AL-Mustaqbal University College
Department of Medical Physics
Lasers in medicine
Class : Third Stage

كلية المستقبل الجامعة
قسم الفيزياء الطبية
المرحلة الثالثة
الليزر في الطب

الليزر في الطب

المحاضرة الاولى

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Absorption of light by Tissue

Optical Properties of Tissues

• Biological tissues- optically inhomogeneous and absorbing media- average refractive index is higher than that of air.

• This is responsible for partial reflection of the radiation at the tissue/air interface- while the remaining part penetrates the tissue.

• Multiple scattering and absorption are responsible for laser beam broadening and eventual decay as it travels through a tissue.

• Bulk scattering is a major cause of the dispersion of a large fraction of the radiation in the backward direction.

Most important among optical tissue properties are:

• The coefficient of reflection

• The coefficient of absorption.

• The coefficient of scattering.

• Together they determine the total transmission of the tissue at a certain wavelength.

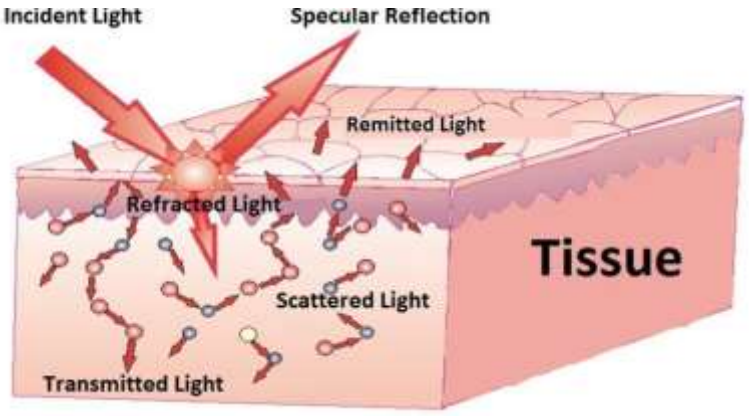
Reflection & Refraction of light by tissue

Diffuse reflection is a common phenomenon of all mtissues, since none of them is provided with highly polished surfaces such as optical mirrors.

• Only in special cases such as wet tissue surfaces might specular reflection surpass.

• In medical laser applications- refraction plays a significant role- irradiating transparent media like corneal tissue.

In opaque media- the effect of refraction is difficult to measure due to absorption and scattering.



Absorption of light by Tissue

Each type of tissue has specific absorption characteristics depending on its specific components.

• The main absorbing components chromophores of tissue are:

Hemoglobin - in blood

Melanin -skin, hair, moles etc.

Water – all biological tissue

Protein – Scatter

Chromophore:

• A part of a molecule responsible for its color.

• Absorbs certain wavelengths of visible light and transmits or reflects others- giving the molecule a color.

• In biological molecules that serve to capture or detect light energy.

• The chromophore is the moiety that causes a conformational change of the molecule when hit by light.

Hemoglobin

• Hemoglobin is predominant in vascularized tissue.

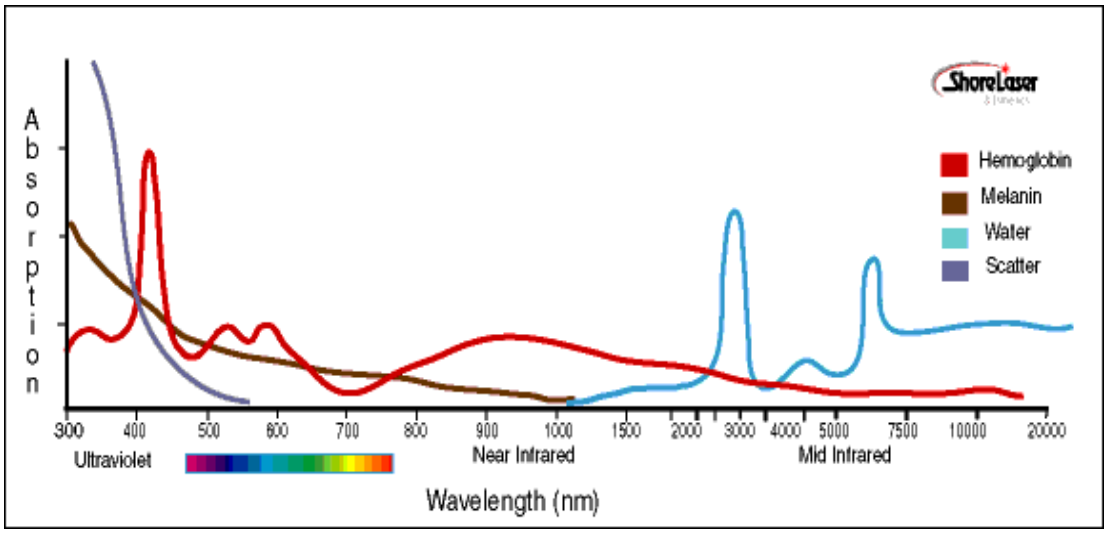
• Visible and ultraviolet light are absorbed mainly by hemoglobin (HbO2) - translucent to light beyond this range.

• It has relative absorption peaks around 280nm, 420nm, 540nm, and 580nm and then exhibits a cut-off at approximately 600nm.

Melanin

• Melanin is the basic pigment of skin and is by far the most important epidermal chromophore.

• Its absorption coefficient monotonically increases across the visible spectrum toward the UV.



Water

• In biological tissues- absorption is mainly caused by water molecules – the main constituent of most tissues.

• Infrared light is absorbed primarily by water beginning with a small amount of absorption from 300-2000nm- a point at which the degree of absorption increases rapidly and continuous for several thousand nanometers.

• The CO2 lasers produces light in the far infrared spectrum (10,600 nm). This is heavily absorbed by water contained in tissue and- does not penetrate deeply.

Protein

• Macromolecules such as proteins are second main absorber in biological tissue.

• Proteins mainly absorbs in the UV and visible range of the spectrum- in particular have an absorption peak at approximately 280nm

• As the wavelength decreases toward the blue violet, and ultraviolet, ***scatter*** - which limits the depth that light may penetrate into tissue- becomes more significant.

• Cellular organelles such as mitochondria are the main scatterers in various tissues.

Scattering of Light by Tissues

The interaction of light with tissue is composed of multiple internal reflections and redirections of incident light.

• In biological media scattering is typically highly forward directed (anisotropic) for visible wavelength

• This phenomenon cannot be explained by Rayleigh scattering.

• On the other hand- the observed wavelength dependence

is somewhat stronger than predicted by Mie scattering.

• Thus neither Rayleigh scattering nor Mie scattering completed describe scattering in amorphous biological shapes.

• With a few exceptions (e.g., cornea)- light propagation in tissues thicker than tens of microns- characterized by multiple scattering.

• Multiple scattering wash out any detailed

structure associated with individual scattering events.

• Scattering in optically thick media can be characterized by two parameters:

1. The scattering coefficient

2. The scattering anisotropy

Thermal Properties of Tissues

• Local tissue properties combined with the wavelength of laser light used- affect the quality of laser-tissue interaction.

• The more dense or opaque a tissue is – greater the degree of absorption of light energy and the greater the transformation to heat.

• Local blood circulation affects the degree of laser energy absorption in two mechanisms.

1. The absorptive properties of individual blood components differ and interact with light in specific wavelength ranges.

2. The circulating blood acts as heat sink or radiator by transporting absorbed thermal energy away from the site of delivery.

Effect of Light on Tissue

• The wavelength of laser light can be proportional to the depth of penetration into specific tissues.

• The longer the wavelength-the deeper the expected penetration.

• Tissue composition and molecular absorption play into laser end effect.

• The Nd:YAG - near infrared (1060nm)- penetrates approximately 5-10 mm in most tissues- not absorbed by water and hemoglobin in significant quantity.

• The CO2 – 10,600nm- penetrates to 0.1mmabsorbed by tissue water