Karbala University-College of veterinary medicine
Medical Physics-Lecture (6)

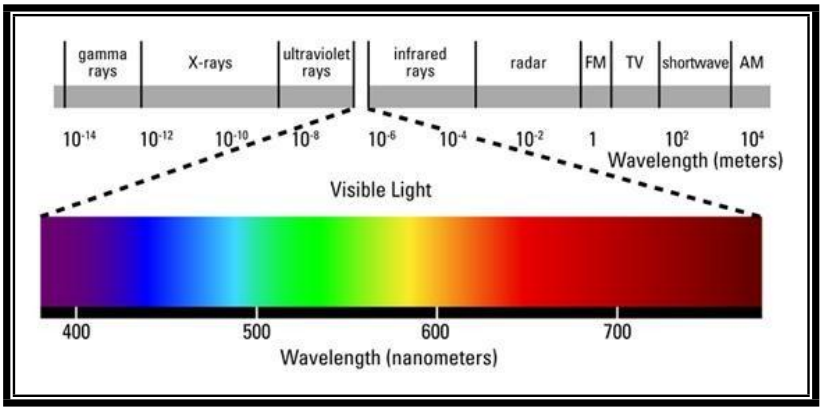
Light in medicine

The Nature of the Light

The nature of the light it's much more difficult to understand than that of sound. **Newton** in the **17th** century was convinced that light was comprised of tiny mass-less particles, whereas **Huygens**, working at the same time, argued that it must be a wave of some sort.

Maxwell derived the mathematical theories of electromagnetic wave, and demonstrated that light exhibited the properties expected of electromagnetic radiation.

In the early **twentieth** century, light was discovered to have both **particle** properties and **electromagnetic wave** properties. The wavelength of electromagnetic radiation with the range from about **10^{-14}m** to about **10^{4}m**. We use electromagnetic radiation over this whole spectrum in various application of medical physics, **visible light** occupies only a narrow band from about **400-700 nm**.



Light as a Ray

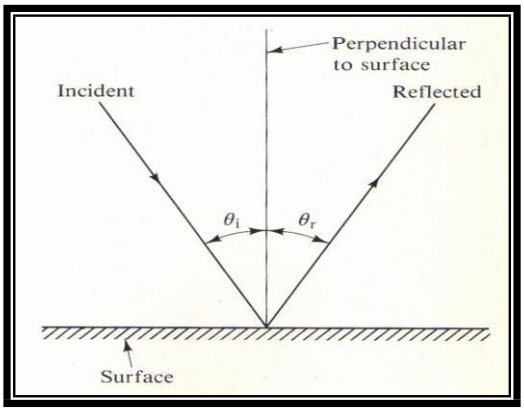
Light comes to an observer's eyes either **directly** or **indirectly** from some source.

The Characteristics of Light

- The Reflection.
- The Refraction.
- The Interference.
- The Diffraction.

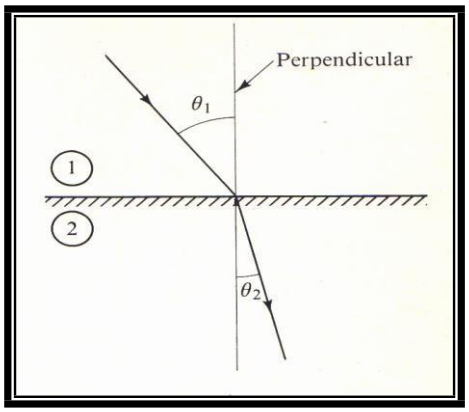
Reflection

Light waves reflect when they strike the surface that separate between two medium, the law of reflection says very simply that when light is reflected the angle of incidence **equals** the angle of reflection.



Refraction

Light waves usually changes directions when it goes from one medium to another **because** of changes there velocity in the different medium. There is most easily observed for objects partially submerged in water.



Interference

Light waves interact and interfere with each other in just the same way as do sound waves. The relative phase of the waves determines whether the interference is **constructive**, increasing the intensity, or **destructive**, reducing the intensity.

Diffraction

All light waves undergo diffraction as they pass through a **small opening**.

Speed of the Light

The speed at which light travels in a vacuum is an approximately (**$c=3x10^{8}m.s^{-1}$**).

Its speed in a transparent medium is always less than this, and is given by (**V=c/n**).

Where (**n**) is the **index of refraction** of the substance. The value of the **index of refraction** depends on both the **composition** of the substance and the **wavelength** of the light.

Intensity of the Light

Intensity of the light is defined in terms of power, per unit area and has dimensions of (**W/m^2**).

(**I=P/A**)

Where: -

P = is the power (**Watt**).

A = is the area (**m**).

The relation between light intensity and distance can be given by: -

(**I$\propto$1/d^2**)

The Medical Applications of Light

The light in medicine is beneficial in diagnostic purposes and therapeutic purposes.

A. Diagnostic use of light

An obvious use of visible light in medicine is to permit the physician to obtain visual information about the patient regarding, ***for example***, the color of his skin and the presence of abnormal structures in or on his body. It is quite easy for a physician to examine the skin under normal lighting conditions, but when she wishes to look into a body opening she is faced with the practical problem of getting light into the opening without obstructing the view. Like a lot of tricks, this one is done with mirrors.

The curved surface focuses the light at the region of interest. More sophisticated instruments, such as the **ophthalmoscope** for looking into the eyes and the **otoscope** for looking into the ears, use basically the same principle. see figure (1).

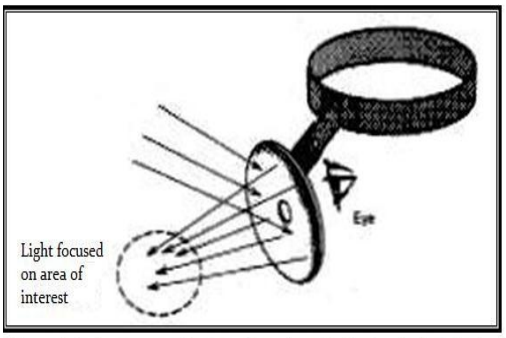


Figure ( ): A concave mirror to direct into the body -the hole is for the physician to look through.

A number of instruments, called **endoscopes**, are used for viewing internal body cavities. Special **purpose** endoscopes are often given names indicating their purpose. ***For example***, **cystoscopes** are used to examine the bladder, **proctoscopes** are used for examining the rectum, **bronchoscopes** are used for examining the air passages into the lungs and **colonoscope**s are used for examining the colon.

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.

The development of **fiberoptic** techniques permitted the construction of **flexible** endoscopes. **Flexible** endoscopes 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. Some **flexible** endoscopes are over a meter in length. The image obtained with a **flexible** endoscope is not as good as that obtained with a **rigid** endoscope, but often the only alternative to a **flexible** endoscopic examination is exploratory surgery.

Flexible endoscopes usually have an opening or channel that permits the physician to take samples of the tissues (**biopsies**). See figure (2).

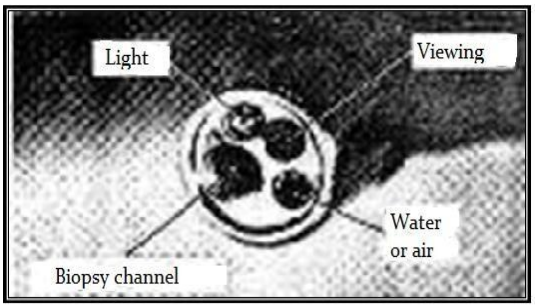


Figure (2) : The tip of colonoscope

Transillumination

Is the transmission of the light through the tissues of the body. Transillumination is used clinically in the detection of hydrocephalus (water-head) in infants. Transillumination is also used to detect pneumothorax (**collapsed lung**) in infants. The bright light penetrates the thin front chest wall and reflects off the back chest wall to indicate the degree of **pneumothorax**. The **testes** have also been studied with **transillumination.**

Light Therapy (phototherapy)

Visible light has an important **therapeutic** use. Since light is a form of energy and is selectively absorbed in certain molecules, it should not be surprising that it can cause important physiological effects. Many premature infants have **jaundice**, a condition in which an excess of **bilirubin** is excreted by the liver into the blood. Relatively recently (**1958**) it was discovered that most premature infants recover from jaundice if their bodies are exposed to visible light (**phototherapy**).

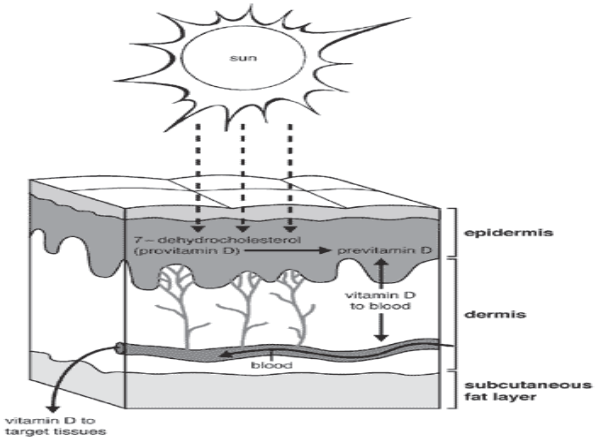
Applications of ultraviolet and infrared light in medicine

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.

UV light in medicine

1-Ultraviolet light with wavelengths below about **290nm** is **germicidal** (مبيد للجراثيم)-that is, it can kill germs-and it is sometimes used to **sterilize** medical instruments(يستخدم في تعقيم الادوات الطبية).

2- **Ultraviolet** light also produces more reactions in the skin than visible light. Some of these reactions are **beneficial**, and some are **harmful**. One of the major beneficial effects of **UV** light from the sun is the conversion of molecular products in the skin into **vitamin D(** يحول ضوء الشمس الى فيتامين**)**.



3-Dermatologists(الأمراض الجلدية والتناسلية) have also found that **UV** light improves certain skin conditions.

4-Ultraviolet light from the sun affects the melanin in the skin to cause

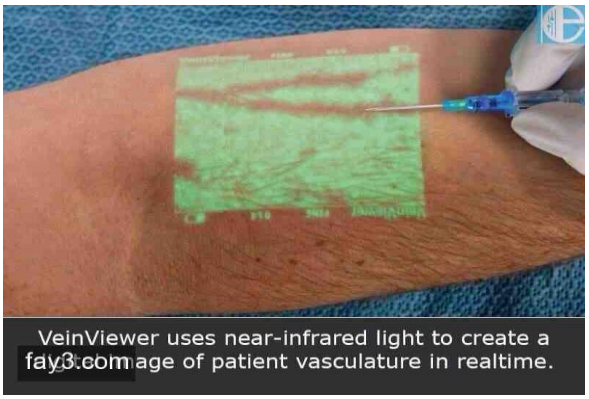
tanning(تؤثر على طبقة الملاين لتسبب الباغة**)**. However, **UV** light can produce sunburn as well as tan the skin. The wavelengths that produce sunburn are around **300nm**. The amount of **300nm** light in the sun's spectrum **depends** on the **amount** of atmosphere that the sunlight must pass through. Ordinary window glass permits some near **UV** to be transmitted but absorbs the sunburn component.

5-Light in Dentistry In light cure: - curing the composite resin.

IR light in medicine

- The warmth(الدفء) we feel from the sun is mainly due to the IR component.
- Heat lumps that produce a large percentage of IR light are often used for physical therapy purposes(العلاج الطبيعي). IR light penetrates further into the tissues than visible light and thus is better able to heat deep tissues(تسخين الانسجة العميقة).

About **half** of the energy from the sun is in the **IR** region. The warmth we feel from the sun is mainly due to the **IR** component. The **IR** 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 (**e.g., 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(الصور) 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 **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. Since the temperature at the skin **depends** on the local blood flow, a **thermogram** with good resolution shows the venous pattern much like a **near-IR** photograph.

Cancer and other diseases can cause changes in the venous pattern, but these changes can be masked by the normal variations. Also, a layer of fat beneath the skin can reduce the appearance of the venous pattern.

Infrared can also be used to photograph the pupil of the eye without stimulating the reflex that changes its size.

lasers In medicine

Some clinical application of laser

1-Opthalmology (طب العيون)

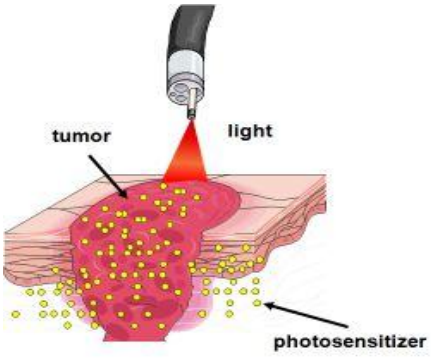
Laser is used to treat some eye problem for example refractive errors (myopia, hyperopia and astigmatism) and retinal problem like retinal detachment

2-Laser in the treatment of cancer(علاج السرطان)

Laser energy can also be used to destroy tumor cells.

3-Laser in dermatolgy (جلدية)

Tatoo Removal(مسح الوشم)



Skin cancer on the tip of the nose

Applications of microscopes in medicine

The use of the microscope in the pathology laboratory is as common as the use of the thermometer in the clinic.

The standard light microscope usually can be set at any of several magnifications by changing the power of the eyepiece or of the objective lens. The highest magnification that can be obtained is limited by the wavelength of **visible** light. Since the wavelengths of **visible** light range from **400** to **700 nm** (**0.4 to 0.7 µm**), the smallest object that can be resolved is about **1µm** in diameter. Since most cells are **5** to **50 µm** in diameter, this type of microscope is adequate for resolving all but sub cellular objects.

If you put a thin slice of tissue under a microscope you will not see much **because** most cells are transparent to all wavelengths of **visible** light-red blood cells are an exception. In order to distinguish different cells it is usually necessary to **stain** them with a chemical that strongly absorbs certain **visible** wavelengths.

Other techniques in addition to staining are useful in microscopy. One technique takes advantage of the different **indexes of refraction** of different cell parts. Since light travels at different speeds in the various parts of a cell, the phase relationships of the light waves change in passing through a specimen. The **phase-contrast microscope** takes advantage of this phenomenon to allow cell structures to be seen without the use of stain. In this type of microscope, a light beam that passes through the tissue is combined with a reference beam directed through an optically uniform zone. The combined beams interfere, producing **dark areas** where there is **destructive interference** and **light areas** where there is **constructive interference**. The darkness **depends** on the degree ofinterference.