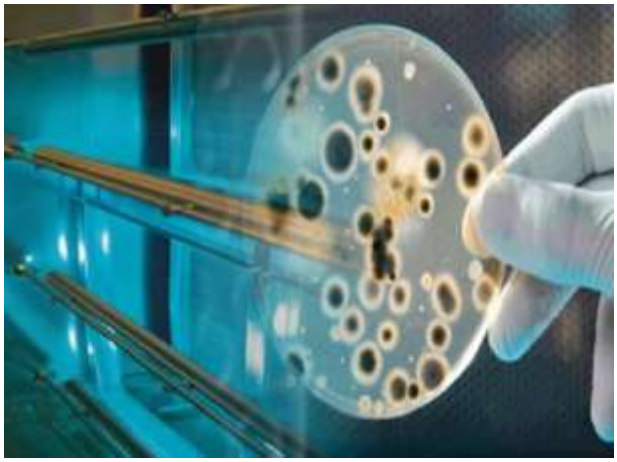
* Dermatologists have found that UV light improves certain skin conditions.

* UV light cannot be seen by the eye because it is absorbed before it reaches the retina.

* Solar UV light: major cause of skin cancer (light absorption by DNA) →cancer.

* light is also the major cause of skin cancer in humans.

This can be related to the fact that the UV wavelengths that produce sunburn are also very well absorbed by the DNA in the cells.



Applications of infrared light in medicine:

Two types of IR photography are used in medicine:

1- reflective IR photography: Which uses wavelength of 700 to 900nm to show patterns of veins just below the skin.

2- **emissive IR photography**: **Which uses the long IR heat waves emitted by the body that give an indication of the body temperature, is usually called thermograph**