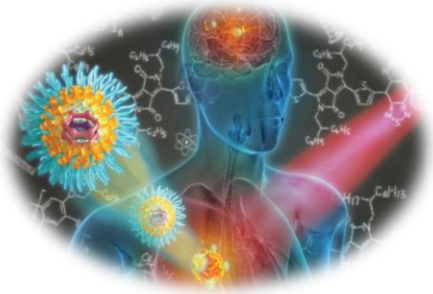
**Salahaddin University-**
**Erbil College of Science**
**Physics Department**



**Medical Optics. 3rd stage**
**Medical branch**

**1st Lecture after course book**

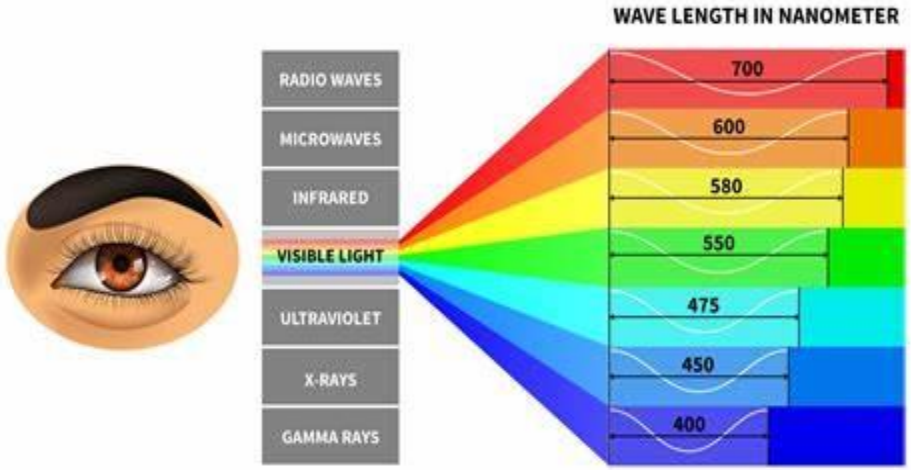
**1st Weak**

**Date 24-1-2023**

# 1-Medical Optics : 1-An Introduction
# 2-Chapter one: Nature of Light

**Dr. Shaida Anwer Kakil**

**24/2/2023**




# Learning Outcomes

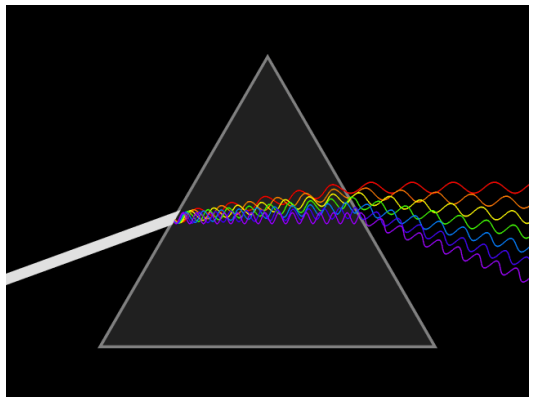

**At the end of todays lecture you would be able to:**

- **Understand the following terminologies: Optics , Photonics, Medical Optics .**
- **Understand the Physical meaning of Light and the properties of light**
- **Explain :Electromagnetic spectrum and Why Optics in Medicine**
- Explain the difference between Biomedical Optics & Biomedical Photonics

# Physical meaning of Optics ,Photonic and Medical Optics

## Optics

- Optics: the scientific study of sight and the behavior of light, or the properties of transmission and deflection of other forms of radiation.
- Optics is a branch of physics that deals with the determination of behaviour and the properties of light, along with its interactions with the matter and also with the instruments which are used to detect it. Optics, in a simple manner, is used to describe the behavior of **visible light, infrared light, and ultraviolet.**



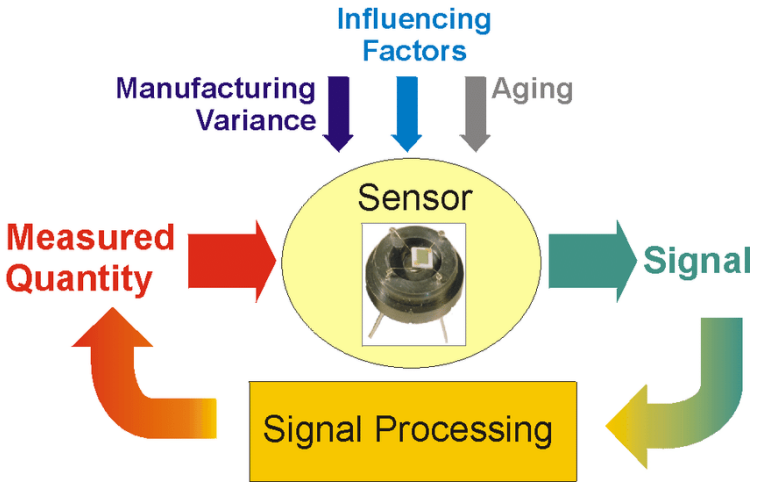
# Physical meaning of Optics ,Photonic and Medical Optics

- **Photonics** is a branch of optics that involves the application of generation, detection, and manipulation of light in form of photons through emission, transmission, modulation, signal processing, switching, amplification, and sensing.
- **What are the differences between optics and photonics?**
- Optics is a general area of physics covering a wide range of topics related to the study of light. Optics includes such subfields as geometrical optics, physical optics, and quantum optics. Photonics is a subset of the optics discipline.

# Physical meaning of Optics ,Photonic and Medical Optics

**How is light generated, detected, and manipulated in photonics?**

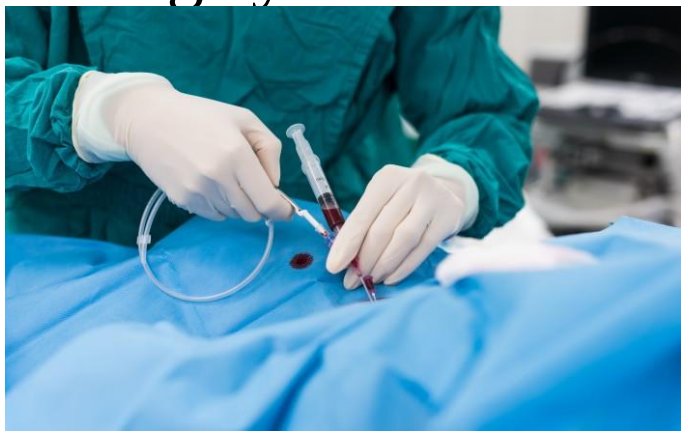
Photonics is a branch of optics that involves the application of generation, detection, and manipulation of light in form of photons through emission, transmission, modulation, signal processing, switching, amplification, and sensing.




**Signal processing for sensors**

# Why Optics in Medicine?

- Nowadays, it is not only optics but also photonics that are used extensively in a myriad(great number) of medical applications, from diagnostics, to therapeutics, to surgical procedures. Hence, when we use the term medical optics, we are referring to **biomedical optics and biophotonics** as well. But it is in reality light and its interaction with living tissues that is at the center of what makes optics in medicine possible. Light possesses energy and is capable of interacting with biological cells, tissues, and organs.
- Such interaction can be used to probe the state of such living matter for diagnostics and analytical purposes or, it could be used to induce changes on the same living systems and be exploited for therapeutic purposes.



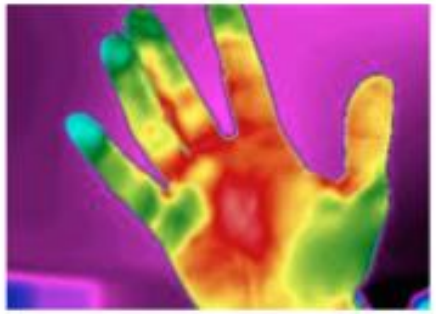
# BioPhotonics

BioPhotonics: interaction of living cells (bio) with electronic control or detection of light (photonics)

Initial ABP Focus

## Imaging

2D & 3D examination of cells, tissue, and organs



example : *IR thermography*

## Biometrics

noninvasive biophysical parameter measurement

example : *blood oxygen sensor*

## Therapeutics

photonic treatment of injured or diseased cells

example : *ABP phototherapy*

## Detection

detecting the presence of injury, disease & distress

example : *UIUC cancer detection*

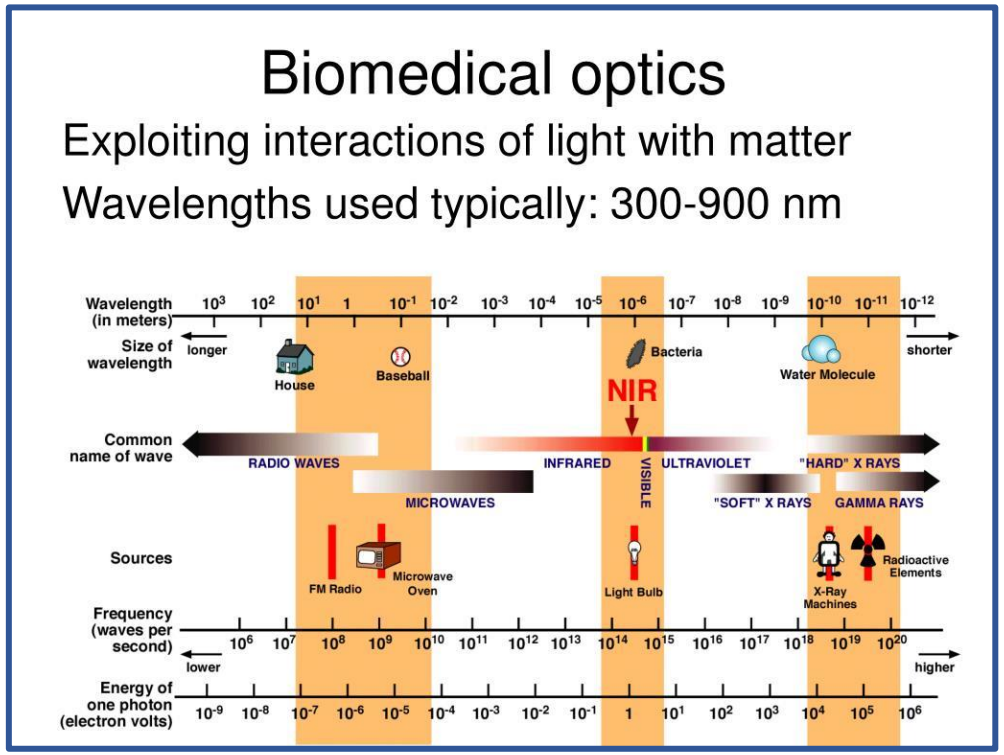
## Surgery

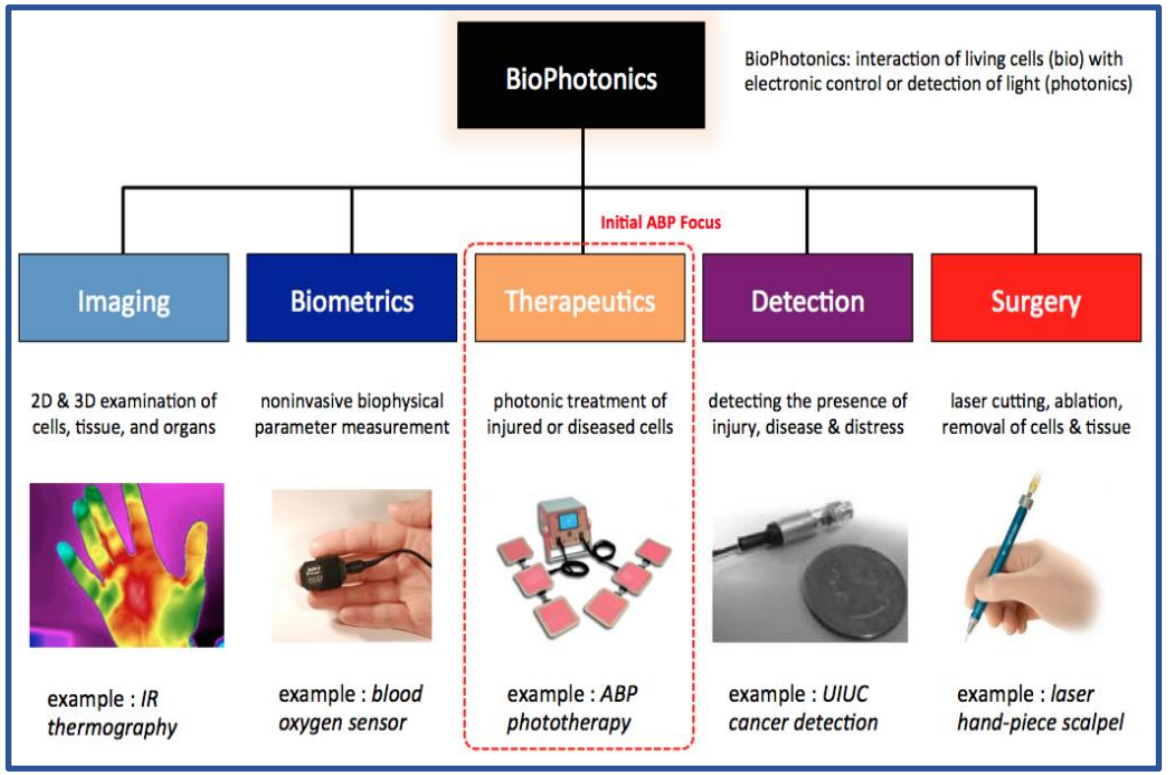
laser cutting, ablation, removal of cells & tissue

example : *laser hand-piece scalpel*

# Q1) Explain the difference between Biomedical Optics & Biomedical Photonics

- **Biomedical** Imaging **Optics** is a branch of physics that examines the behavior and properties of light and the interaction of light with matter. **Photonics** is the science and technology of generating, controlling, and detecting **photons**, which are particles of light.

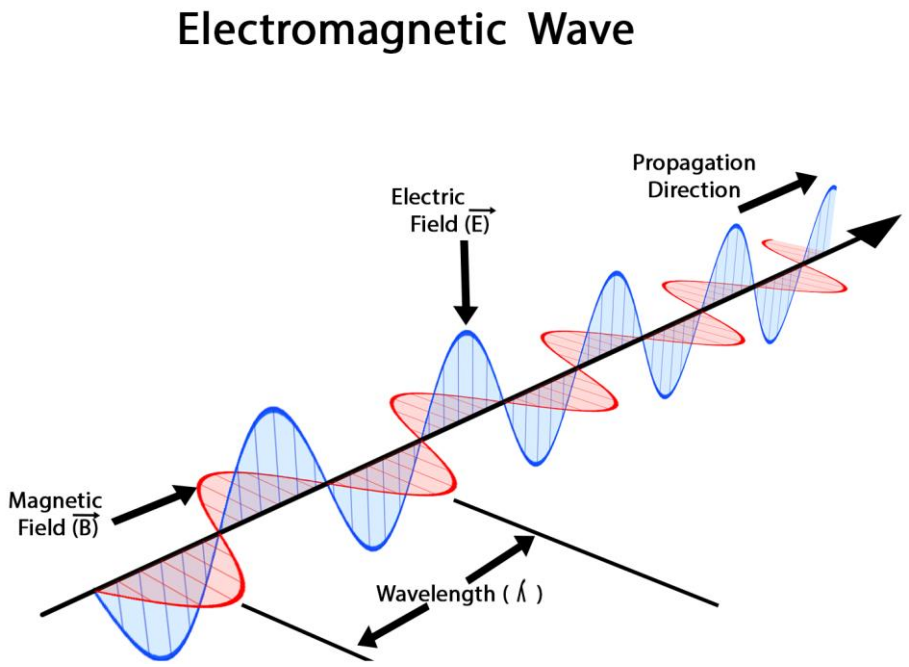


# Chapter one “Nature of Light”

# Chapter one  Nature of Light

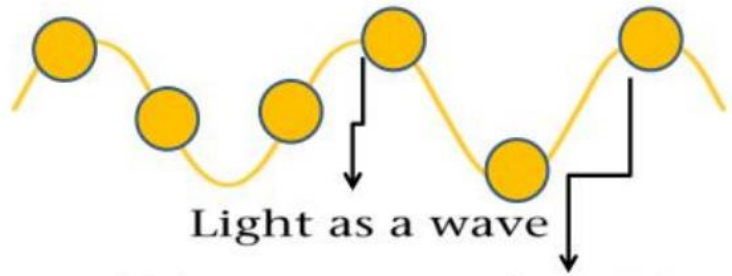
- Light is **electromagnetic radiation** that can be detected by the human eye. Electromagnetic radiation occurs over an extremely wide range of wavelengths, from gamma rays with wavelengths less than about $1 \times 10^{-11}$ metres to radio waves measured in metres.




Albert Einstein proposed that light not only behaves as a wave, but as a particle too.

Light is a particle in addition to a wave-Dual nature of light.

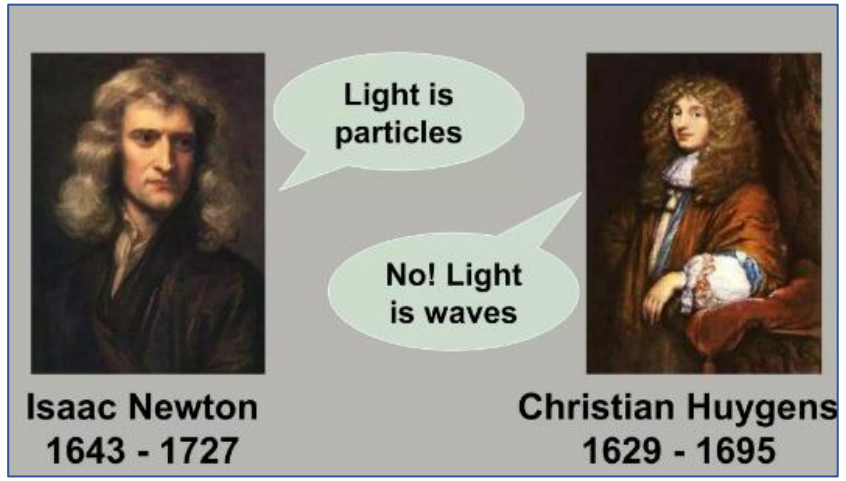
Dual nature of light - treated as
1) a wave or
2) as a particle



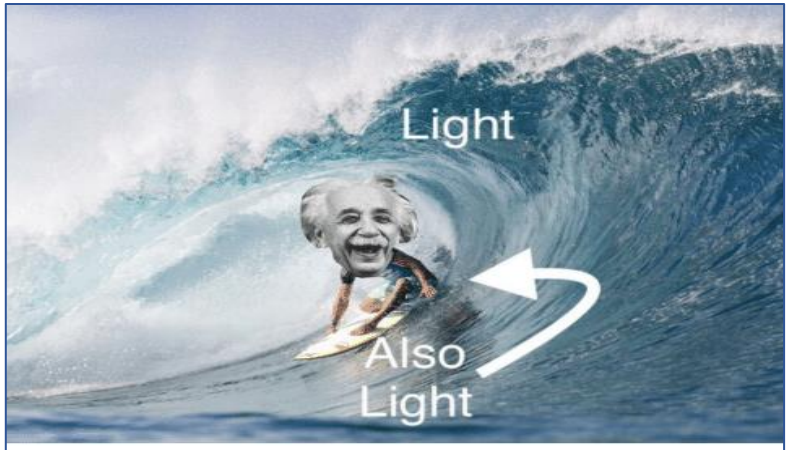

Dual nature of light successfully explains all the phenomena connected with light.

# Is a light a wave or particle?

- Light is both a particle and a wave. Light has properties of both a particle and an electromagnetic wave but not all the properties of either. It consists of photons that travel in a wave like pattern. The debate has raged for generations amongst the giants of the physics community regarding the nature of light, namely whether it is a particle or an electromagnetic wave.



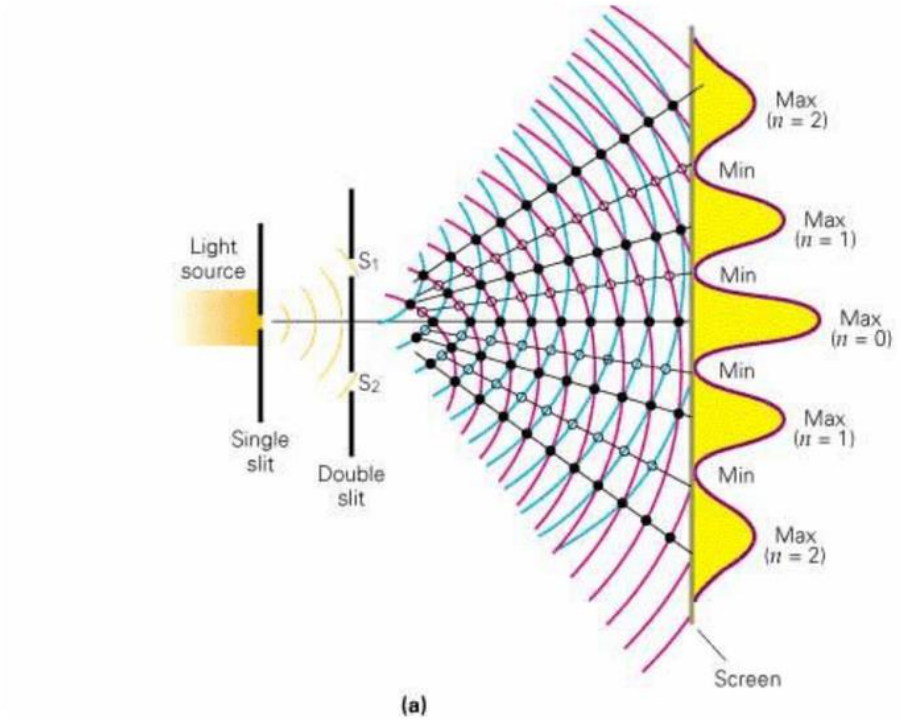

- Light has a dual nature.
- Depending on the phenomenon or behavior in question, light can be treated either as a wave or as a particle.
- To examine this wave-particle duality, we will examine two experimental proofs.

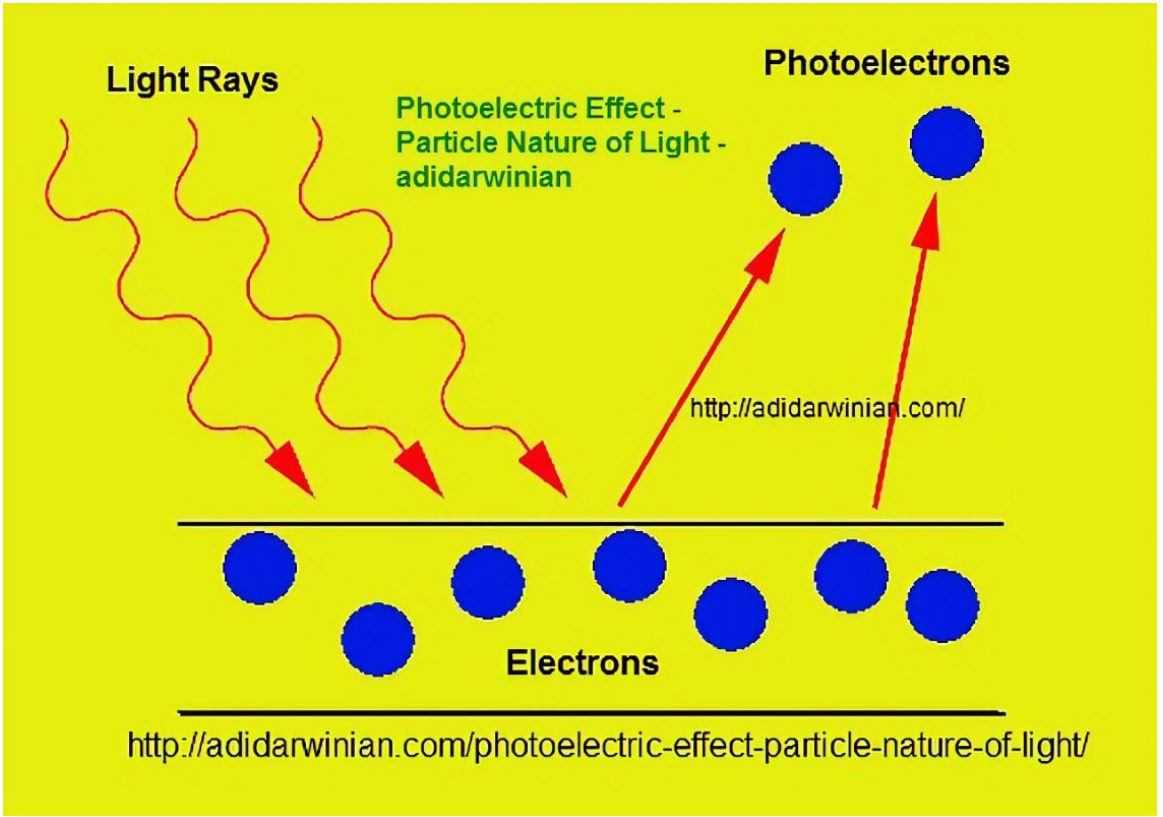



Einstein illustrates how light is both a wave and a particle (1905)

# Is a light a wave or particle?

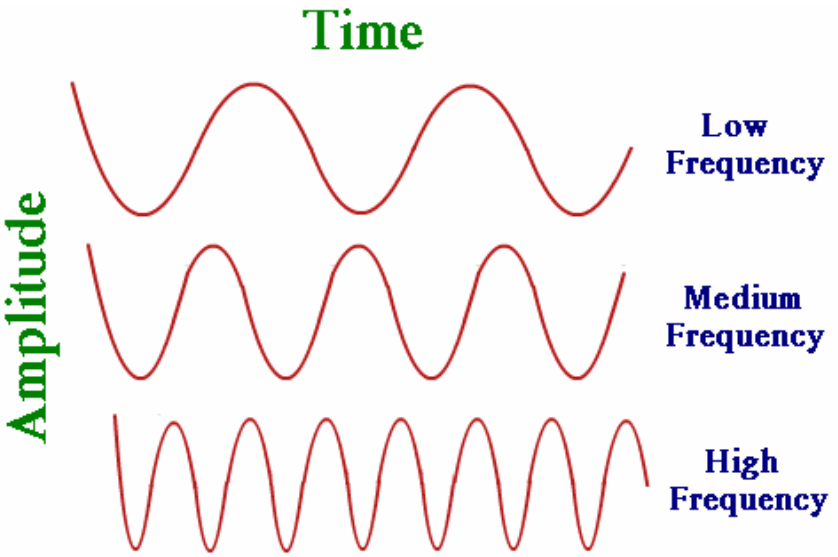
Young's Double Slit Experiment- models light as a wave.




The photoelectric effect proves that light delivers discrete quanta of energy, and it proves that the amount of energy in each quantum is a function of the wavelength. In other words, you can count photons. That sounds very particle-like, but it is not proof that photons bear any other resemblance to your idea of what "particle" means.

# Nature of Light”



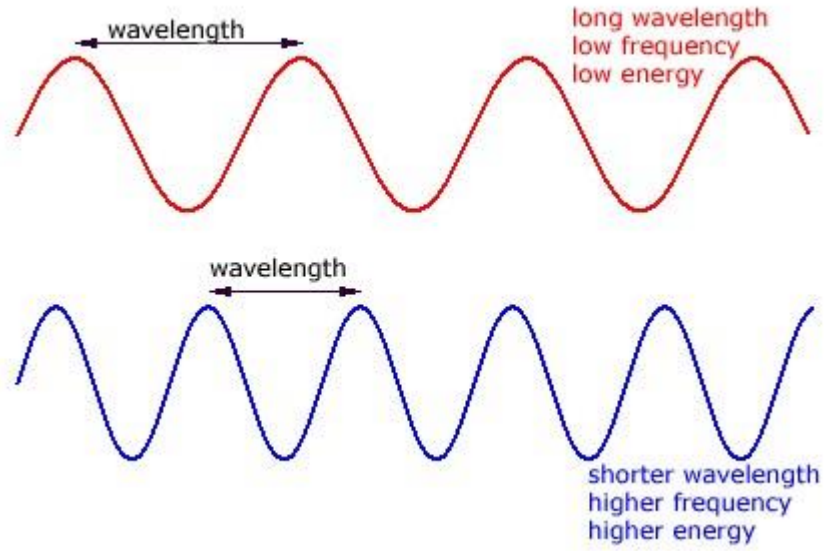

Waves are characterized by **frequency, wavelength, speed and phase.**

$$\lambda \nu = c$$

C is speed of light in a vacuum (≈air) = $2.997 \times 10^8$ m/s

**- all types of electromagnetic radiation travel at the speed of light, so the short wavelength radiation must have a high frequency**

-The speed of light and wavelength, which change as electromagnetic energy is propagated through media of different densities, frequency remains constant and is therefore a more fundamental property.




Light behaves like waves in its propagation and in the phenomena of **interference and diffraction**

# Particulate nature of radiation:

- The radiation can be described in terms of particles of energy called **photons**
- Planck was used the idea that black bodies emit light (and other electromagnetic radiation) only as discrete packets of energy called photons.
- The Photon has energy, but it has no mass and no charge
- Energy of photon is given by:

$$E_{\textbf{photon}} = h\,\nu$$

$$E = h\frac{c}{\lambda}$$

where h is Plank's constant ($h = 6.6256 \times 10^{-34}$ J s).

The quantized nature of light is most important when considering absorption and emission of electromagnetic radiation.

Light exhibits particle-like behaviour when exchanging energy with matter**, as in the Compton and photoelectric effects**

# What are the Characteristics of Light?

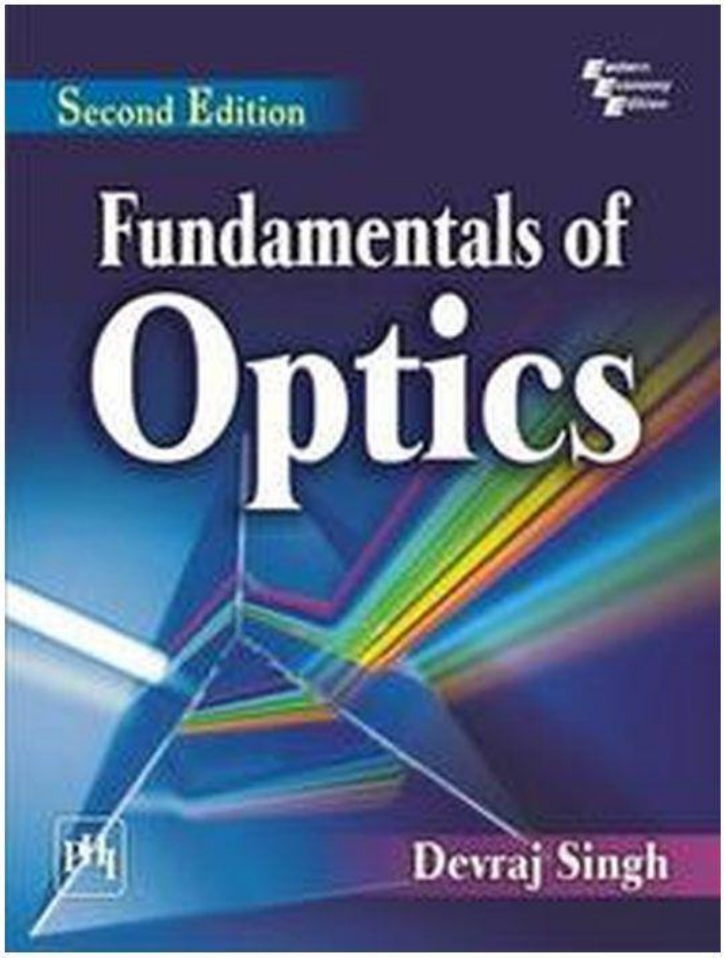
- Light is an **electromagnetic wave**.
- Light travels in a straight line.
- Light is a transverse wave, and does not need any medium to travel. Light can travel through vaccum.
- Its speed through vaccum is $3 \times 10^{8}$ m/s.
- The velocity of light changes when it travels from one medium to another.

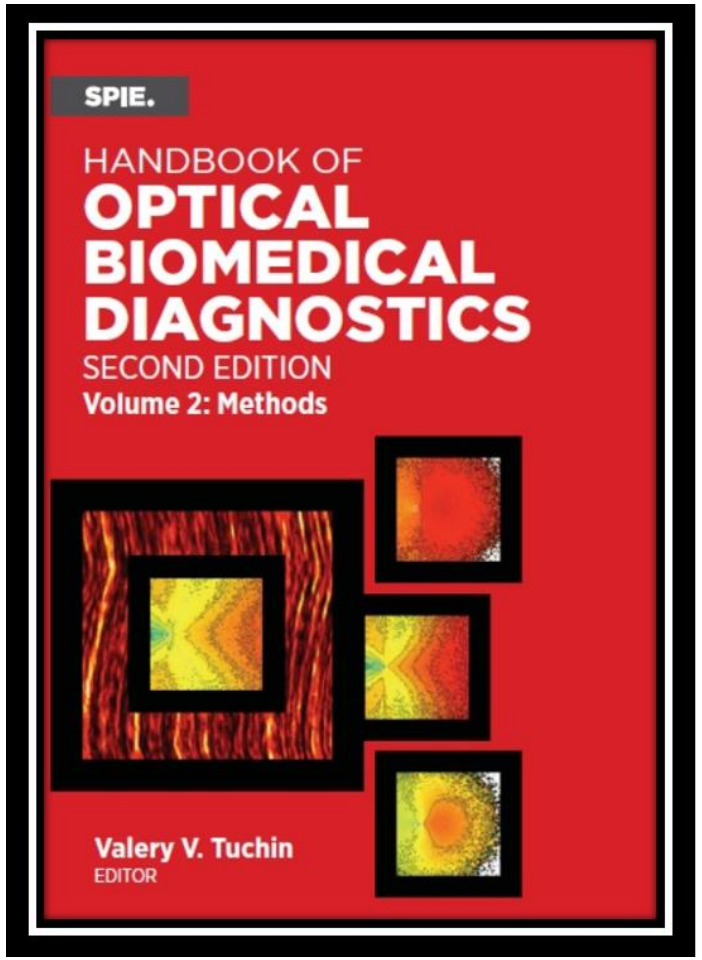
## Effects of Materials on Light

Materials can be classified based on how it responds to light incident on them:

1. **Opaque materials** – absorb light; do not let light to pass through
2. **Transparent materials** – allow light to easily pass through them
3. **Translucent materials** – allow light to pass through but distorts the light during the passage

# Reference

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