TEACHING METHODOLOGY OF INFRARED LIGHT ABSORPTION IN LIVING TISSUES

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Annotation:

The article describes medical physics, one of the newest important directions of modern physical science, which emerged on the border of different departments of physics based on the integration of biological and physical sciences. The main task of the medical physics course is to study the structure of living organisms and their physical foundations. Scientific-theoretical analysis of the processes occurring in a living organism, for example, from some molecules and their collections to cells, their categories, tissues, organs, and whole organisms.

The scientific-theoretical basis of the use of light rays in the study of cells and tissues with the help of infrared light is given. Also, the prospects of researching biological tissues using the laws of physics are analyzed.

Keywords: medicine, physics, optical radiation, thermal radiation, biology, integration, x-ray structure, electron microscope, radioisotope, electron, nuclear, magnetic, radiospectroscopy, optical spectroscopy, mass spectrometry, activation, radioelectronics, cybernetics, modeling, infrared light, tissue, cell.

DOI Number: 10.14704/NQ.2022.20.12.NQ77317 **NeuroQuantology2022;20(12): 3153-3158**

Advances in modern medicine are largely based on advances in physics, technology, and medical equipment. The nature of diseases and the mechanism of healing are often explained on the basis of biophysical concepts. That's why students of medical universities acquire special knowledge of physics, technical, biological physics and mathematics in the course of "Medical Physics" in the first year.

The ideological direction is of great importance in the "Medical Physics" course, which helps students to understand the processes occurring in a living organism, that is, biological objects of varying complexity (from individual molecules and their collections to cells, their families, tissues, organs, whole organisms), helps to learn and analyze.

By the 21st century, medical physics, like other sciences, has developed at a high level.

Currently, the basis of physics is x-ray structural analysis, electron microscopy, radioisotopes, electron and nuclear magnetic resonance radiospectroscopy, optical spectroscopy, mass spectrometry, activation analysis, various methods of radioelectronics and cybernetics, computing techniques, mathematical modeling and many other tools.

The study of biological tissues, applying the laws of physics, is developing widely. The basis of such laws are the laws of optics. In particular, rays with a long wavelength and lying outside the red part of the spectrum are called infrared rays, and rays with a short wavelength and lying outside the violet end of the spectrum are called ultraviolet rays. We call all the rays of the spectrum as light rays, they have the same nature. Infrared rays are often called thermal radiation, because they appear mainly due to their own heat.

The main reason for the use of light rays in the study of tissues is the strength of the ability of certain wavelengths of light rays to penetrate between tissues. The advantage of studying tissues using this method is the very precise operation of optical instruments, some simplicity and low cost.

Methods section (Methods) One such method is the method of studying cells and tissues using infrared light. The advantage of this method is that the infrared light has a stronger ability to reach the tissues without being absorbed than other rays, and the infrared light is harmless to living tissues. Infrared light, penetrating deeper into cells and tissues, interacts with the substances inside the tissues, causing the rays to be reflected or absorbed and scattered. The main reason for the change in light intensity in this process is hemoglobin in the blood. By studying the light intensity, we will be able to monitor the tissue's blood supply.

Blood supply is the most important vital factor for the tissue and indicates its high level of health or vice versa. Some diseases can be determined by slowing down and speeding up blood circulation. For example, a decrease in blood circulation in the tissues indicates a possible infarction in the heart, or vice versa. Acceleration of blood circulation in a certain part of the tissues indicates that a dangerous tumor is emerging. Knowing the amount of absorbed and scattered rays, we can make an opinion about the internal processes taking place in the tissue.

As we know, when an electromagnetic wave passes through a substance, part of the wave energy is used to excite the vibration of electrons. This energy returns in the form of a secondary wave caused by partial electrons; and partially turns into another type of energy (for example, the energy of movement of atoms, that is, the internal energy of matter). Thus, when light passes through a substance, its intensity decreases, light is partially absorbed in the substance [1]. The forced vibration of electrons and, therefore, the absorption of light is especially intense at the resonant frequency (Fig. 1).

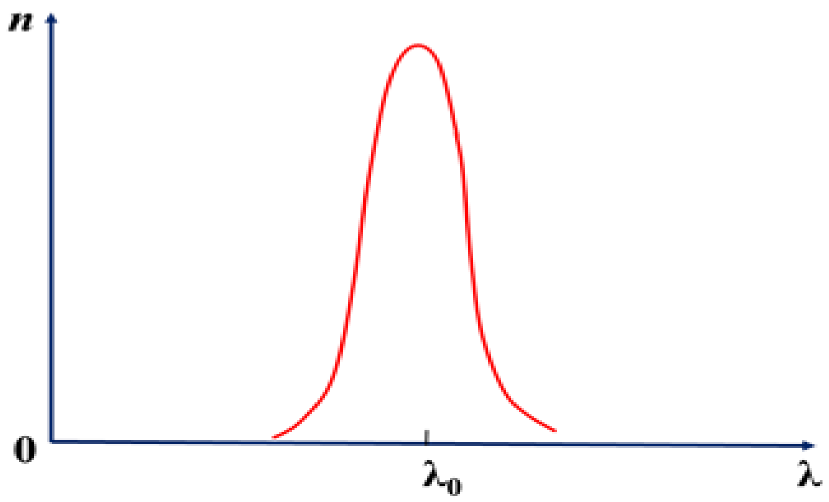

Figure 1. Absorption curve graph.

Studies show that the change in light intensity at a distance dl is proportional to this distance and the magnitude of this intensity:

$$dI = -\chi \cdot I\, dl \qquad (1)$$

Here χ - is an invariant quantity called absorption coefficient, which depends on the properties of the absorbing material. The minus sign is because dI and dl have different signs.

Let the intensity of light at the time of entering the absorbing layer (boundary or somewhere inside the substance) be equal to I0. Let's find the intensity I of light passing through a layer of thickness l of the substance. To do this, we divide expression (1) into variables and then integrate:

$$\int_{I_0}^{I} \frac{dI}{I} = -\chi \int_0^l dl$$

As a result: *lnI - lnI₀*= $-\chi\, l$ will be derived from this

$$I = I_0 \cdot e^{-\chi l} \qquad (2)$$

The relation (2) is called Bouguere's law. According to this law, the intensity of light decreases exponentially in an absorbing substance. $l = \frac{1}{\chi}$ when I the intensity is ***e*** times less than ***I₀***. Thus, the absorption coefficient is a quantity that is inversely proportional to the thickness of the layer that reduces the intensity of the passing light by e times [3].

The absorption coefficient λ depends on the wavelength (or frequency ω). In substances whose atoms or molecules are in an almost non-interacting state (gases and metal vapors at low pressure), the absorption coefficient is close to zero for most wavelengths and has maxima formed only in very short (with a width of the order of hundredths of an angstrom) spectral regions (Fig. 2).

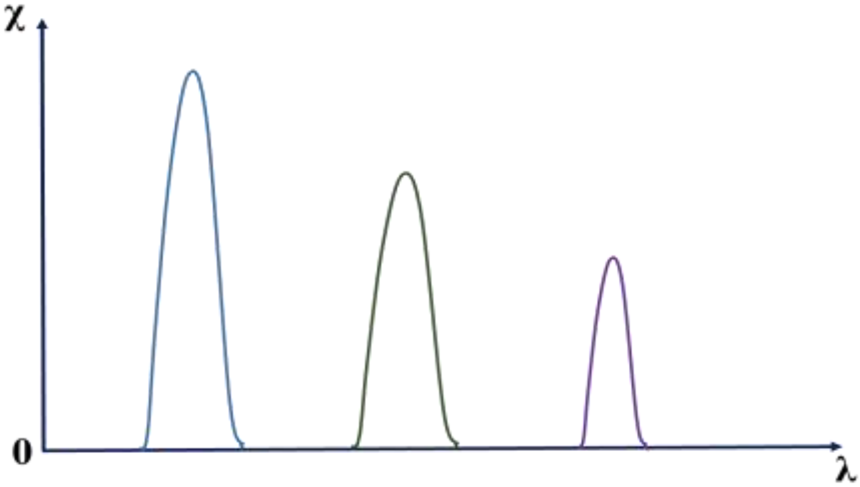

Figure 2. Formation of maxima in spectral fields.

These maxima correspond to resonance frequencies of electron vibrations inside the atom. Even for polyatomic molecules, frequencies corresponding to the vibrations of the atoms in the molecules are observed. Since the mass of an atom is several tens of thousands of times greater than the mass of an electron, the molecular frequencies are much smaller than the atomic frequencies. They correspond to the infrared region of the spectrum.

Solids, liquids, and gases have a much wider absorption band at higher pressures (Figure 3). As the pressure of gases increases, the absorption maxima first become very narrow (see Fig. 2), then broaden, and at higher pressures the absorption spectrum of gases approaches the absorption spectrum of liquids. It only shows that the broadening of the absorption band is the result of atomic interactions.

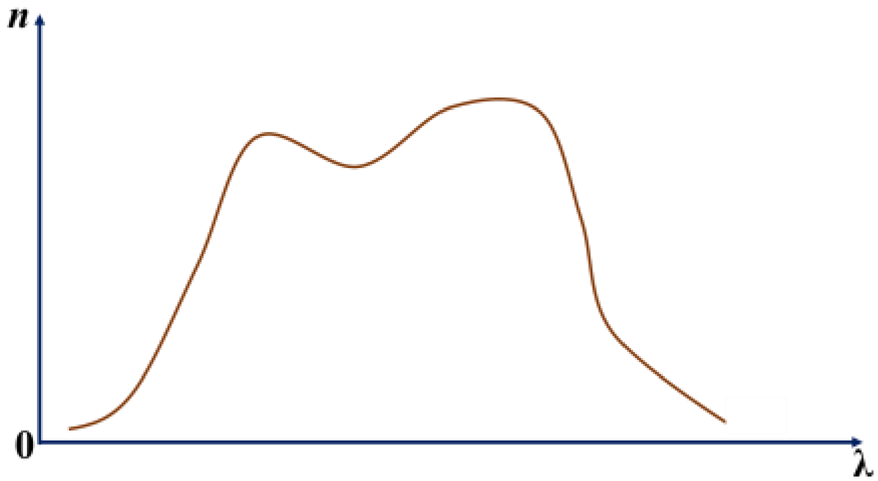

Figure 3. Absorption curve graph (at high pressure).

Metals are opaque to light (for them x is on the order of ten thousandths of a centimeter; for comparison we show that x ≈ 10-2cm-1 for glass). This situation is caused by the presence of free electrons in metals. When light waves change under the influence of an electric field, free electrons move. Rapid alternating currents are generated in metals, which generate Joule-Lents heat. As a result, the energy of the light wave quickly decreases and turns into the internal energy of the metal.

Results section In the living tissues that we are studying, the main substances that absorb infrared light are hemoglobin in fat, water and blood. The amount of fat and water in the tissue is kept constant, and even if it changes, it changes very slowly. Experiments show that the fat in the tissues is the substance that absorbs the least amount of light. The maximum value of its absorption coefficient corresponds to 920 - 940 nm. The minimum absorption areas correspond to rays of 600-700 nm and 850-900 nm. Because tissue fat is a quantitatively constant quantity, the absorbance values in the spectrum are kept constant. The maximum absorption coefficient of water in tissues corresponds to the range of 930-960 nm, and the minimum values correspond to the wavelength range of 600-700 nm. The concentration of water in the tissue changes slowly. This change can be considered instantaneous [2].

There are two types of hemoglobin in tissues: hemoglobin saturated with oxygen and saturated with carbonic anhydride. The maximum absorption coefficient of both types of hemoglobin decreases from the short wavelength range to the wavelength of 700 nm. After that, the absorbance of hemoglobin saturated with oxygen gradually increases from

700 nm, and the absorption coefficient of hemoglobin saturated with carbon dioxide continues to decrease unevenly from 700 nm.

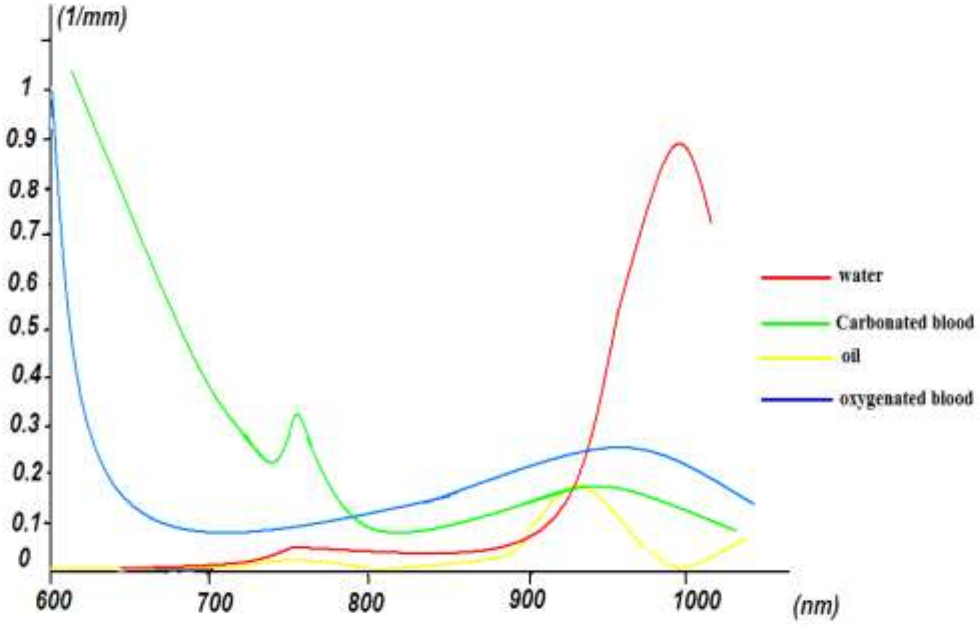

Figure 4. Absorption spectrum of infrared light in substances.

Discussion section (Discussion) As can be seen from the graph, the minimum absorption wavelength of all substances corresponds to the range of 780-880 nm. The wavelength of the infrared light that penetrates the tissues also corresponds to the range of 780-880 nm. These rays pass through the tissues, scatter between them and come back. They give us information about what is happening inside them. Changes in the absorption of light in tissues are mainly due to changes in hemoglobin, since the content of other substances, fat and water, does not change. Depending on the change in the intensity of the light output, we can know that this tissue is supplied with blood [4,5].

In conclusion, it can be said that physico-mathematical and biophysical knowledge is not only an important element for students studying in the field of medical physics in higher education, but also helps to study the biochemical and biophysical processes in the human body in depth. This is very important for the formation of the science of medical physics as an exact science. The study of physical processes and laws not only allows to obtain accurate anatomic data, which helps in the perfect formation of a future highly qualified medical worker, but also leads to the formation of competences to be applied in practice in specialists through knowledge.

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TIBBIYOT FIZIKASI FANI MA‟RUZLARINI O„QITISHDA "VENN DIAGRAMMASI" USULINI QO„LLASH // Academic research in educational sciences. 2022. №3.