College of Medicine | Time : 2 hrs
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Light in Medicine | Course : MPH2

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Light in Medicine /PART2

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.

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 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** and improves certain skin condition.

Ultraviolet light from the sun affects the melanin in the skin to cause ***tanning***. However, **UV** can produce sunburn as well as tan the skin. The wavelengths that produce sunburn are around 300 nm, just at the edge of the solar spectrum. The amount of 300 nm light in the sun's spectrum ***depends*** on the amount of atmosphere that the sunlight must pass through. In winter in northern climates the angle of the sun is such that the atmosphere absorbs nearly all of the wavelengths that produce sunburn. In the early morning and late afternoon of summer days the angle of the sun is again such that the **UV** wavelengths that produce sunburn are filtered out by the atmosphere.

Ordinary window glass permits some near **UV** to be transmitted but absorbs the sunburn component.

Solar **UV** light is also the major cause of ***skin cancer*** in humans. The high incidence of skin cancer among people, who have been exposed to the sun a great deal, such as fishermen and agricultural workers, may be related to the fact that the **UV** wavelengths that produce sunburn are also very well absorbed by the **DNA** in the cells. Skin cancer usually appears on those portions of the body that have received the most sunlight, such as the tip of the nose, the tops of the ears, and the back of the neck. Fortunately, skin cancer is easily cured if it is detected in its early stage.

You probably know that the sky is blue because light of short (blue) wavelengths is scattered more easily than light of long wavelengths. Ultraviolet light has even shorter wavelengths than blue light and is scattered even more easily. About half of the **UV** light hitting the skin on a summer day comes directly from the sun and the other half is scattered from the air in other parts of the sky. Thus you can get a sunburn even when you are sitting in the shade under a small tree. Even when the sky is completely covered with clouds about one half of the **UV** light gets through.

Ultraviolet light cannot be seen by the eye because it is absorbed before it reaches the retina . The large percentage of near-**UV** light absorbed by the lens may be the cause of some cataracts (***opacities of the lens***).

Individuals who have had the lens of an eye removed because of a cataract are able to see in to the near–**UV** region because the major absorber is no longer present.

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 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.

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. 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. Nevertheless, **IR** photograph 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. Also, differently colored skins reflect about the same amount of **IR**, so that

IR photographs of blacks and whites appear about the same. The **IR** photograph shows the venous pattern, but the variations in the melanin content of the skin due to the suntan are not apparent.

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

Infrared photographs of biological specimens illuminated with blue-green light sometimes show **IR** luminescence (fluorescence or phosphorescence).

Lasers in medicine

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). Laser is an acronym for Light Amplification by Stimulated Emission of Radiation.

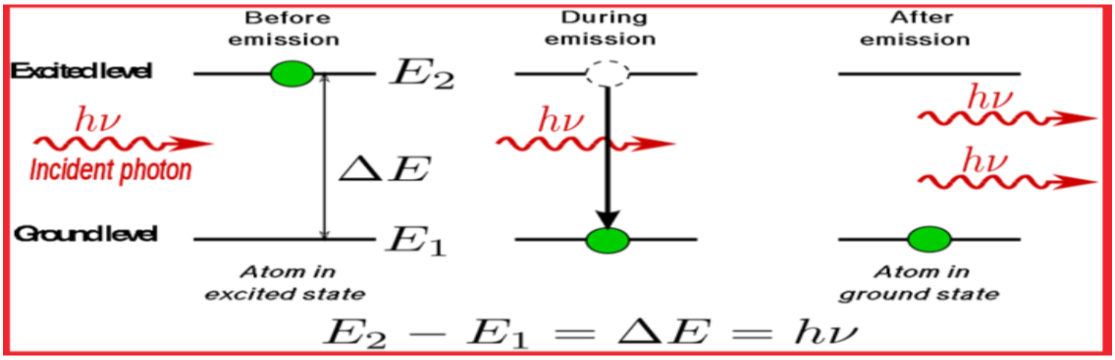
While the basic theory for lasers was proposed by Albert Einstein in 1917, the first successful laser was not made until 1960, when T. H. Maiman produced a laser beam from a ruby crystal. Since 1960 scientists have made many types of lasers using gases and liquids as well as solids as the laser materials.

In a laser, energy that has been stored in the laser material (e.g., ruby) is released as a narrow beam of light-either as a steady beam continuous wave (CW) or an intense pulse. The beam remains narrow over long distances and can be thought of as an ideal "spot" light. A laser beam can be focused to be 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. The total energy of a typical laser pulse used in medicine, which is measured in millijoules (mJ), can be delivered in less, than a microsecond .

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. To produce stimulated emission, however, the incoming photon must have energy that exactly matches the difference between the energies of two levels .



The operation of lasers depends on stimulated emission.

Stimulated emission has three important features.

1-One photon goes in and two photons come out .The process amplifies the number of photons. This is the origin the word laser which is an a crony for light amplification by the stimulated emission radiation

2-The emitted photon travels in the same direction as incoming photon.

3-The emitted photon is exactly in step with or has same phase as the incoming photon. In other word, the two electromagnetic waves that these two photons represent are coherent.

In medicine laser are used primarily to deliver energy to tissue.

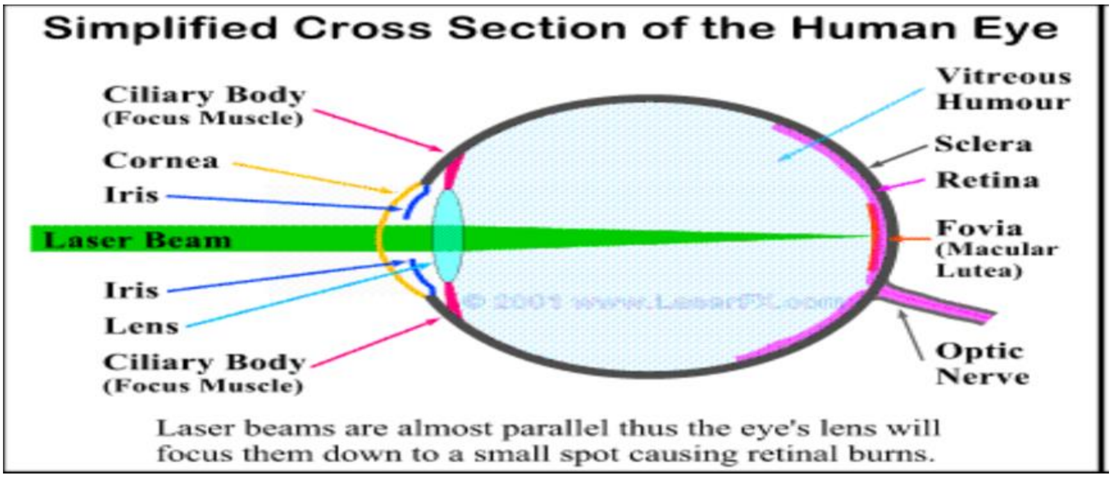
i.The laser wave length used should be strongly absorbed by tissue .The short wave (400-600nm) are always absorbed better than the long wave (700nm) .

ii. Laser energy directed to human tissue cause a rapid rise in temperature and can destroy the tissue .The amount of damage to living tissue depends on time the tissue is exposed to increased temperature.

Useful

1. It is used by surgeons for the painless **removed of eye tumors**
2. It is used as a **(bloodless knife)** in surgery.
3. Repairing retinal tears or holes that develop prior to retinal detachment. **(Photocoagulation).**
4. Treatment of the diabetic ethnography i.e. the complications of diabetes that affect the retina, **(photocoagulation)**.
5. In medical research it is used for special three-dimensional imaging called**(holography)**.

6.The amount of laser energy needed for **photocoagulation** depends on the spot size 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**).