

MEDICAL AND BIOLOGICAL PHYSICS: MAGNETIC RESONANCE IMAGING.

<https://doi.org/10.5281/zenodo.19720560>

Associate Professor **Maxsud Raxmatov**,
Samarkand "Zarmed" University,
Shodiyev Shoxjahonbek Shuxratovich
1st-year student, General Medicine program,

Abstract

This article demonstrates the importance of lesson plans in improving educational quality in Medical and Biological Physics, illustrated through the topic of "Magnetic Resonance Imaging, Positron Emission Tomography, and Computed Tomography."

Keywords

magnetic resonance imaging, positron emission tomography, magnetic resonance spectroscopy, computed tomography, angiography, lesson plan, educational quality.

It is well known that improving educational quality is a matter of national importance, representing one of the most pressing challenges in training competitive specialists. Numerous documents and programs have been developed and implemented at the initiative of the President. For instance, at the expanded Cabinet of Ministers meeting on January 14, 2017, the Head of State emphasized the necessity of fundamentally revising curricula and educational methodological support in educational institutions. Similarly, the Decree of the President of the Republic of Uzbekistan on the "Concept for the Development of the Higher Education System of the Republic of Uzbekistan until 2030" also addresses the issue of educational quality.

The Law on Education (No. ORQ-637, September 23, 2020) covers reforms of the education system, development of vocational education (schools, colleges, technical schools), establishment of the two-tier higher education system (bachelor's and master's degrees), as well as the rights and duties of students, the status of educators, and licensing of non-state education. One of the key changes is the opening of various pathways for vocational and higher education after nine years of basic secondary education, along with the opportunity to obtain a second professional education through contract-based study. Other documents also consistently address the improvement of educational quality.

In this article, we examine the role of lesson plans in improving educational quality in Medical and Biological Physics, using the topic of “Magnetic Resonance Imaging” as a practical example.

Magnetic Resonance Imaging (MRI). Magnetic Resonance Imaging (MRI) is a method based on the nuclear magnetic resonance phenomenon, which produces tomographic medical images of internal organs and tissues. The method relies on the ability of atomic nuclei to emit electromagnetic signals. Primarily, hydrogen atoms are considered in this context.

Today, medicine is advancing rapidly. The emergence of new diagnostic methods is linked to the development of high-quality medical equipment. We are speaking of tomography (Greek: tomos – “to cut”) – including magnetic resonance tomography (MRI), computed tomography (CT), and positron emission tomography (PET).

Magnetic Resonance Tomography. MRI technology is relatively new, having appeared in the early 1980s, after computed tomography. Its foundation was the electron paramagnetic resonance phenomenon observed by Yevgeny Zavoisky in 1944. The essence of this phenomenon is that electrons of certain element atoms absorb energy in a specific radiofrequency range under the influence of a magnetic field and then emit it. In 1947, Felix Bloch and Richard Purcell discovered the nuclear magnetic resonance phenomenon.

The first tomograph (EMI MARK I) was produced by EMI Company in 1972. Despite its high cost, it became widely popular worldwide. MRI technology is based on the nuclear magnetic resonance phenomenon: the method relies on the change in frequency of hydrogen nuclei when irradiated with electromagnetic waves of a specific frequency. MRI technology enables determination of the chemical composition of the tissues being examined.

MRI is primarily used to visualize muscles, nerves, the brain, and other soft tissue structures.

MRI is a relatively harmless method – its impact is comparable to that of a mobile phone. While we use mobile phones daily, MRI is performed only once or twice in a lifetime.

This method is applied in the following conditions:

- 1) Anomalies of the brain and cerebral blood vessels;
- 2) Chronic diseases of the nervous system;
- 3) Detection of various tumors;
- 4) Joint diseases;
- 5) Examination of the spinal cord;

- 6) Examination of the abdominal cavity;
- 7) Examination of the spinal column;
- 8) Pre- and post-operative assessment of brain capillaries and tissue condition.

MRI cannot be performed under the following circumstances:

- 1) First trimester of pregnancy;
- 2) Extremely high body weight;
- 3) Presence of metal braces;
- 4) Tattoos made with iron-containing pigments;
- 5)
- 6) Artificial heart valves;
- 7) Claustrophobia (fear of enclosed spaces);
- 8) Inadequate psychiatric condition of the patient;
- 9) Critically severe general condition of the patient;
- 10) Cochlear (inner ear) implants.

Titanium, widely used in prosthetics, is not ferromagnetic and is safe during MRI. However, tattoos made with titanium-based pigments (e.g., titanium dioxide) are contraindicated.

In addition, PET (Positron Emission Tomography), also known as two-photon emission tomography, is now widely used. It is a radionuclide tomographic method for examining the internal organs of humans and animals. PET is a developing diagnostic and research method of nuclear medicine. It involves monitoring the distribution of biologically active compounds labeled with positron-emitting radioisotopes in the body using a specialized detecting device (PET scanner). Using special radiopharmaceuticals (RPP), PET studies various processes such as metabolism, substance transport, and gene expression.

In addition to the above methods, angiography is also available and is one of the most modern techniques today. Angiography is a contrast radiological method for examining blood vessels. It evaluates the functional state of vessels, blood flow, and pathological processes.

Angiography is performed on an outpatient basis. The patient is placed on a CT table and approximately 100 ml of iodine-based contrast medium is injected through an intravenous catheter at a controlled rate. As the contrast medium is administered, the area under examination is scanned with X-rays. As the contrast spreads through the vascular system, the vessels become clearly visible. The physician then examines the images using multiplanar and three-dimensional computer reconstruction. Angiography is contraindicated in acute infectious

diseases, psychiatric conditions, certain cardiac, hepatic and renal diseases, iodine preparation allergies, and in critically ill patients.

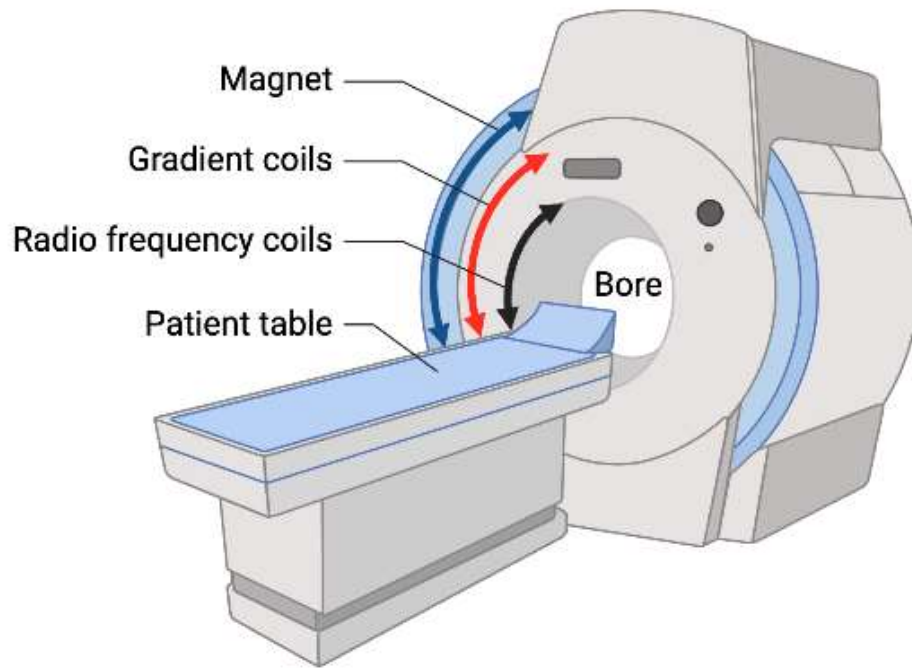
MRI appeared in 1973. That same year, chemistry professor Paul Lauterbur published an article in the journal "Nature" on image formation using the magnetic resonance phenomenon. Later, Peter Mansfield improved the mathematical algorithms for image acquisition. These scientists, recognized as the pioneers of MRI, were awarded the Nobel Prize in Medicine in 2003.

For a long time, this method was called NMR (Nuclear Magnetic Resonance) tomography. However, after the Chernobyl accident in 1986, radiophobia was observed in some people and the term NMR was replaced by MRI. Nevertheless, the old name is still occasionally used today.

Tomography enables high-quality visualization of the brain, spinal cord, and internal organs. Modern MRI technologies non-invasively examine the function of various organs – blood flow velocity, cerebrospinal fluid flow, diffusion rate in tissues, and cerebral cortex activity.

Early tomographs had a magnetic field induction of approximately 0.005 Tesla, resulting in relatively low image quality. Modern tomographs are equipped with powerful magnets. The field strength of electromagnets ranges from 1–3 Tesla up to 9.4 Tesla, while permanent magnets have a field strength of 0.7 Tesla. During MRI, the patient must not have any metal objects. Scanning duration is typically 20–30 minutes; in particular, abdominal scanning takes longer than brain scanning. Due to the loud noise produced by MRI scanners, patients' ears are protected. In some examination protocols, contrast medium is injected intravenously.

MRI Perfusion. This method evaluates the passage of blood through body tissues. It allows determination of key parameters such as volumetric blood flow, vascular wall permeability, and venous blood flow. These parameters help identify healthy and pathological tissues: blood passage through brain tissue and through liver tissue.



Structure of the MRI Machine

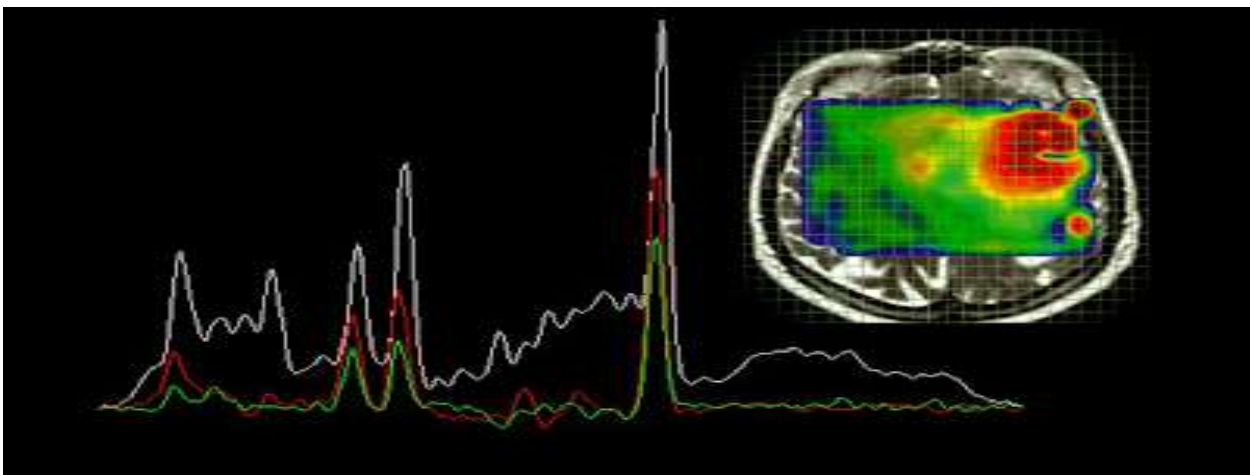
This method enables detection of ischemia in the brain and other organs.

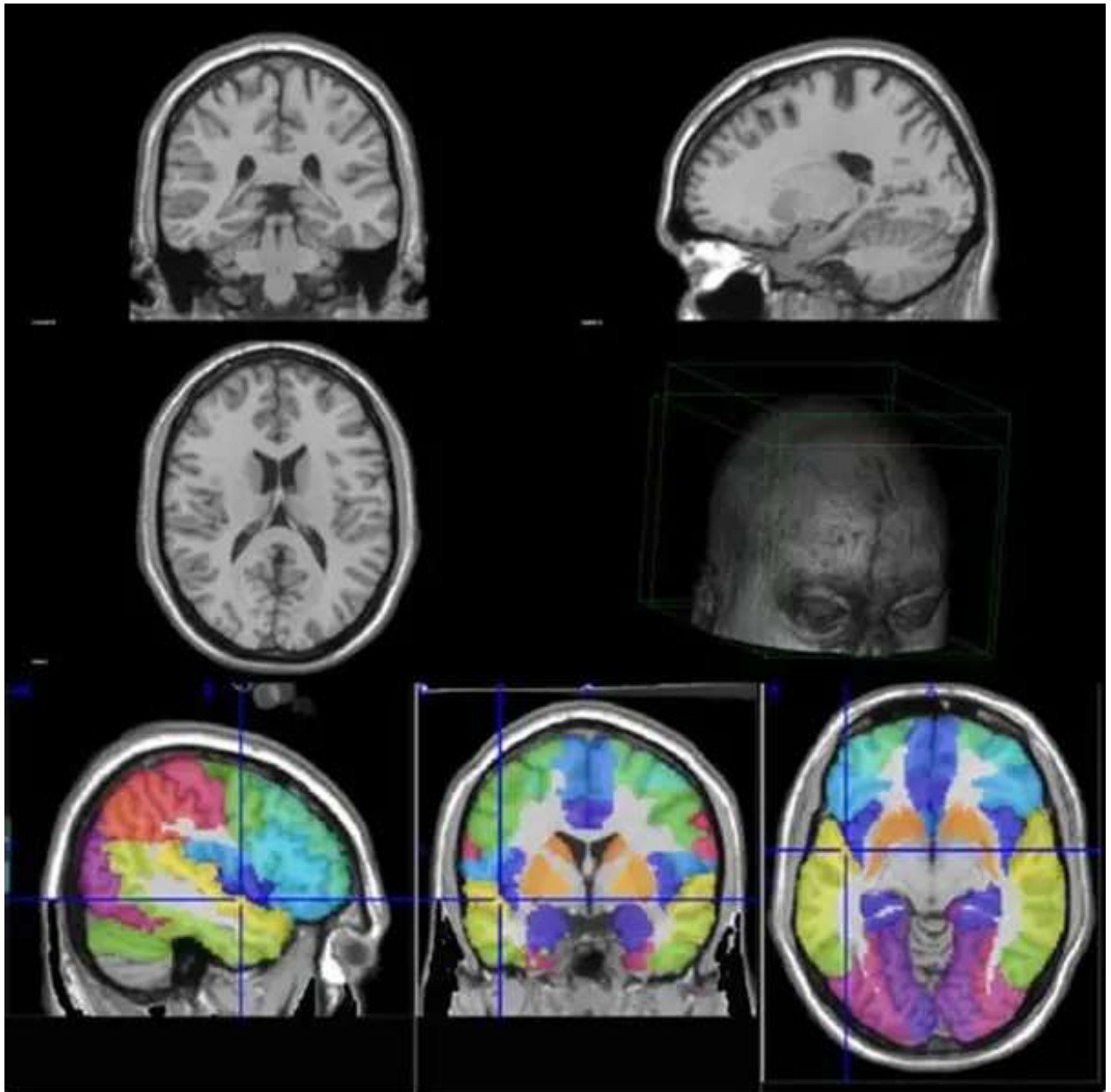
MRI Spectroscopy (MRS). Magnetic Resonance Spectroscopy (MRS) records biochemical changes in tissues across various diseases.

MRS spectra reflect the concentration of biologically active compounds in a specific tissue region.

Metabolic changes become detectable before the clinical manifestation of diseases. Therefore, diseases can be diagnosed early based on MRS results: MRS of internal organs (in vivo), MRS of biological fluids (in vitro).

MRI Spectroscopy

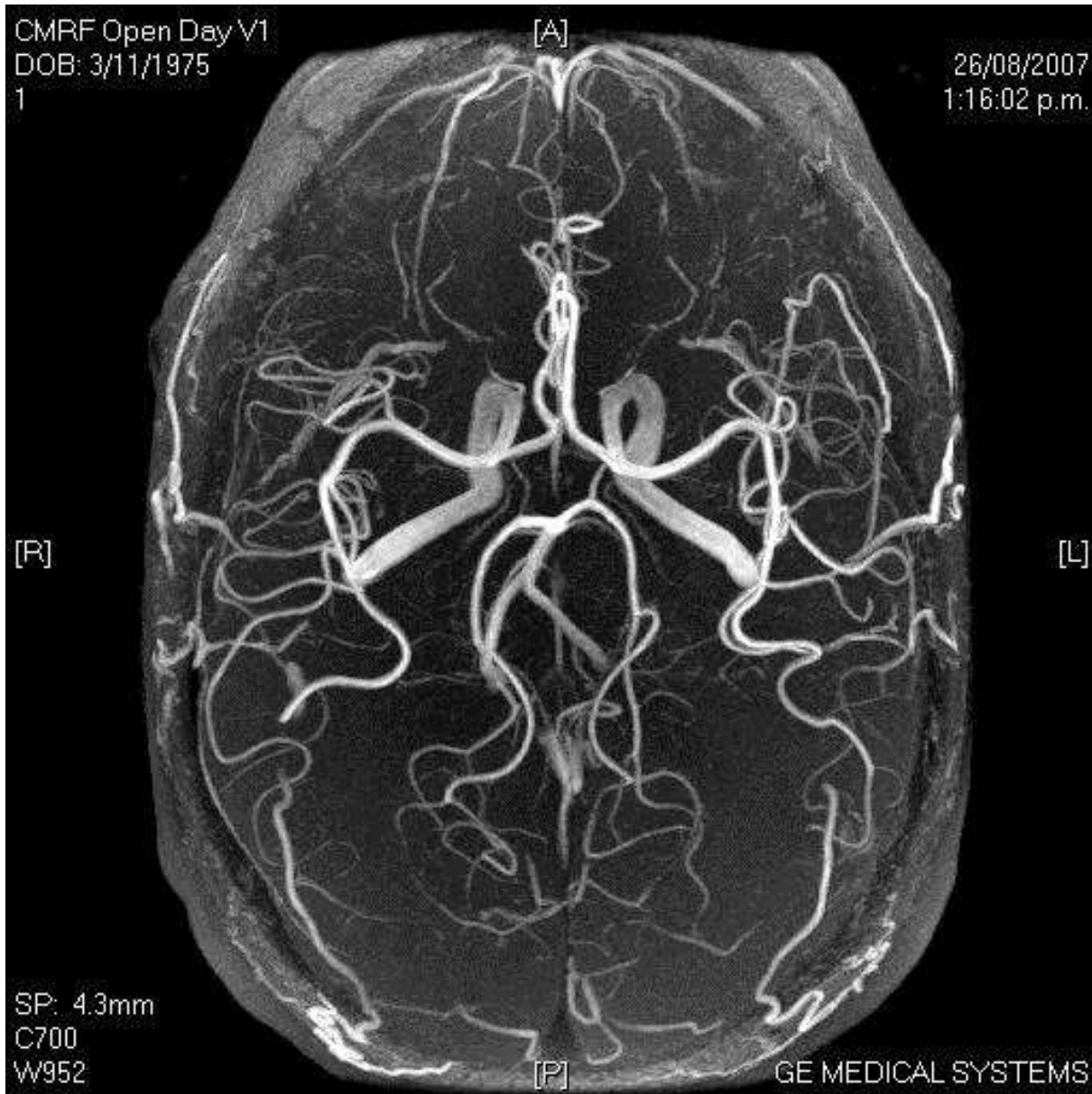




Brain MRI Spectroscopy

MR Angiography (MRA). Magnetic Resonance Angiography (MRA) is the assessment of vascular patency using an MRI system. This method helps evaluate both the anatomical and functional characteristics of blood flow.

Functional MRI (fMRI). Functional MRI (fMRI) is a method for examining the cerebral cortex that enables identification of the characteristics of various brain



regions responsible for movement, vision, memory, and other functions. The principle is that blood flow increases in specific brain areas when they are active. During fMRI, the patient is given specific tasks, and images obtained during their performance are overlaid on standard MRI images, compared, and necessary conclusions are drawn.

Brain MR Angiography.

Positron Emission Tomography (PET). PET (Positron Emission Tomography), also known as two-photon emission tomography, is a radionuclide tomographic method for examining internal human organs. This method is based on detecting pairs of gamma quanta generated during the annihilation of positrons with electrons.

Positrons are produced as a result of positron-beta decay of radionuclides contained in radiopharmaceuticals introduced into the patient's body before the examination.

Positron Emission Tomography is a developing diagnostic and research method of nuclear medicine. Using a detecting device (PET scanner), the distribution of positron-emitting radioisotopes in the body is monitored. Metabolism, substance transport, gene expression, and other processes are studied. Currently, the following positron-emitting elements of the periodic table are used in PET: carbon-11, nitrogen-13, oxygen-15, fluorine-18. Unlike CT and MRI, PET studies not the anatomical features of tissues and organs but their functional activity. This method is sometimes called "functional tomography." Any functional process occurring in the body can be studied using PET. In clinical practice, this method is most often used in oncology diagnostics. PET enables detection of even the smallest tumors and identification of their type. PET is also used in diagnosing cardiac diseases and brain conditions such as epilepsy, Alzheimer's disease, and cerebral ischemia. Radiolabeled glucose is most commonly used as a radiopharmaceutical. Tumor cells consume glucose much more actively than normal cells. PET results are obtained by tracking the distribution of labeled glucose throughout the body. Positron Emission Tomography alone cannot precisely localize the radiopharmaceutical, and therefore it is combined with computed tomography. CT shows the anatomical structure of the examined zone, while PET displays functional processes (e.g., tumor development). This examination is called PET-CT and is currently used for many patients. The method is only contraindicated during pregnancy and lactation, in certain types of diabetes, and in critically ill patients. The scanner is placed in a separate room and resembles CT and MRI scanners. Before the examination, a radiopharmaceutical (usually labeled glucose) is injected intravenously, and the patient rests quietly for 30–60 minutes while the compound distributes throughout the body. After the PET scan, it is necessary to drink plenty of fluids to excrete the labeled glucose.

Conclusion: Magnetic Resonance Imaging (MRI) is a widely used, highly accurate, and relatively safe diagnostic method in modern medicine. Based on the nuclear magnetic resonance phenomenon, it provides detailed images of internal organs and tissues. It is particularly important in identifying diseases of the brain, spinal cord, nervous system, muscles, and joints. The advantage of MRI is that it does not harm the body and helps detect diseases at an early stage. At the same time, its use is limited in certain circumstances. In modern medicine, CT, PET, and angiography are also used alongside MRI, and together they serve to establish accurate diagnoses. In general, MRI and other tomography methods occupy an

important place in the development of medicine, making a significant contribution to the effective treatment of patients and improving their quality of life.

Thus, experience and observations show that preparing lesson plans on course topics enables students to master the material more easily and efficiently. Similarly, other instructors teaching the same subject can also use these lesson plans, which saves valuable time for both students and teachers.

REFERENCES:

1. Action Strategy for the Five Priority Areas of Development of the Republic of Uzbekistan for 2017–2021 **“Scientific and Methodological Manual for the Year of Dialogue with the People and Human Interests.”** Tashkent: “Ma’naviyat,” 2017.
2. Republic of Uzbekistan **“Law on Education”**, Tashkent, September 23, 2020, No. ORQ-637.
3. M.I. Bazarboyev. **Medical and Biological Physics** Tashkent: Innovatsiya Ziyoy, 2024.
4. Akhmedov A.A., Karimov Sh.I. **Fundamentals of Medical Diagnostics.** Tashkent: O’qituvchi, 2018.
5. Rasulov H.R. **Radiology and Medical Imaging Methods.** Tashkent: Fan va Texnologiya, 2020.
6. Yusupov B.M. **Modern Medical Technologies.** Tashkent: Ibn Sino Publishing House, 2019.