

## Applications of Physics in Diagnostic Imaging

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**Abstract:** This article will explore the various ways in which physics is applied in diagnostic imaging, with a focus on X-ray, computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound. Diagnostic imaging has become a cornerstone of modern medicine, since the advent of radiography. Over the years, various diagnostic imaging techniques have been developed, each with its indications and contraindications. However, all diagnostic imaging techniques have one underlying commonality: they rely on the fundamental principles of physics. Consequentially, it becomes of further importance to know and understand the concepts of applied physics, to produce better healthcare professionals.

**Keywords:** Image Quality, X-rays, Magnetic resonance imaging, Computed tomography, Ultrasound, contrast sensitivity, Image noise.



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### Introduction

Physical techniques have always had a key role in medicine, and the second half of the 20th century in particular saw a revolution in medical diagnostic techniques with the development of key imaging instruments: x-ray imaging and emission tomography (nuclear imaging and PET), MRI, and ultrasound. Wilhelm Konrad Röntgen (1845–1923), a German physicist, discovered x-rays in 1895, a discovery for which he received the first Nobel prize for physics in 1901. Internal imaging of the human body has been possible only since this discovery. Thereafter, imaging science evolved in three overlapping stages.[1,2]

During the first stage, the aim was to develop imaging techniques to define the morphologic features and function of the internal organs. In addition to x-rays, additional “rays” for this purpose were discovered, including ultrasound and emissions from radionuclide tracers. Contrast agents were developed to reveal previously indiscernible structures. These techniques all contributed greatly to the visualization of disease processes, enhanced the precision of therapies, and improved understanding of pathophysiology. [3]

The second stage of the development of imaging was marked by the achievement of access to the vascular tree and by improved characterization of tissues. The interior of the heart and blood vessels could be delineated by contrast angiography. Other important new tools were computed tomography and magnetic resonance imaging, which permitted resolution of very small structures throughout the body. [1,3] In 1979, Sir Godfrey Hounsfield and Allan Cormack were awarded the Nobel prize for medicine or physiology for their work on computerized axial tomography. Better imaging permitted the development of new treatments for cancer and vascular and cardiac diseases, as well as more accurate determination of the stages of a variety of disease processes. In the third, current stage of

development, imaging methods are used to guide therapy directly — from long-term guidance of cancer therapy to immediate, on-line guidance of minimally invasive surgery.[4] As imaging expanded into all areas of medicine, the specialty of diagnostic radiology evolved and eventually became responsible for most advances in the field.

Today, radiologists are integrating the work of basic scientists from many areas for the advancement of imaging methods. They are collaborating with and becoming knowledgeable about the medical and surgical specialties they serve. The current advanced imaging techniques can be properly applied only when both the imaging science and the medical science are brought to bear on a problem.

These techniques use the full width of the electromagnetic spectrum, from gamma rays to radio waves, and sound. In most cases, the development of a medical imaging device was opportunistic; many scientists in physics laboratories were experimenting with simple x-ray images within the first year of the discovery of such rays, the development of the cyclotron and later nuclear reactors created the opportunity for nuclear medicine, and one of the co-inventors of MRI was initially attempting to develop an alternative to x-ray diffraction for the analysis of crystal structures. What all these techniques have in common is the brilliant insight of a few pioneering physical scientists and engineers who had the tenacity to develop their inventions, followed by a series of technical innovations that enabled the full diagnostic potential of these instruments to be grasped.

The main disadvantage for all x-ray and gamma ray imaging modalities is the risk of radiation exposure for patients. Ultrasound imaging is convenient because it does not expose patients or radiologists to radiation, but it has poor penetration through bone or air, which makes images difficult to interpret. MRI and CT images can capture anatomical changes in tissues, while PET images detects biochemical and physiological changes, which often occur before anatomical changes. [9,10] Disadvantageously, patients with ferromagnetic orthopedic implants, materials, and devices cannot undergo MRI procedures. MRIs also have relatively long scanning times which imposes limitations for patients in need of urgent care. The broader use of radiological image analysis increases the workload for radiologists, and therefore the development of intelligent computer-aided systems for automated image analysis that can achieve faster and more accurate results for large volumes of imaging data is essential.[4,5]

The visibility of specific anatomical features depends on the characteristics of the imaging system and the manner in which it is operated. Most medical imaging systems have a considerable number of variables that must be selected by the operator. They can be changeable system components, such as intensifying screens in radiography, transducers in sonography, or coils in magnetic resonance imaging (MRI). However, most variables are adjustable physical quantities associated with the imaging process, such as kilovoltage in radiography, gain in sonography, and echo time (TE) in MRI. The values selected will determine the quality of the image and the visibility of specific body features. The ability of an observer to detect signs of a pathologic process depends on a combination of three major factors: (1) image quality, (2) viewing conditions, and (3) observer performance characteristics.

In an image, contrast can be in the form of different shades of gray, light intensities, or colors. Contrast is the most fundamental characteristic of an image. An object within the body will be visible in an image only if it has sufficient physical contrast relative to surrounding tissue. Structures and objects in the body vary not only in physical contrast but also in size. Objects range from large organs and bones to small structural features such as trabecula patterns and small calcifications. It is the small anatomical features that add detail to a medical image. Each imaging method has a limit as to the smallest object that can be imaged and thus on visibility of detail. Visibility of detail is limited because all imaging methods introduce blurring into the process. The primary effect of image blur is to reduce the contrast and visibility of small objects or detail. The amount of blur in an image can be quantified in units of length.

Contrast sensitivity is a characteristic of the imaging method and the variables of the particular imaging system. It is the characteristic that relates to the system's ability to translate physical object contrast into image contrast.

Another characteristic of all medical images is image noise. Image noise, sometimes referred to as image mottle, gives an image a textured or grainy appearance. Noise can arise from a number of sources, including:

- ✓ Generation of the signal carriers,
- ✓ Propagation and transformation of these carriers through the imaging process, and
- ✓ Addition of Extraneous Noise from various sources such as the imaging electronics

**X-Ray:** X-ray imaging is based on the principles of attenuation, which is the reduction in the intensity of a beam of X-rays as it passes through a material, and absorption of some or all of the energy of a beam of X-rays as it interacts with the body. The visibility of both normal structures and diseases depends on this differential absorption. X-ray images are produced by passing a beam of X-rays through the body and detecting the number of X-rays that pass through the body and reach a detector on the other side. The production of X-Rays involves bombardment of the target substance with thick electrons.

Electrons undergo a complex series of collisions and scattering processes during the slowing down processes which results in the production (a) Bremsstrahlung and (b) Characteristic Radiation.

**Computed Tomography:**

CT is also based on the principle of attenuation. It differs from conventional radiography in that a more sensitive X-ray detection system is used. The images constitute sections (slices) through the body, which are then reconstructed by a computer to produce a three-dimensional image of the body. The range of densities recorded is increased approximately 10-fold. CT imaging is particularly useful for imaging complex structures such as the brain and chest. The different images are produced by various sources: (A) detectors with hundreds of detector elements along the detector arc (generally 800-900 detector elements), (B) by rotation of the x ray tube around the patient, taking about 1000 angular measurements (C) and by tens or even hundreds of detector rows aligned next to each other along the axis of rotation. [6,7,8]

The values that are assigned to the pixels in a CT image are associated with the average linear attenuation coefficient  $\mu$  ( $m^{-1}$ ) of the tissue represented within that pixel. The linear attenuation coefficient ( $\mu$ ) depends on the composition of the material, the density of the material, and the photon energy as seen in Beer's Law:

$$I(x) = I_0 e^{-\mu x}$$

Where  $I(x)$  is the intensity of attenuated X-Ray beam;  $I_0$  is the intensity of unattenuated X-Ray beam; and  $X$  is the thickness of the material.

**MRI:** The basic principle of nuclear magnetic resonance imaging depends on the fact that certain atomic nuclei align along the magnetic force when placed in a strong magnetic field. MRI images are produced by placing the patient in a strong magnetic field and then applying radio waves to the body. The radio waves cause the atomic nuclei to emit electromagnetic radiation, which is detected by a receiver and used to produce an image of the body. At the field strengths currently used in medical imaging, hydrogen nuclei in water molecules and lipids are responsible for producing anatomical images. If a radiofrequency pulse at the resonant frequency of hydrogen is applied, a proportion of protons change alignment, flipping through a preset angle, and rotate in phase with one another.

Following the pulse, the protons realign to their original positions, inducing a radio signal which despite being weak can be detected and localized by antenna coils placed around the patient. The strength of the signal depends not only on proton density but also on two relaxation times,  $T_1$  and  $T_2$ . A  $T_1$ -weighted image is the one in which the contrast between tissues is mainly due to their  $T_1$  relaxation properties, while  $T_2$  relaxation properties produce  $T_2$ -weighted image.  $T_1$  and  $T_2$ -weighting of an image can be selected by approximately altering the timing and sequence of radiofrequency pulses.

**Ultrasounds:** Ultrasound imaging is based on the principles of reflection and scattering of sound waves. Ultrasound images are produced by placing a small transducer in contact with the skin that emits high-frequency sound waves. As the sound waves travel through the body, it is reflected back by the tissue interfaces to produce echoes which are picked up by the same transducer and converted to an electrical signal. Ultrasound is often used to determine whether a structure is solid or cystic. At the energies and doses currently used in diagnostic ultrasound, no harmful effects on any tissues have been demonstrated.

### Methods and materials

This study is based on an online survey conducted through Google forms and circulated by communications apps(Telegram and WhatsApp). The survey was conducted anonymously, no participant was asked their contact information or any relevant details.

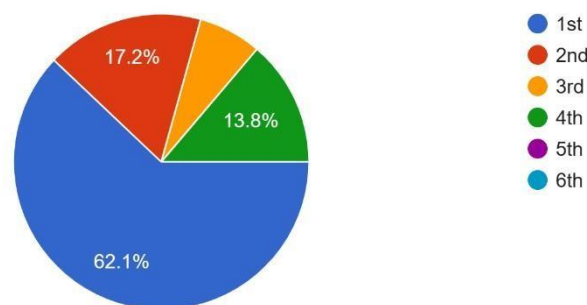
The target respondents of this study are the medical students studying in Tashkent Medical Academy, Uzbekistan; as having a basic understanding of the fundamental Physics involved in diagnostic imaging is crucial. Furthermore, comprehension of diagnostic imaging techniques will pave the way towards performing better in radiology for junior and senior medical students alike. Thus, having the scientific knowledge to bridge the gaps in understanding radiology and to become better diagnosticians is paramount.

### Results

The survey was conducted online through google forms and a total of 29 responses were recorded. Of those, students of first course (62%), second course(17.2%), third course(6.9%), and Fourth course(13.8%) participated.

What course are you in?

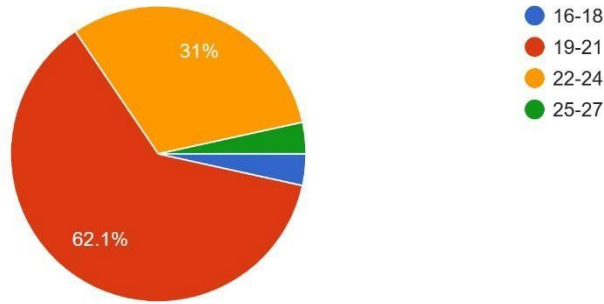
29 responses



Majority of the students were in the age group 19-24.

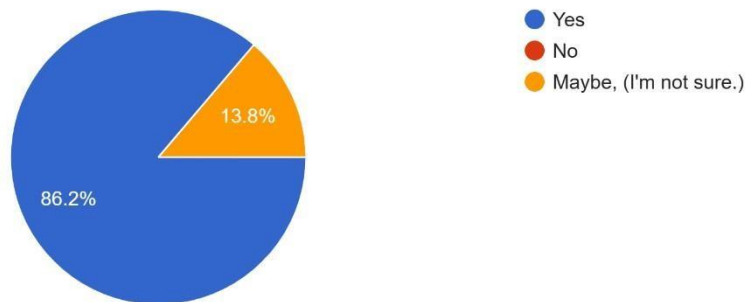
How old are you?

29 responses



Do you think a basic understanding of physics is important in understanding Diagnostic Imaging?

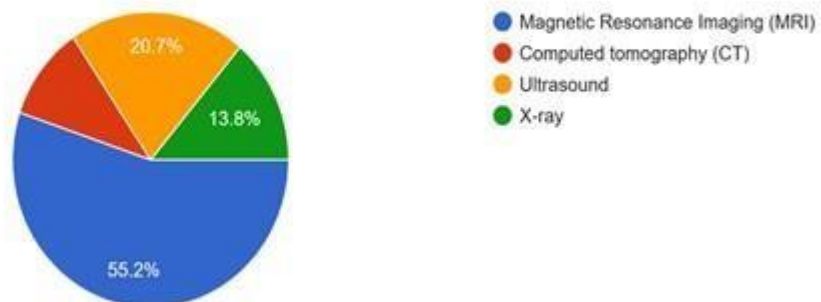
29 responses



Most of the participants(86.2%) agreed that physics is important in understanding Diagnostic imaging while few did not(13.8%).

Which of the following is the safest diagnostic imaging technique?

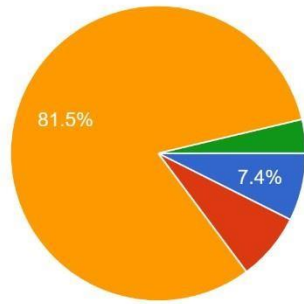
29 responses



More than half (55%)of the participants answered MRI while rest answered ultrasound(20.7%), X-Ray(13.8%) and computed tomography(10.3%), in that order.

What do you think are the adverse health effects of ionizing radiation used in X-rays, if any?

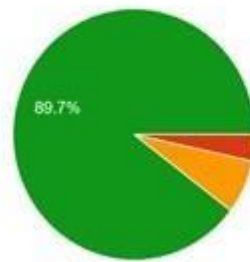
27 responses



- Deterministic (harmful tissue reactions)
- Stochastic effects, i.e., cancer/ mutation of somatic cells
- Both A and B
- I don't think there are any adverse effects.

What does Diagnostic technique does the image show?

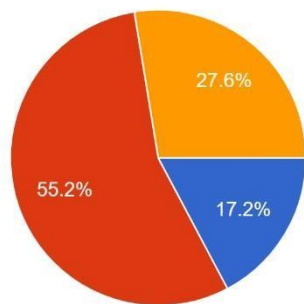
29 responses



- X-ray
- CT scan
- MRI
- Ultrasound

How is Computed Tomography different from X-ray scan?

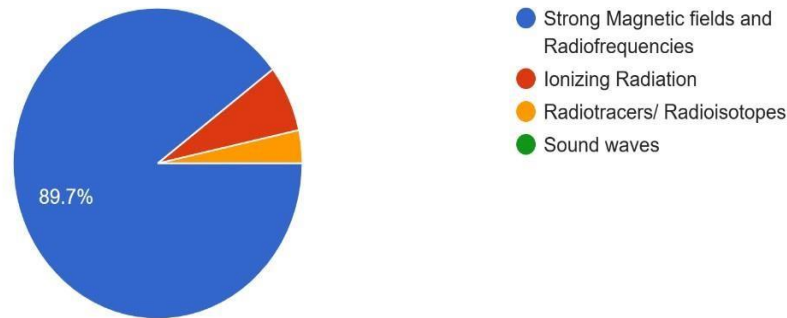
29 responses



- CT scan is not very different from X-Ray scan
- CT scan uses a rotating motorized X-ray scan unlike a fixed X-Ray tube
- CT uses non-ionizing radiation, unlike X-rays

What is the fundamental principle of physics behind Magnetic Resonance Imaging?

29 responses



### Discussion

While most participants were aware of the Working principle of MRI, most did not know the safest diagnostic technique. Majority of the students were able to identify correctly the Diagnostic Imaging technique by its image. Yet, only half of the participants seemed to know the basic knowledge of CT scan, and couldn't accurately differentiate it from X-ray scan. The results of this survey may not be accurate and the data pool is small, and limited to only one medical school.

### Conclusion

The main goal of this survey was to assess the knowledge of students in regards to applied physics in diagnostic radiology. Although, majority of the students were accurate in correctly parsing out the answers, there are still knowledge gaps that must be covered to produce better healthcare professionals.

### References

1. Diagnostic imaging, by Peter Armstrong, Martin Wastie, Andrea G. Rockall; <https://books.google.co.uz/books>
2. Diagnostic Imaging by Prof. Peter Morris and Prof. Alan Perkins DOI:[https://doi.org/10.1016/S0140-6736\(12\)60429-2](https://doi.org/10.1016/S0140-6736(12)60429-2); The lancet
3. Physical Principles of Medical Imaging Online, Resources for Learning and Teaching, Perry Sprawls, P.hd
4. Christensen's Physics Diagnostic Radiology [Humanhealth.iaea.org](http://Humanhealth.iaea.org);
5. Swensen SJ, Jett JR, Hartman TE, Midthun DE, Mandrekar SJ, Hillman SL, Sykes A.-m., Aughenbaugh GL, Bungum AO, and Allen KL, "Radiology CT screening for lung cancer : five-year prospective," *Cancer*, pp. 259–265, 2005. [PubMed] [Google Scholar]
6. Frush DP, Donnelly LF, and Rosen NS, "Computed tomography and radiation risks: what pediatric health care providers should know." *Pediatrics*, vol. 112, no. 4, pp. 951–957, 2003. [PubMed] [Google Scholar]
7. Sundaram M and Mcguire MH, "Computed tomography or magnetic resonance for evaluating the solitary tumor or tumor-like lesion of bone?" *Skeletal Radiology*, vol. 17, no. 6, pp. 393–401, 1988. [PubMed] [Google Scholar]
8. Sundaram M and Mcguire MH, "Computed tomography or magnetic resonance for evaluating the solitary tumor or tumor-like lesion of bone?" *Skeletal Radiology*, vol. 17, no. 6, pp. 393–401, 1988. [PubMed] [Google Scholar]

9. Wang Y, Zhang P, An L, Ma G, Kang J, Shi F, Wu X, Zhou J, Lalush DS, Lin W, and Shen D, "Predicting standard-dose PET image from low-dose PET and multimodal MR images using mapping-based sparse representation," *Physics in Medicine and Biology*, vol. 61, no. 2, p. 791, 2016. [PubMed] [Google Scholar]
10. Djanaev G. Y. et al. Effect on the Organism When Chronic Administration of a New Phytopreparation //Scholastic: Journal of Natural and Medical Education. – 2023. – Т. 2. – №. 4. – С. 188-195.
11. Djanaev G. Y., Askarov O. O., Sultanov S. A. Phytotherapy of Gastric Ulcer (Literature Review) //Texas Journal of Medical Science. – 2022. – Т. 15. – С. 51-59.
12. Djanaev G. Y. et al. PHARMACOTHERAPEUTIC EFFECTIVENESS OF HERBAL MEDICINE" YAZVANOL" IN THE EXPERIMENTAL INDOMETHACINE GASTROPATY MODEL //World Bulletin of Public Health. – 2023. – Т. 21. – С. 144-147.
13. Khakimov Z. Z., Djanaev G. Y., Askarov O. O. Study Of the Effect of a Mixture of Extracts of Medicinal Plants on the State of the Gastric Mucosa in Gastropathy Induced by Indomethacin //Eurasian Medical Research Periodical. – 2023. – Т. 19. – С. 90-95.
14. Jurakulovna, A. M., Allayarovich, S. S., & Zaynutdinovich, X. Z. (2022). Indometasin ta'sirida rivojlangan gastropatiyada ba'zi farmakologik vositalarni mye'da shilliq qavatida erkin radikalli jarayonlarga ta'siri
15. Djanaev, G. Y., Khakimov, Z. Z., Allaeva, M. J., Makhsumov Sh, M., Zaytseva, O. A., & Mamadjanova, M. A. Comparative Study of the Influence of Lesbochole, Misoprostol and Mucagen on the Gastric Mucous Barrier in Indometacin Gastropathy.
16. Ali SI, Gopalakrishnan B, Venkatesalu V. Pharmacognosy, Phytochemistry and Pharmacological Properties of *Achillea millefolium* L.: A Review. *Phyther Res*. 2017 Aug;31(8):1140-1161. doi: 10.1002/ptr.5840. Epub 2017 Jun 15. PMID: 28618131.
17. de Souza P, Crestani S, da Silva Rde C, Gasparotto F, Kassuya CA, da Silva-Santos JE, Gasparotto A Jr. Involvement of bradykinin and prostaglandins in the diuretic effects of *Achillea millefolium* L. (Asteraceae). *J Ethnopharmacol*. 2013 Aug 26;149(1):157-61. doi: 10.1016/j.jep.2013.06.015. Epub 2013 Jun 18. PMID: 23791807.
18. Vahid S, Dashti-Khavidaki S, Ahmadi F, Amini M, Salehi Surmaghi MH. Effect of herbal medicine *achillea millefolium* on plasma nitrite and nitrate levels in patients with chronic kidney disease: a preliminary study. *Iran J Kidney Dis*. 2012 Sep;6(5):350-4. PMID: 22976260.
19. Chen Y, Luo Z, Lin J, Qi B, Sun Y, Li F, Guo C, Lin W, Kang X, He X, Wang Q, Chen S, Chen J. Exploring the Potential Mechanisms of *Melilotus officinalis* (L.) Pall. in Chronic Muscle Repair Patterns Using Single Cell Receptor-Ligand Marker Analysis and Molecular Dynamics Simulations. *Dis Markers*. 2022 Jun 1;2022:9082576. doi: 10.1155/2022/9082576. PMID: 35692879; PMCID: PMC9177293.
20. Акрамова Я. З. и др. Эффективность глицерама в коррекции нарушений желчеобразовательной функции печени при остром токсическом гепатите //Sciences of Europe. – 2020. – №. 48-2 (48). – С. 36-38.
21. Хакимов З. З. и др. Влияние глицерама на желчеобразовательную функцию печени при остром токсическом гепатите. – 2020.
22. Джанаев Г. Ю. ФИТОДИАБЕТОЛ-СОВРЕМЕННЫЙ ГИПОГЛИКЕМИЧЕСКИЙ ФИТОПРЕПАРАТ. – 2020.
23. Джанаев Г. Ю. ИЗУЧЕНИЕ БЕЗВРЕДНОСТИ ПРЕПАРАТА ПАРАКАИН-С. – 2020.
24. Джанаев Г. Ю., Атабаева Г. ОЦЕНКА ФАРМАКОЛОГИЧЕСКОЙ АКТИВНОСТИ НОВОГО ФИТОПРЕПАРАТА ПРИ ГАСТРОПАТИИ //Материалы Международной научной

- конференции молодых ученых и студентов «Перспективы развития биологии, медицины и фармации», организованной Южно-Казахстанской медицинской академией и Фондом Назарбаева в режиме видеоконференцсвязи 10-11 декабря 2020 года, г. Шымкент, Республика Казахстан. – 2019. – Т. 12. – №. 2. – С. 56.
25. Djanayev G. Y. Dorivor o'simliklar quruq ekstraktining rezerpinli me'da yarasiga ta'siri : dis. – Tibbiyotdagi zamonaviy ilmiy tadqiqotlar, 2022.
26. ALLAeva M. J. i dr. INDOMETASIN TA'SIRIDA RIVOJLANGAN GASTROPATIYADA BA'ZI FARMAKOLOGIK VOSITALARNI ME'DA SHILLIQ QAVATIDA ERKIN RADIKALLI JARAYONLARGA TA'SIRI //jurnal biomeditsiny i praktiki. – 2022. – Т. 7. – №. 6.
27. Allaeva M. Z. et al. Influence of lesbochol dry extract on the current of experimental nervo-reflective gastric ultra //European Journal of Molecular and Clinical Medicine. – 2020. – Т. 7. – №. 3. – S. 2749-2753.
28. Hakimov Z., Djanaev G., Xolmatov J. PROKINETICHESKAYA AKTIVNOST NOVOGO FITOPREPARATA «LESBOXOL» //Eurasian Journal of Medical and Natural Sciences. – 2022. – Т. 2. – №. 13. – S. 205-209.
29. Djanayev G. et al. IMMOBILIZATSIYA STRESSI FONIDA OQ KALAMUSHLARDA ME'DA SHILLIQ QAVATINING SHIKASTLANISHIGA" LESBOXOL" O 'SIMLIK VOSITASINING TA'SIRI : dis. – TIBBIYOTNINGDOLZARBMU AMMOLARIGAINNOVATSION YONDASHUV 2 0 2 2, 2022.
30. Аллаева М. Ж., Джанаев Г. Ю., Ачилов Д. Д. АCHILLEA MILLEFOLIUM L. ЎСИМЛИГИ ҚУРУҚ ЭКСТРАКТИНИНГ ҚОН ИВИШ ЖАРАЁНИГА ТАЪСИРИНИ ЎРГАНИШ ИЗУЧЕНИЕ ВЛИЯНИЯ СУХОГО ЭКСТРАКТА АCHILLEA MILLEFOLIUM L. НА СВЕРТЫВАЮЩЕЕ СИСТЕМЫ КРОВИ Тошкент тиббиёт академияси //ЎЗБЕКИСТОН ФАРМАЦЕВТИК ХАБАРНОМАСИ. – С. 61.
31. Джанаев Г. Achillea millefolium L ўсимлиги курук экстрактининг қон ивиш жараёнига таъсирини ўрганиш. – 2018.
32. Худайбердиев, Х. И., Мустанов, Т. Б., Мамаджанова, М. А., & Джанаев, Г. Ю. ИССЛЕДОВАНИЕ ХОЛЕРЕТИЧЕСКОЙ АКТИВНОСТИ НИГЛИЗИНА.
33. Джанаев Г. Ю. Influence Of Lesbochol Dry Extract On The Current Of Experimental Nervo-Reflective Gastric Ultra. – 2020.
34. Джанаев, Гайрат Юсупович. "Уткир токсик гепатитда глицерамнинг сафро ва унинг таркибидаги модаларнинг экскрециясига таъсирини ўрганиш." (2020).
35. Djanaev, G. Y., Sh, M., Mamadzhanova, M. A., & Kholmatov, J. A. (2023). PHARMACOTHERAPEUTIC EFFECTIVENESS OF HERBAL MEDICINE" YAZVANOL" IN THE EXPERIMENTAL INDOMETHACINE GASTROPATY MODEL. *World Bulletin of Public Health*, 21, 144-147.
36. YU, D. G., & ALLAYEVA, M. (2022). ОЦЕНКА ЭФФЕКТИВНОСТИ НОВОГО ПРЕПАРАТА СЭЛР В ПРОФИЛАКТИКИ И ЛЕЧЕНИИ ГАСТРОПАТИЙ.
37. Юсупович, Джанаев Гайрат, Зиявиддин Зайниддинович Хакимов, and Хужамурат Исоқович Худайбердиев. "ИНДОМЕТАЦИН ТАЪСИРИДА РИВОЖЛАНГАН ГАСТРОПАТИЯДА ЛЕСБОХОЛ, МИЗОПРОСТОЛ ВА МУКАГЕННИНГ МЕЪДА ШИЛЛИК ҚАВАТИ ҚИМОЯ ТИЗИМИГА ТАЪСИРИНИ ҚИЁСИЙ ЎРГАНИШ." (2022).
38. Djanaev, G. Y., & Mamadjanova, M. A. (2023). Effect on the Organism When Chronic Administration of a New Phytopreparation. *Scholastic: Journal of Natural and Medical Education*, 2(4), 188-195.

39. Khakimov Z. Z., Djanaev G. Y., Askarov O. O. Study Of the Effect of a Mixture of Extracts of Medicinal Plants on the State of the Gastric Mucosa in Gastropathy Induced by Indomethacin //Eurasian Medical Research Periodical. – 2023. – Т. 19. – С. 90-95.
40. Djanaev G. Y. et al. Comparative Study of the Influence of Lesbochole, Misoprostol and Mucagen on the Gastric Mucous Barrier in Indometacin Gastropathy.
41. АЛЛАЕВА, М. Ж., ХАКИМОВ, З. З., Юсупович, Д. Ф., & СУЛТОНОВ, С. А. (2022). ИНДОМЕТАЦИН ТАЪСИРИДА РИВОЖЛАНГАН ГАСТРОПАТИЯДА БАЪЗИ ФАРМАКОЛОГИК ВОСИТАЛАРНИ МЕЪДА ШИЛЛИҚ ҚАВАТИДА ЭРКИН РАДИКАЛЛИ ЖАРАЁНЛАРГА ТАЪСИРИ. *журнал биомедицины и практики*, 7(6).
42. Аллаева М. Ж., Джанаев Г. Ю., Ачилов Д. Д. АСНILLEA MILLEFOLIUM L. ЎСИМЛИГИ ҚУРУҚ ЭКСТРАКТИНИНГ ҚОН ИВИШ ЖАРАЁНИГА ТАЪСИРИНИ ЎРГАНИШ ИЗУЧЕНИЕ ВЛИЯНИЯ СУХОГО ЭКСТРАКТА АСНILLEA MILLEFOLIUM L. НА СВЕРТЫВАЮЩЕЕ СИСТЕМЫ КРОВИ Тошкент тиббиёт академияси //ЎЗБЕКИСТОН ФАРМАЦЕВТИК ХАБАРНОМАСИ. – С. 61.
43. Джанаев Г. Achillea millefolium L ўсимлиги курук экстрактининг қон ивиш жараёнига таъсирини ўрганиш. – 2018.
44. Аллаева М. Ж. и др. ФАРМАКОЛОГИЧЕСКИЕ СВОЙСТВА СУХОГО ЭКСТРАКТА CONVULVULUS ARVENSIS L. CONVULVULUS ARVENSIS L. ҚУРУҚ ЭКСТРАКТИНИНГ ФАРМАКОЛОГИК ХУСУСИЯТЛАРИ Ташкентская медицинская академия //ЎЗБЕКИСТОН ФАРМАЦЕВТИК ХАБАРНОМАСИ. – С. 70.
45. Шадманов А. К. и др. МАРКЕРЫ НАРУШЕНИЙ ВАЗОМОТОРНОЙ ФУНКЦИИ ЭНДОТЕЛИЯ //Re-health journal. – 2021. – №. 2 (10). – С. 130-133.
46. Шадманов А. К. и др. РОЛЬ ДИСФУНКЦИИ ЭНДОТЕЛИЯ В ПАТОГЕНЕЗЕ ЗАБОЛЕВАНИЙ //Re-health journal. – 2021. – №. 2 (10). – С. 122-129.
47. Olimdjanovich A. O. et al. Studying the Sugar reducing Activity of the Preparation of Dry Extract of Chicory //Texas Journal of Multidisciplinary Studies. – 2023. – Т. 17. – С. 1-5.
48. Аллаева М. Ж., Аскарлов О. О., Кдырниязова С. А. The study of hypoglycemic effect of dry extract of chicory //Биология и интегративная медицина. – 2017. – №. 3. – С. 184-191.
49. Хакимов З., Джанаев Г., Холматов Ж. ПРОКИНЕТИЧЕСКАЯ АКТИВНОСТЬ НОВОГО ФИТОПРЕПАРАТА «ЛЕСБОХОЛ» //Eurasian Journal of Medical and Natural Sciences. – 2022. – Т. 2. – №. 13. – С. 205-209.
50. Pearce MS, Salotti JA, LitTle MP, McHugh K, Lee C, Kim KP, Howe NL, Ronckers CM, Rajaraman P, Craft AW, Parker L, and De González AB, “Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: A retrospective cohort study,” *The Lancet*, vol. 380, no. 9840, pp. 499–505, 2012. [PMC free article] [PubMed] [Google Scholar].