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Review Article

Electromagnetic radiation in modern medicine: Physical and biophysical properties

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ABSTRACT

Introduction: The widespread application of electromagnetic radiation (EMR) in modern medicine requires healthcare professionals and undergraduates to be familiar with its physical and biological properties.
Aim: The aim of this paper was to review current literature on EMR physical principles.
Materials and methods: Available literature on EMR has been reviewed and grouped thematically.
Results and discussion: The electromagnetic spectrum is divided into radio waves, microwaves, infrared, visible, ultraviolet, X-, gamma- and cosmic rays. Electromagnetic waves (EMWs) are characterized by frequency, velocity, period of vibration and wavelength. Depending on the medium, EMR may decelerate, reflect, refract, diffract, interfere or polarize. These phenomena apply to EMWs (light waves), pressure and water waves. The wave-particle duality of radiation is widely accepted and explains its nature and mechanism of action. Principles of quantum mechanics help to predict the potential biological impact of EMR.
Conclusions: From humble beginnings, more than 100 years ago, EMR has become an important component of modern medicine. Therefore, there exists an urgent need for education and better understanding with respect to its principles and applications.

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1. Introduction

The electromagnetic spectrum is traditionally divided into radio (Hertz) waves, microwaves (MWs) (radar), infrared, visible, ultraviolet, X-, gamma- and cosmic rays (Fig. 1). The boundaries between these electromagnetic regions and subregions are not hard and fast ones. The bounds of visible light are determined by the physiology of the human eye. The visible subregions range from about 0.40 μm (blue end) to 0.78 μm (red end) and serve as a good example of the nonuniqueness of the subbands of regions. Table 1 shows the approximate wavelengths and frequencies of key electromagnetic bands. Hence, as the boundaries of particular ranges of electromagnetic radiation (EMR) are conventional and not sharp, radiation of the same length can be known as radio wave or microwave, depending on the application.[3,6,10,11,13,17]

2. Materials and methods

Available literature on EMR has been reviewed and grouped thematically.

3. Aim

The widespread application of EMR in modern medicine requires healthcare professionals and undergraduates to possess some knowledge of its physical and biological properties. This paper discusses the biophysical principles of EMR, its interactions with living organisms and its application in clinical practice.

4. Results and discussion

4.1. *Physical properties of EMR*

EMR is produced by the coupled activity of alternating electric and magnetic fields, which propagates itself in space as a transverse EMW or as a stream of small portions (quanta) of energy called photons. The wave nature of EMR dominates in long waves, MW, infrared, ultraviolet, visible light, and laser radiation. Cosmic-, gamma- and X-rays are more commonly perceived as a stream of photons.

Similar to mechanical waves, electromagnetic waves are characterized by frequency (f), velocity (v) of propagation in the medium, period of vibration (T) and wavelength (λ). The movement of an electromagnetic beam in vacuum occurs with a constant, maximum speed for any form of energy ($c = 299\,792\,458$ m/s). The speed of EMWs changes as they cross between different media, but their frequency remains constant. Fission (dispersion) depends on the density of the medium and a wavelength and frequency. It accounts for the deceleration of the wave in a gas, liquid or solid medium. Its speed is always lower than in vacuum. EMW velocity is directly proportional to its frequency and wavelength. Frequency and wavelength of a particular type of EMWs are always related. High frequency corresponds with short waves and low frequency with long

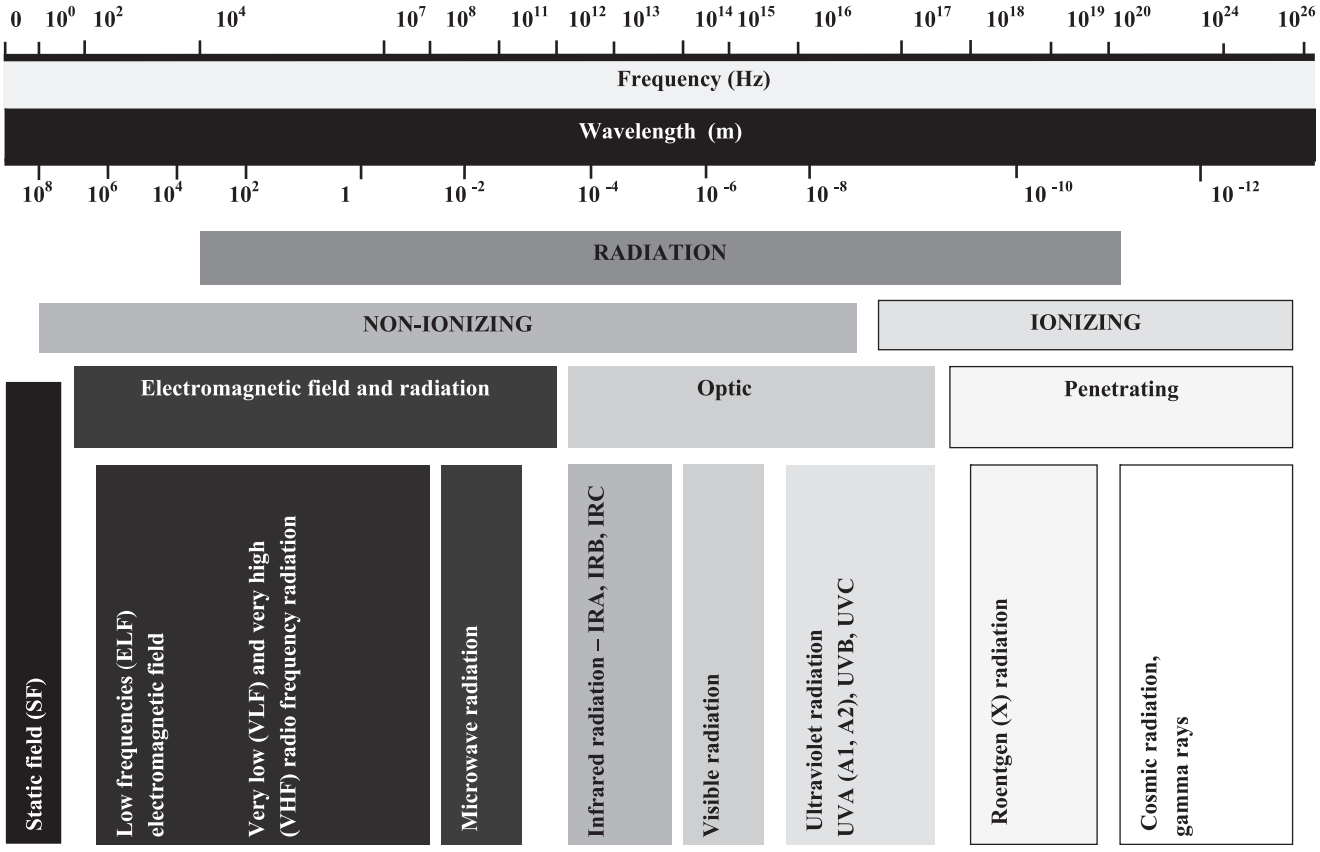

Fig. 1 – Electromagnetic spectrum.[13]