Ministry of Higher Education and Scientific Research
Al-Mustaqbal University
College of Medicine

Medical Physics

Light in medicine

Lecture 6

First Stage

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

1- 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***

$$n = c / v$$

c: speed of light in vacuum

v: speed of light in material

where

$c = 3*10^{+8}\ m/s^2$

2- Light behaves as both a wave and a particle.

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 .

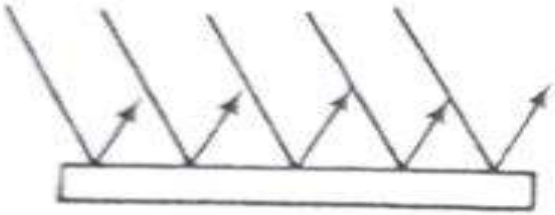
The indexes of refraction of the Cornea and other optical parts of the eye

Part of the eye	Index of refraction
Cornea	1.37
Aqueous humor	1.33
Lens cover	1.38
Lens center	1.41
Vitreous humor	1.33

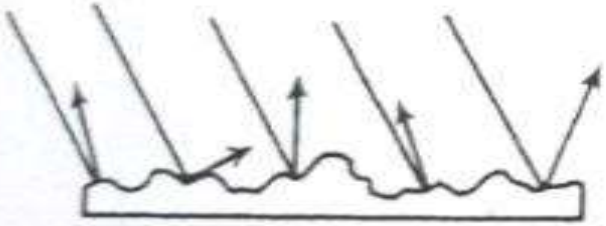
4- Light is reflected to some extent from all surfaces. There are two types of reflection

a) *Regular reflection*: it is obtained from very smooth surface *such as mirrors*.

b) *Diffuse (irregular) reflection*: occurs when rough surface



(a)



(b)

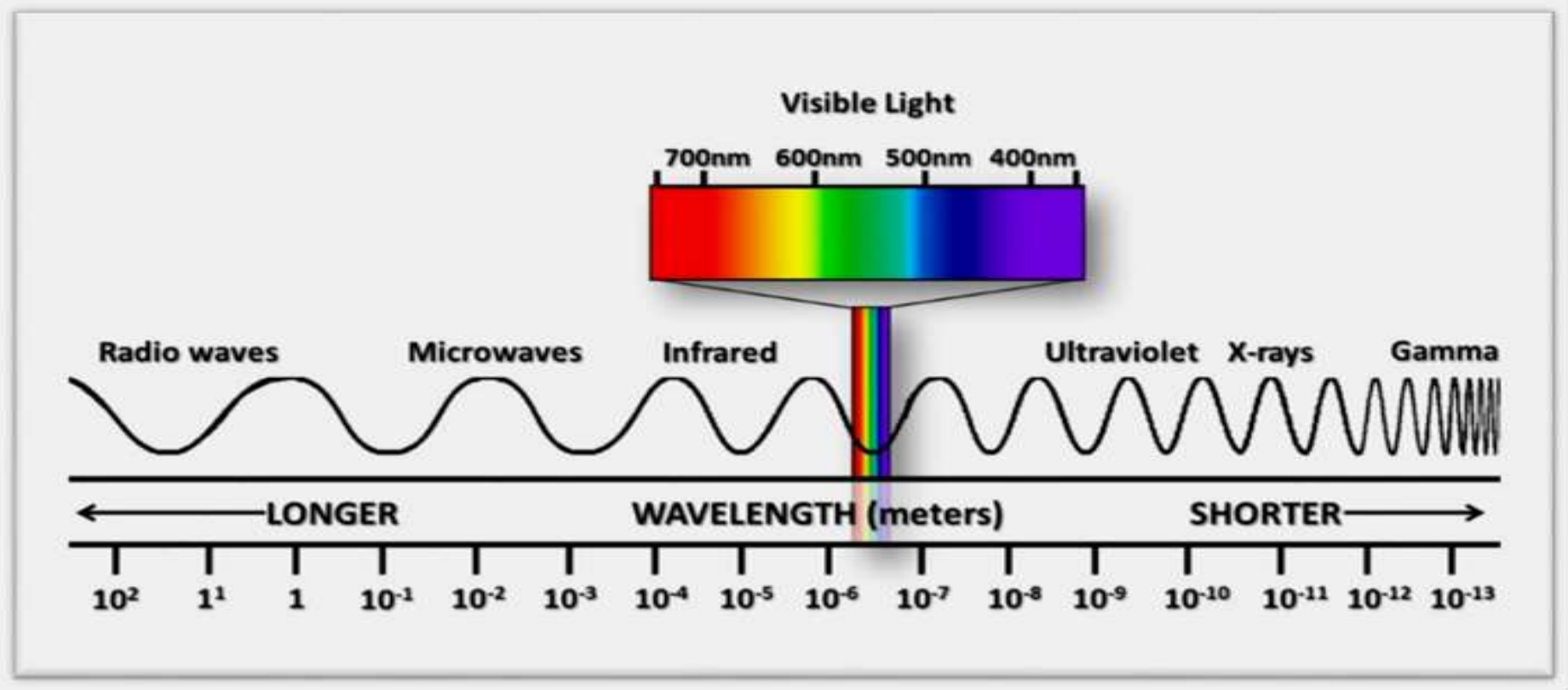
Figure 14.2. The two types of reflection: (a) specular reflection and (b) diffuse reflection.

MEASUREMENT OF LIGHT AND its UNITS

- The three general categories of light-UV, Visible, and IR- are defined in terms of their wavelengths.

Wavelength of light used to be measured in

- Microns 1 μ = 10^{-6} m
- Angstroms 1 A° = 10^{-10} m
- Nanometer 1 nm= 10^{-9} m



- Ultraviolet light has wavelengths from 100 to 400nm

- Visible light has wavelengths 400 to 700nm
- IR light has wavelengths from 700 to 10^4nm.

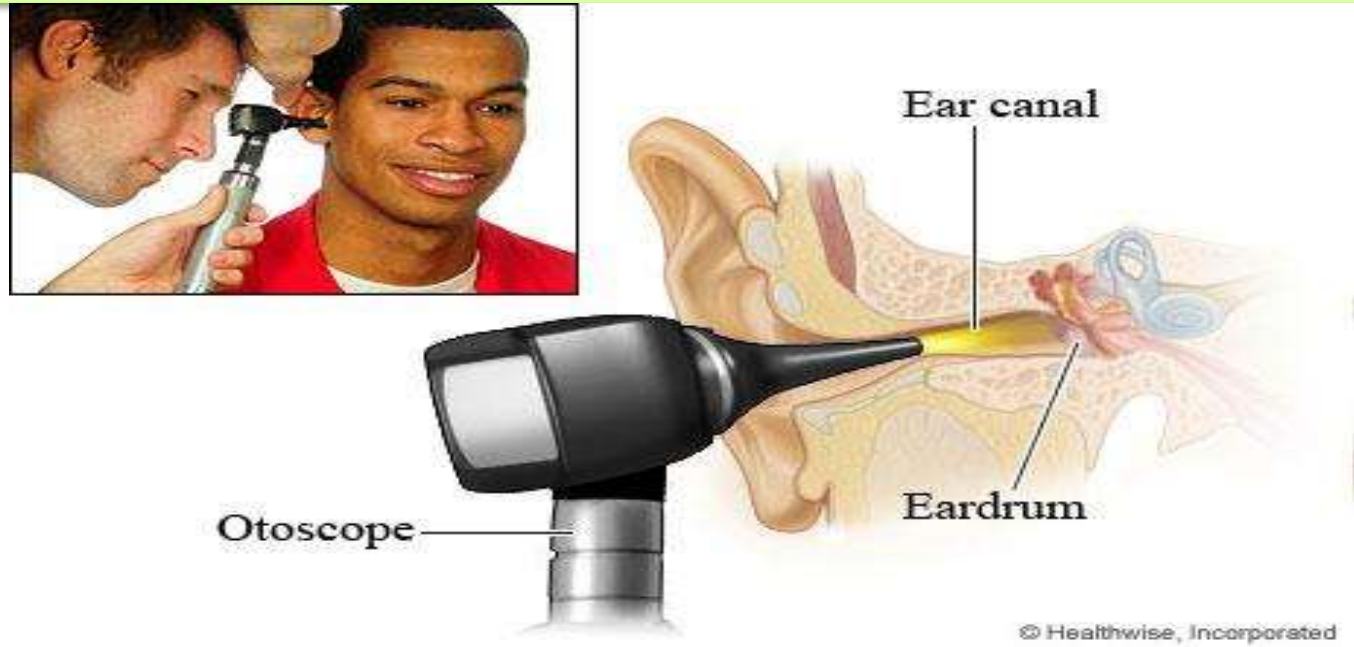
Each of these categories subdivided according to wavelength

- Ultraviolet **UV-A** has wave lengths from **320 – 400nm**
- **UV-B** has wavelengths from **290 -320nm**.
- **UV-C** has wavelengths from **100 – 290nm**.

APPLICATIONS OF VISIBLE LIGHT IN MEDICINE

1. Endoscopy When we wish to look into a body opening, we have to get light into the opening without obstructing the view. The curved surface focuses the light at the region of interest. More sophisticated instruments, such as the

- **Otoscope** for looking into the ears, use basically the same principle

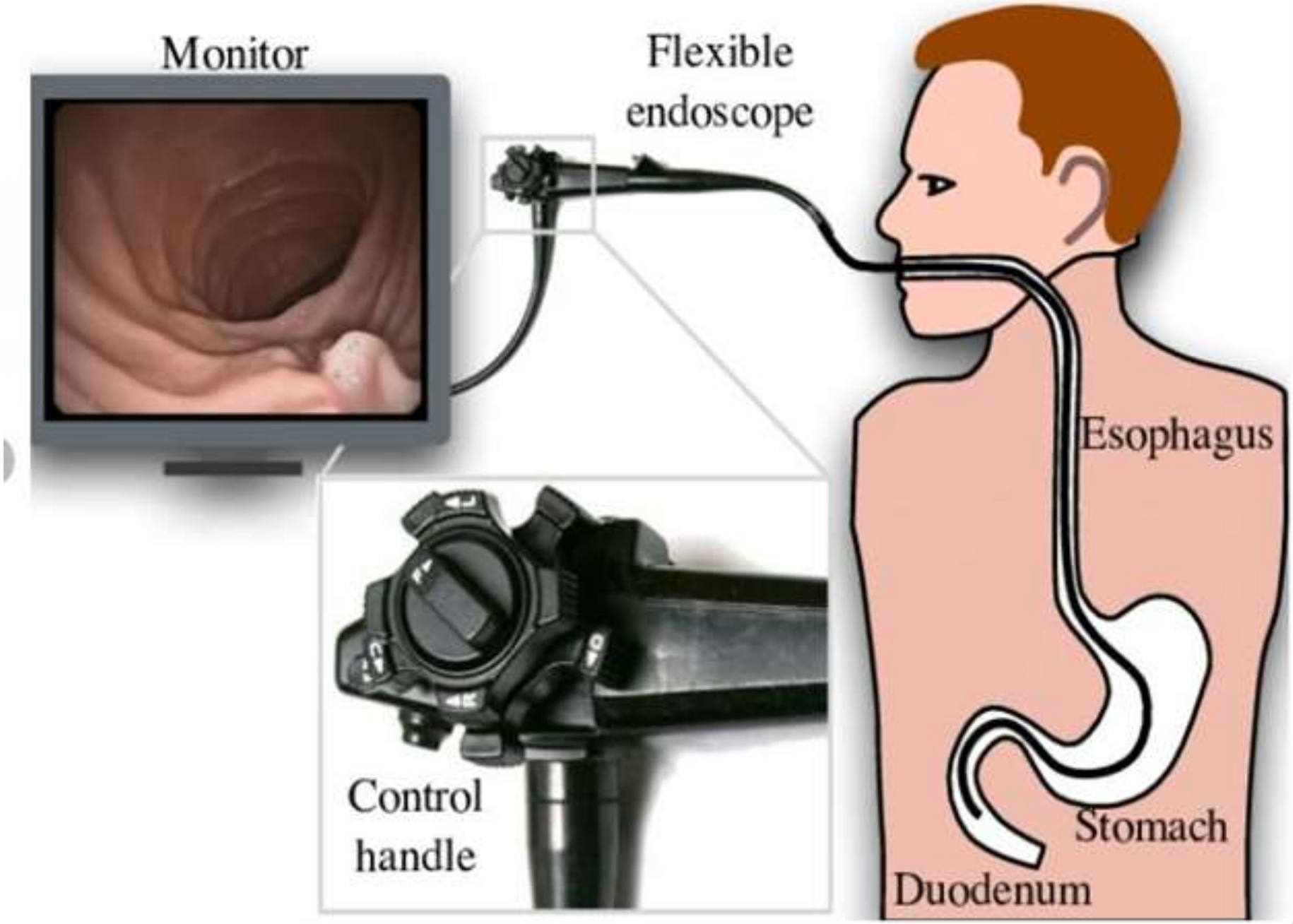


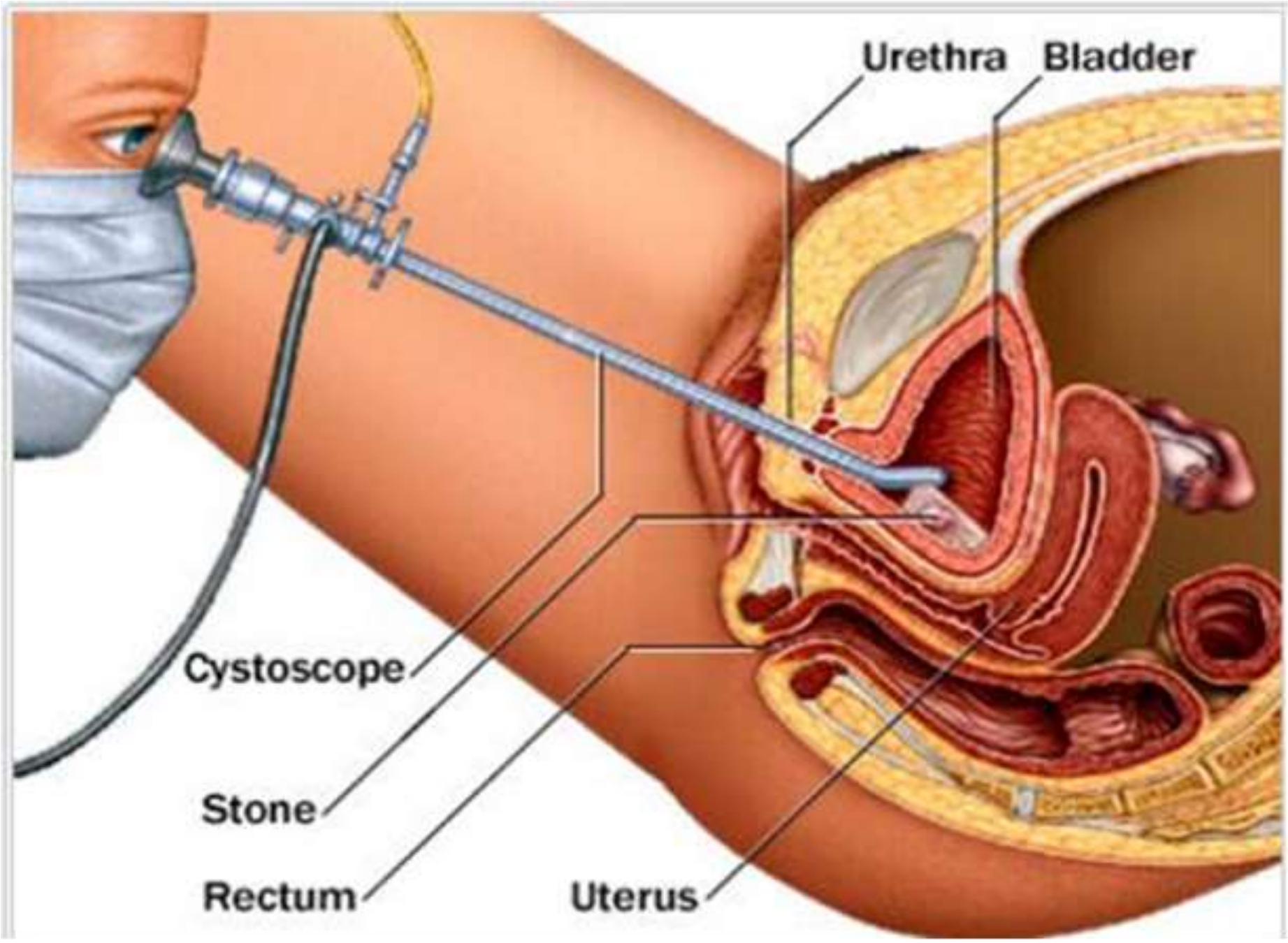
Endoscopes, are used for viewing internal body cavities. Their names indicates their purpose

- *Cystoscopes* are used to examine the bladder.
- *Proctoscopes* are used for examining the rectum.
- *Enteroscopy* are 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.

Some endoscopes are

- **rigid tubes**
- **Flexible endoscopes**


Monitor
Flexible endoscope
Esophagus
Control handle
Stomach
Duodenum

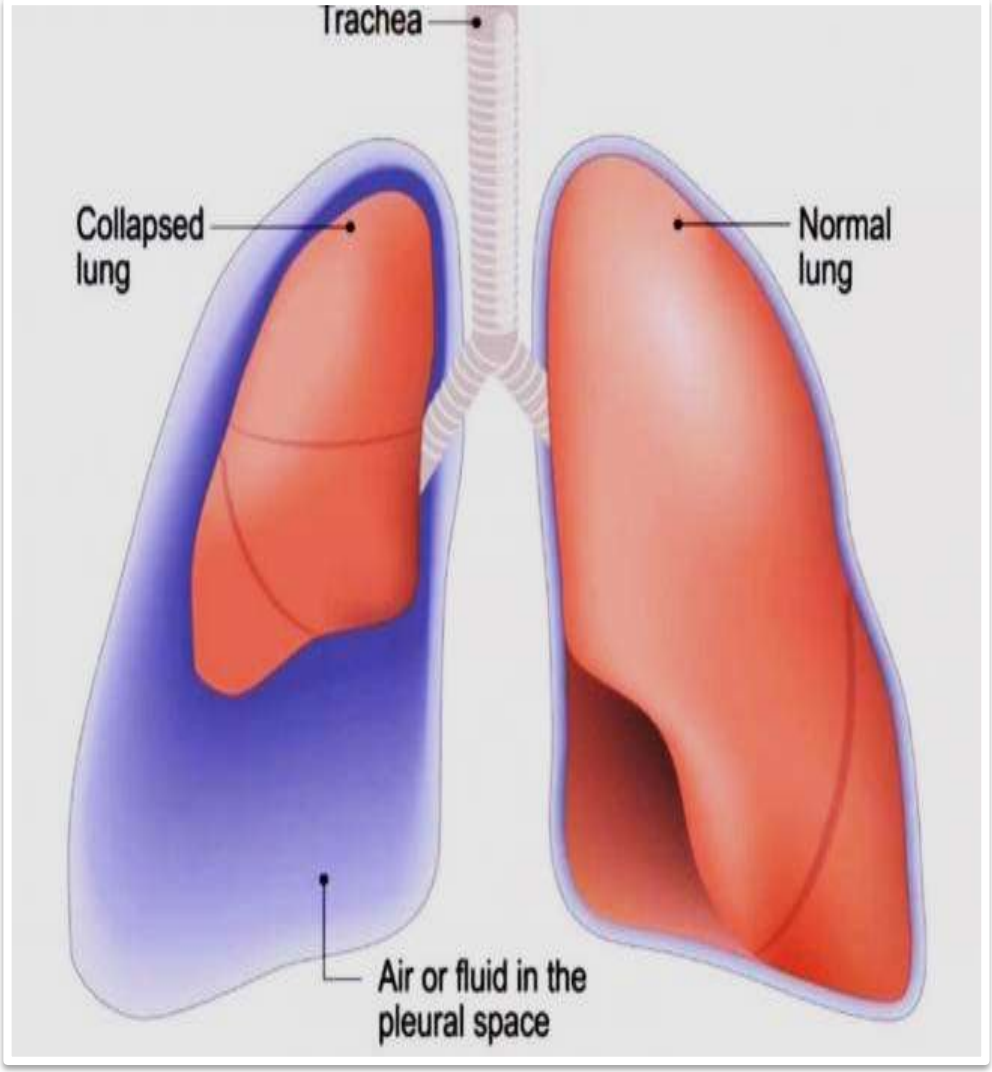

Urethra
Bladder
Cystoscope
Stone
Rectum
Uterus

2. ***Transillumination*** It is the transmission of light through the tissues of the body

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).

2) Detection of pneumothorax (collapsed lung) in infants.

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)



3) Recovering from jaundice

Many premature infants have jaundice,
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 UV AND IR 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

- UV with (λ below about 290 nm) can kill **g**erms and used to sterilize medical instruments.
- UV produces more **reaction** in the **skin** some of these reactions are beneficial, and some are harmful

Two types of IR photography are used in medicine

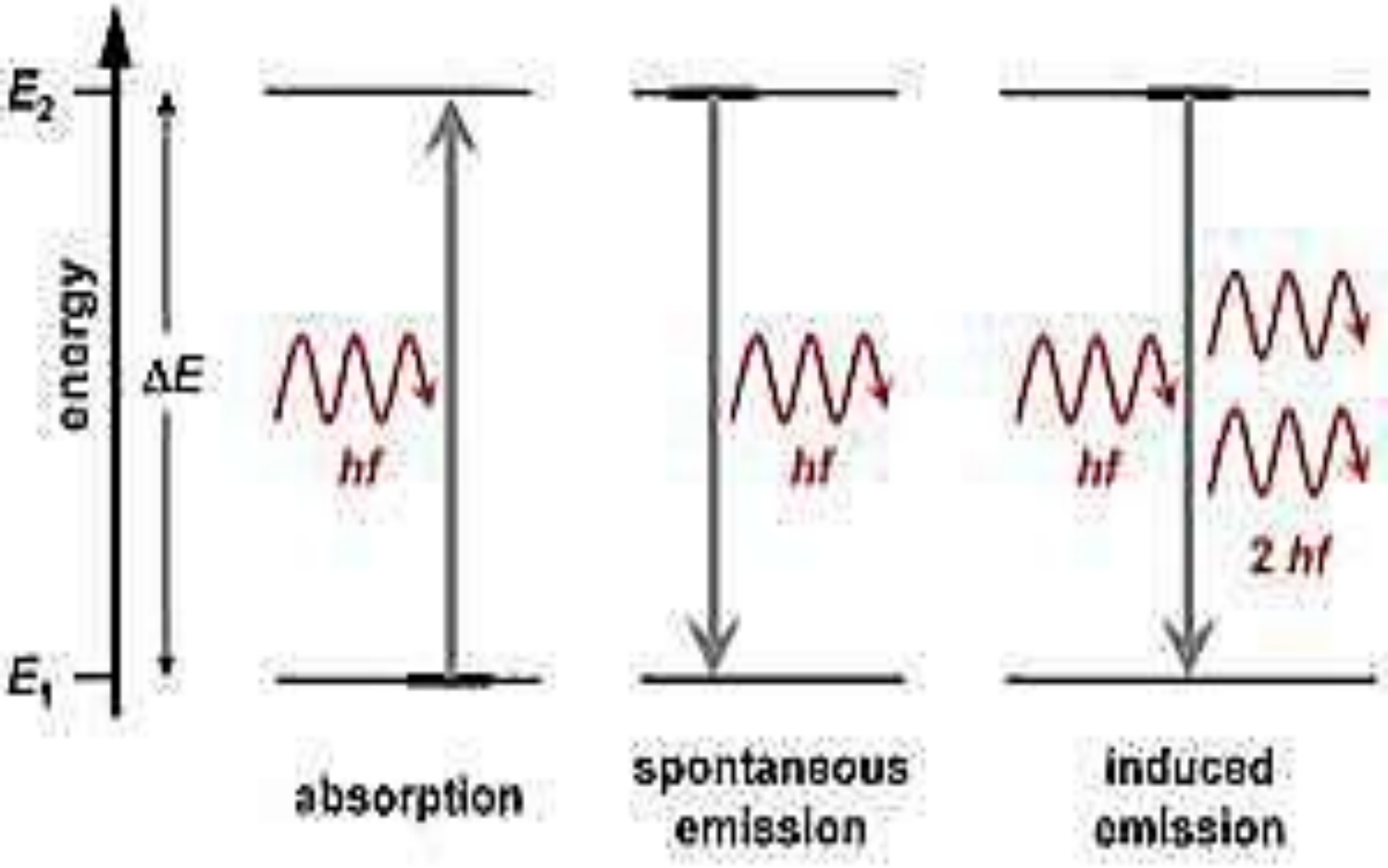
1- Reflective IR photography, which **uses** wavelength of **700 to 900nm** to show patterns of veins just below the skin.

2- Emissive IR photography. Which **uses** the long IR heat(**14000-900nm**) waves emitted by the body that give an indication of the body temperature, is usually called **thermograph**

LASER IN MEDICINE

When an electron makes a transition from higher energy to lower energy state, a photon is emitted. The emission process can be one of two types, spontaneous emission or stimulated emission.

- **In spontaneous emission**, the photon is emitted spontaneously, in **a random direction**, without external provocation.
- **In stimulated emission**, an incoming photon stimulates the electron to change energy levels


E_2
energy
ΔE
E_1
hf
absorption
hf
spontaneous
emission
hf
2 hf
induced
emission

- The operation of lasers depends on stimulated emission
- Laser production (population inversion).

A laser is a **unique light source** that emits a **narrow beam** of light of **single wavelength** in which each wave is in phase with others near it. This is the origin the word laser which is a crony for

***L**ight **A**mplification by the **S**timulated **E**mission of **R**adiation*

? ***type of Laser***:

1. *Pulse Laser*: i.e.

i. Ruby laser (**λ** =**694 nm**).

ii. Semiconductor (**λ** is dependent on the applied current).

iii. Glass laser.

2. Continuous wave laser (cw) e.g. ,**gas** filled tubes laser

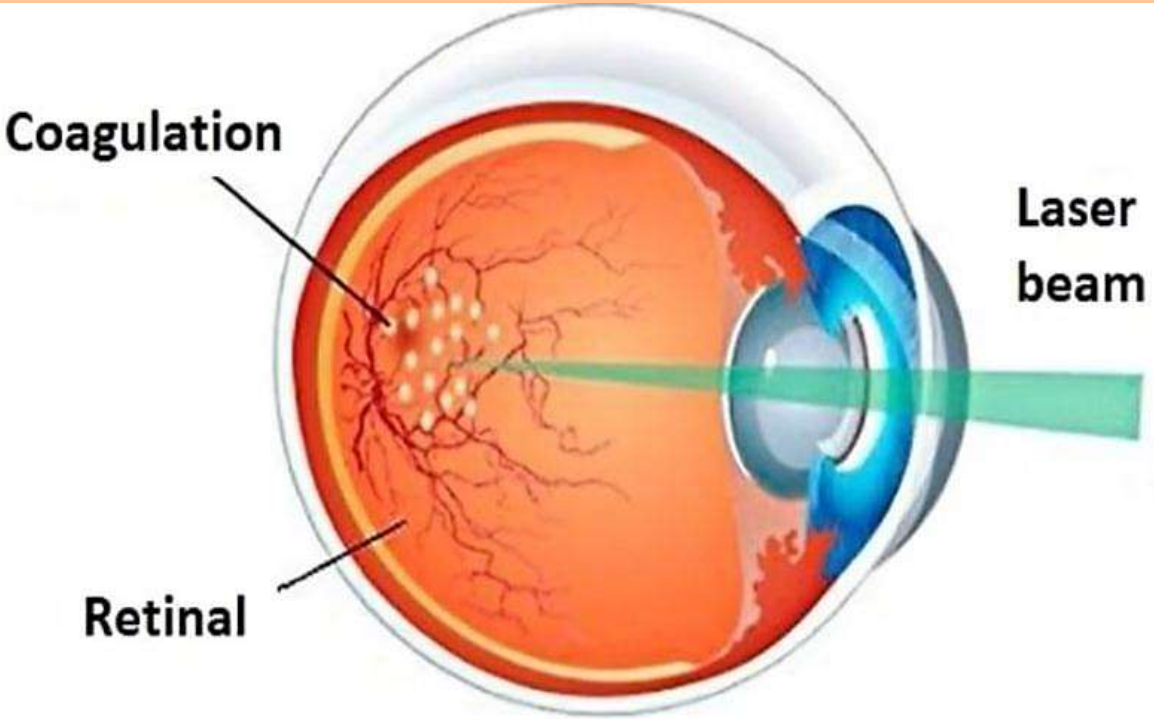
i. Neon-helium laser (**λ**=632.8 nm)

ii. Argon laser (**λ**=488-514nm).

APPLICATIONS OF Laser

1. The laser used in medicine as ***a blood less knife for surgery***. A lens to almost a mathematical point can focus it. This means that the energy per unit area in the focal spot can be made enormous, and small regions can be vaporized without harming the surroundings

2-uses of lasers has been in ophthalmic **surgery. In eye**



3-Laser cosmetic And Plastic Surgery