University of Al-Mustaqbal
College of Science
Department of Medical Physics

Name of material : Medical Physics II

Number stage : 3rd

Lecture name : Light in Medicine

Lecture number : 2

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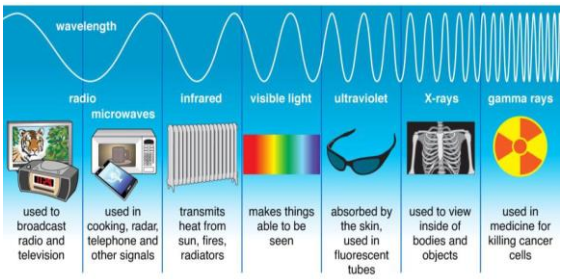
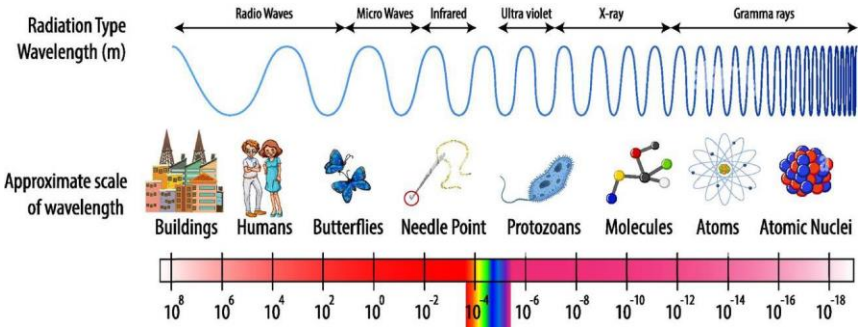
Introduction

Light is part of the electromagnetic spectrum which consist of Radio waves, Infrared, Visible light, Ultraviolet, X-ray and Gama ray. Each of those are classified in to sub-categories depending on the wavelength. **In this lesson we will discuss the Infrared, Visible light and Ultraviolet.**





Some important properties of light

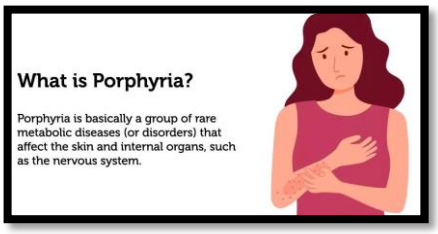
 The **speed of light** changes when it goes from one material into another. The ratio of the speed of light in a vacuum to its speed in a given material is called the **index of refraction.**

 Light behaves both as a **wave** and as **a particle**. As a wave it produces **interference** and **diffraction**. As a particle it can be absorbed by a single molecule. **Absorption** of photons can produce another type of energy such as; chemical changes (like in retina), heat as in IR to heat tissue and or photons with lower energy.

 Sometimes when a light photon is absorbed, a lower energy light

photon is emitted. This property is known as **fluorescence**. Certain

materials fluoresce in the presence of UV light, giving visible light.



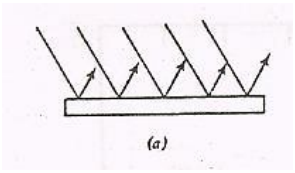
One way fluorescence is used in medicine is in the detection of

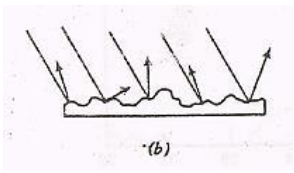
porphyria, a condition in which the teeth fluoresce red when

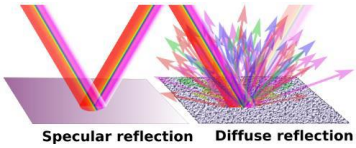
irradiated with UV light.

 Light is **reflected** to some extent from all surfaces. There are two

types of reflection; specular reflection (a) and diffuse reflection (b)







Measurements of light and units

Ultraviolet (UV) light has wavelengths from about 100 to 400 nm; visible light extends from about 400 to 700 nm; and infrared (IR) light extends from about 700 to over 10000 nm

Visible light is measured in photometric units that relate to how is seen by human eye.

In photometry, the quantity of light striking a surface is called **illuminance** and the intensity of light source is called it**s luminance.**

UV and IR radiation can be measured in radiometric units.

In radiometry, the quantity of light striking a surface is called irradiance and the intensity of light source is its radiance

The units are as follows:

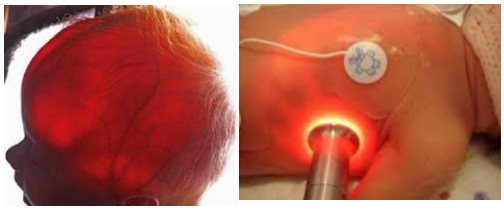
Illuminance	Lumina/m2
Luminance	watts/m2
Irradiance	watts/m2

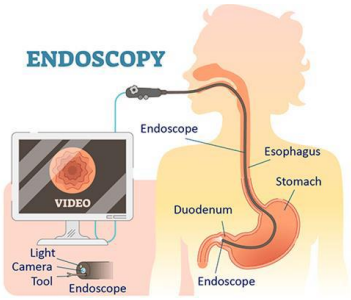
Radiance watts/m2

Visible light has energies ranging from about 2 electron volts (eV) up to about 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.

Applications of visible light in medicine

Pediatricians shine light into the bodies of infants and observe the amount of scattered light produced in order to detect **hydrocephalus** (water-head) or **pneumothorax** (collapsed lung). This transmission of light through tissues of the body is called *transillumination*





Pediatricians also use visible light for treating jaundice in infants (**phototherapy**).

Internists use tubes with built-in light sources, called **endoscopes**.

Endoscope: a number of instruments are used for viewing internal body cavities.

- ***Cystoscopies:*** are used to examine the bladder.

- ***Bronchoscope:*** Is used for examining the air passages into the lungs. Some endoscopes are rigid tubes with a light source illuminating the area of interest.

- ***Flexible endoscopes:*** can obtain information from body regions that cannot be examined with rigid endoscopes, such as the small intestine and much of the large intestine.

Applications of UV and IR light in medicine

The wavelengths adjacent to the visible spectrum also have important uses in medicine.
Ultraviolet photons have energies greater than visible photons, while **IR photons** have lower energies. Because of their higher energies, UV photons are more useful than IR photons.

Ultraviolet light with wavelengths below about 290 nm is **germicidal** that is, it can kill germs and it is sometimes used to sterilize medical instruments.
Ultraviolet light also produces more reactions in the skin than visible light. Some of these reaction are beneficial, and some are harmful. Ultraviolet light from the sun affects the melanin in the skin to cause tanning. However, UV light can produce sunburn. The wavelengths that produce sunburn are around 300 nm, just at the edge of the solar spectrum.
Solar UV light is also the major cause of **skin cancer in humans**.
The UV wavelengths that produce sunburn are also very well absorbed by the DNA in the cells.
The large percentage of near-UV light absorbed by the lens may be the cause of some cataracts (**opacities of the lens**)..

About half of the energy from the sun is in the **IR region**. The IR rays are not usually hazardous even though they are focused by the cornea and lens of the eye onto the retina.
The IR wavelengths can cause a burn on the retina. Heat lamps that produce a large percentage of IR light with wavelengths of 1000-2000 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:

- ***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 **thermography**.

- ***Reflective IR photography***, which uses wavelengths of 700-900 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.

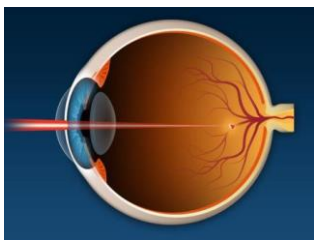
Laser in medicine

A **laser** is a unique light source that emits a narrow light beam.

When all of the energy of the laser is concentrated in a small area,

the power density (power per unit area) becomes very large.

Experiments with monkey eyes indicate that a laser wavelength of **1064 nm** damages the retina.



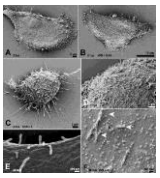
In ***ophthalmology***, the laser is used for photocoagulation of the retina, heating blood vessels to the point where the blood coagulates and blocks the vessel.

Bloodless Knife for Surgery Laser:

At **441.6 nm** wavelength used as bloodless knife for surgery Laser in three dimensional imaging is called **holography**.

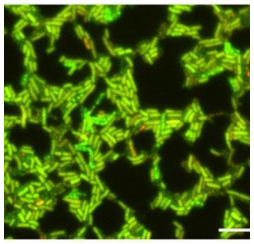
Microscope in medicine

Microscopes are typically used in surgical fields such as dentistry and ophthalmic surgery which involves the eyes, ear, nose and throat surgery, and neurosurgery.
A microscope is a tool used by scientists to see small particles that are not visible to the naked eye. There are several kinds of microscopes used today. These include **light microscopes, fluorescence microscopes, electron microscopes**, and variations of these general models.



The **magnification** of objects up to **1000** allows the study of **cells** (*cytology*) and **tissue** (*histology*).
Microscopes **used** different source of light and different wavelength.

- Light microscope uses visible light
- Fluorescent microscope uses UV light.
- Electron microscope uses electron gun



Exercise

1- The ratio of the speed of light in a vacuum to its speed in a given material is called

(a) Index of refraction (b) Speed of light (c) Reflection (d) Interference (e) Absorption

2- Sometimes when a light photon is absorbed, a lower energy light photon is emitted, This property is known as ---------

(a) Luminescence (b) Irradiation (c) Fluorescence (d) Emitting (e) Phosphorescence

3- ---------- has wavelengths from about 100-400 nm

(a) Visible light (b) Infrared (c) Gama ray (d) X-ray (e) Ultraviolet

4- ---------- are used to examine the bladder

(a) Cystoscopies (b) Microscopies (c) Bronchoscopies (d) Light (e) None of them

5- Ultraviolet light with wavelengths below ---------- nm is used to kill germs

(a) 29000 (b) 2900 (c) 290 (d) 29 (e) 2.9