National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute"

Translational Medical Bioengineering

Biomaterials and Biocompatibility

Working program of basic discipline (Syllabus)

Requisites for basic discipline	
Level of higher education	***First (bachelor's)***
Field of knowledge	***16 Chemical and Bioengineering***
Specialty	***163 Biomedical Engineering***
Educational program	***Medical engineering***
Discipline status	***Normative discipline***
Form of study	***full-time / day / mixed / remote***
Year of training, semester	***2th course, spring semester***
Course volume	***4 ECTS credits / 120 hours***
Semester control / Control measures	***Test / modular test / essay***
Lessons schedule	***26 lecture hours and 28 hours of practical classes***
Language of instruction	***English, Ukrainian***
Information about course leader / teachers	***Lecturer:*** ***Associate Professor, Bespalova Olena*** *http://bi.fbmi.kpi.ua/uk/bespalovaua/*, *o.bespalova@kpi.ua* ***Practical:*** ***Associate Professor, Bespalova Olena*** *http://bi.fbmi.kpi.ua/uk/bespalovaua/*, *o.bespalova@kpi.ua*
Course placement	*https://do.ipo.kpi.ua*

Program educational disciplines

1. Description of the discipline, its purpose, subject of study and learning outcomes

What will be studied.

Current main directions of using biomaterials in medicine, classification and medical and technical requirements for materials that come into contact with the biological environment. The concepts of biocompatibility, bioinertness, bioactivity, as well as the study of mechanisms of processes occurring at the interface of a biomaterial with blood and tissues, and the physicochemical aspects of the initial stages of interaction of a foreign surface with protein and cellular components of a living organism, the development of calcification and biodegradation processes. Materials for medical equipment and instruments.

Why is this interesting/needs to be studied?

The academic discipline "Biomaterials and Biocompatibility" studies biocompatible materials that are in high demand today in general and cardiovascular surgery, orthopedics and dentistry, as well as in the manufacture of blood vessel prostheses, artificial heart valves, circulatory systems, new generation dosage forms, sorbents, etc. The development of new medical materials that must come into contact with the environment of a living organism is a particularly complex task. Interest in such biocompatible materials has especially increased with the emergence in recent years of a new direction in biomedical materials science - cell and tissue engineering, which is associated with reconstructive surgery and the development of

bioartificial organs. When creating medical devices, materials of both natural and artificial origin are used, belonging to classes well-known in materials science (metals, ceramics, polymers, carbon and their derivatives), as well as biotissues and hybrid materials, which are a combination of biomaterials with functional cells of tissues and other living organs.

What can be learned.

Knowledge:

- on the modern classification of materials according to their biological effect on a living organism, the main directions of use of biomaterials in medicine;
- on general medical and technical requirements for materials in contact with the biological environment, biological reactions of the body to implantable materials;
- on the international system of tests for assessing the biocompatibility of medical materials and products;
- on materials for medical equipment and instruments, tissue and cell engineering.

Ability to:

• determine the biological reaction of the organism to the implanted medical material;
• define the concepts of biocompatibility, bioinertness, bioactivity of medical materials;
• use physical, biophysical and physicochemical laws in experimental, theoretical and design activities;
• explain the interaction of bioceramics with bone tissue, osseointegration, calcification, biodegradation of biomaterials used for implants.

Вміння:

How to use the acquired knowledge and skills.

The acquired knowledge and skills are an important tool in conducting research and organizational and production work in the field of biomedical engineering.

Program competencies that must be formed after studying the discipline and that correspond to the educational program "Medical Engineering":

General competencies (EP put into effect by the Order of the Rector NON/434/2024 dated June 10, 2024)

GC – **02-** Knowledge and understanding of the subject area and understanding of professional activities
GC – **06-** Ability to search, process, and analyze information from various sources

Special (professional) competencies (EP put into effect by the Order of the Rector NON/434/2024 dated June 10, 2024):
P**C- 04-** Ability to ensure the technical and functional characteristics of systems and tools used in medicine and biology (for prevention, diagnosis, treatment, and rehabilitation)
P**C- 08-** Ability to conduct research and observation on the interaction of biological, natural, and artificial systems (prostheses, artificial organs, etc.)
P**C- 09-** Ability to identify, formulate, and solve engineering problems related to the interaction between living and non-living systems.

The program learning outcomes after studying the discipline " Biomaterials and Biocompatibility*" are (EP put into effect by the Order of the Rector NON/434/2024 dated June 10, 2024):*

PLO-09- Understand theoretical and practical approaches to the creation and application of artificial biological and biotechnical objects and materials for medical purposes

PLO-11- Conduct quality control and operational monitoring of medical equipment and materials for medical purposes, artificial organs, and prostheses
PLO-15- Select and recommend appropriate medical equipment and biomaterials for equipping medical institutions and ensuring the main stages of the technological process of diagnosis, prevention, and treatment
PLO-17- Application of knowledge in chemistry and bioengineering to create, synthesize, and apply artificial biotechnical and biological objects
PLO-21- Understanding and use of scientific and technical principles, methods, and research tools for the development, planning, and design of experimental and new researches in the field of biomedical engineering using
medical, biological, biomedical devices and biotechnical systems, medical biomaterials, as well as for quantitative assessment of the functioning of physiological systems

2. Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of education according to the relevant educational program)

The discipline "Biomaterials and Biocompatibility" is interdisciplinary in nature. According to the structural and logical scheme of the specialist training program, the discipline integrates, in accordance with its subject, knowledge from other academic disciplines: "Materials Science and Structural Materials"; "Biochemistry". The practical skills obtained and theoretical knowledge acquired during the study of the academic discipline "Biomaterials and Biocompatibility" can be used in the future when mastering the academic discipline: "Fundamentals of Standardization and Industrial Engineering"

3. Content of the academic discipline

Lecture topics*:*
1. Basic theoretical and practical information about medical materials for creation and use in artificial biological and biotechnical objects.
2. Classification of materials according to their biological effect on the living organism and quality control, operating conditions of medical materials.
3. Materials for biomedical equipment and instruments, operating conditions of medical equipment.
4. Bioceramics and its role in implantation, materials for artificial organs and prostheses.
5. Materials for implantation in orthopedics, dentistry and biomaterials for equipping medical institutions and ensuring the main stages of the technological process of diagnostics, prevention and treatment.
6. Composite materials for the creation, synthesis and application of artificial biotechnical and biological objects.
7. General characteristics of polymers, theoretical and practical approaches to the creation and application of artificial biological and biotechnical objects and materials for medical purposes.
8. The use of polymeric materials in reconstructive surgery, and quality control and operating conditions of medical materials, artificial organs and prostheses.
9. Polymeric materials for cardiovascular surgery and quantitative assessment of physiological system functioning.
10. Materials for artificial heart valves, operating conditions of medical equipment and materials for medical purposes, artificial organs and prostheses.
11. Suture materials, be able to select and recommend appropriate biomaterials for equipping medical institutions and ensuring the main stages of the technological process of treatment.

12. Polymers with targeted biological action for the creation, synthesis and application of artificial biotechnical and biological objects.
13. Materials for cell and tissue engineering, the use of scientific and technical methods and research methods in the field of biomedical engineering objects using medical, biological, biotechnical systems, biomaterials for medical purposes.

4. Training materials and resources

Basic literature:

1. Беспалова О.Я. Біоматеріли та біосумісність: Навчальний посібник для здобувачів ступеня бакалавра за освітньою програмою «Медична інженерія» «Регенеративна та біофармацевтична інженерія» спеціальність 163 «Біомедична інженерія» . О.Я. Беспалова. – Київ : КПІ ім. Ігоря Сікорського, 2021. – 97 с. https://ela.kpi.ua/handle/123456789/41413
2. Прикладна біохімія та біоматеріали. Частина 2. Біоматеріали та біосумісність. Практикум. Навчальний посібник для практичних робіт з кредитного модуля дисципліни «Прикладна біохімія та біоматеріали. Частина 2. Біоматеріали та біосумісність» для здобувачів ступеня бакалавра за освітньою програмою «Регенеративна та біофармацевтична інженерія» [Електронний ресурс]: навчальний посібник для студ. спеціальності 163 «Біомедична інженерія» / КПІ ім. Ігоря Сікорського: уклад. О.Я. Беспалова. - Електронні текстові дані (1 файл: 3,8 Мбайт). – Київ : КПІ ім. Ігоря Сікорського, 2022. – 45 с. https://ela.kpi.ua/handle/123456789/48536
3. Біоматеріали та покриття : навчальний посібник / Л. Ф. Суходуб. – Суми : Сумський державний університет, 2020. – 300 с. https://drive.google.com/file/d/1s8_5WjzJMxT6dQPlChwnFNXLpMKJRnXP/view?usp=sharing
4. Біомедичні матеріали: від історії до сьогодення : навчальний посібник / Х. В. Берладір, Т. П. Говорун, О. М. Олешко. – Суми : Сумський державний університет, 2022. – 223 с. https://drive.google.com/file/d/1OiPjb5CG8ehjfAPfmwjh8hP07XHfB6Ex/view?usp=sharing
5. Біоактивні матеріали для регенерації кісткової тканини : навч. посібник / О. В. Саввова, Г. К. Воронов, О. І. Фесенко, Ю. О. Смирнова ; Харків. нац. ун-т міськ. госп-ва ім. О. М. Бекетова. – Харків : ХНУМГ ім. О. М. Бекетова, 2021. – 142 с. https://drive.google.com/file/d/1MAE__uF1kV1i4FJiJpB7q8i6HA4DrZV/view?usp=sharing

Additional literature:

1. Панченко С.П. Проектування матеріалів медичного призначення. Конспект лекцій для здобувачів ступеня бакалавра спеціальності 132 Матеріалознавство / С.П. Панченко; Нац. техн. ун-т «Дніпровська політехніка». – Д. : НТУ «ДП», 2022. – 73 с. https://drive.google.com/file/d/1GkdNBT5mVSXkKljCd68N7TidpUh6ud7o/view?usp=sharing
2. Boutrand, J.-P. (2012) Biocompatibility and performance of medical devices, Woodhead Publishing Limited eBooks. https://doi.org/10.1533/9780857096456.
3. María Rosa Aguilar, Julio San Román. Smart Polymers and their Applications' (2019) in Elsevier eBooks. https://doi.org/10.1016/c2017-0-00049-6.
4. Ebara, M. et al. (2014) Smart Biomaterials, NIMS monographs. https://doi.org/10.1007/978-4-431-54400-5.
5. Handbook of Harnessing Biomaterials in Nanomedicine (2021). https://doi.org/10.1201/9781003125259.

Educational content

5. Methods of mastering the discipline (educational component)

№ s/n	Lecture topics	Program learning outcomes	Main tasks	
			Control measure	Term implementation
1.	Basic theoretical and practical information about medical materials for creation and use in artificial biological and biotechnical objects.	PLO *9*	Practical work *1*	*1*-- nd week
2.	Classification of materials according to their biological effect on the living organism and quality control, operating conditions of medical materials.	PLO *11*	Practical work *2*	*2*-- nd week
3.	Materials for biomedical equipment and instruments, operating conditions of medical equipment.	PLO *11*	Practical work *3*,	*3*-- nd week
4.	Bioceramics and its role in implantation, materials for artificial organs and prostheses.	PLO *11*	Practical work *4*	*4* - nd week
5.	Materials for implantation in orthopedics, dentistry and biomaterials for equipping medical institutions and ensuring the main stages of the technological process of diagnostics, prevention and treatment.	PLO *15*	Practical work *5*	*5*- nd week
6.	Composite materials for the creation, synthesis and application of artificial biotechnical and biological objects.	PLO *17*	Practical work *6*	*6*- nd week
7.	General characteristics of polymers, theoretical and practical approaches to the creation and application of artificial biological and biotechnical objects and materials for medical purposes.	PLO *09*	Practical work 7	*7*- nd week
8.	The use of polymeric materials in reconstructive surgery, and quality control and operating conditions of medical materials, artificial organs and prostheses.	PLO *11*	Practical work *8*	*8*-- nd week
9.	Polymeric materials for cardiovascular surgery and quantitative assessment of physiological system functioning.	PLO *21*	Practical work *9*	*9*- nd week
10.	Materials for artificial heart valves, operating conditions of medical equipment and materials for medical purposes, artificial organs and prostheses.	PLO *11*	Practical work *10*	*10*- nd week
11.	. Suture materials, be able to select and recommend appropriate biomaterials for equipping medical institutions and ensuring the main stages of the technological process of treatment.	PLO *15*	Practical work *11*	*11*- nd week
12.	Polymers with targeted biological action for the creation, synthesis and application of artificial biotechnical and biological objects	PLO *17*	Practical work *12*	*12*- nd week
13	Materials for cell and tissue engineering, the use of scientific and technical methods and research methods in the field of biomedical engineering objects using medical, biological, biotechnical systems, biomaterials for medical purposes.	PLO *21*	Practical work *13*	*13*- nd week
14	Modular test work		Practical work	*14* -nd

№ s/n	Lecture topics	Program learning outcomes	Main tasks	
			Control measure	Term implementation
			14	week
	Credit work			

Topics of practical classes*:*

Practical work 1. Biomedical materials.

Get acquainted with medical materials

Practical work 2. Biological reactions of the body to implantable materials. *Biological properties of biocompatible biomaterials. Requirements for biomaterials in terms of their effect on a living organism*.

Practical work 3. Biological reactions to implantable materials.

Getting acquainted with the basic properties of biomaterials, defining the concept of biocompatibility.

Practical work 4. Biocompatibility of metals and their alloys.

Features of the use of metals and their alloys in the medical industry. Biocompatibility of metals and their alloys used as implants in traumatology

Practical work 5. Interaction of bioceramics with bone tissue.

Bioceramic materials for restoring lost functions of individual organs. Ceramics based on aluminum and zirconium oxides. General properties of biological and synthetic materials for implantation. Osseointegration, calcification of biomaterials.

Practical work 6. Adhesion and adhesive properties of materials.

Main types of adhesion. Determination of the interaction of polymers with blood components. Mechanisms of formation of adhesive compounds. Conditions for the formation and nature of destruction of adhesive compounds.

Practical work 7. Biodegradation of biomaterials used for implants. *Biodegradation rate of biomaterial. Biodegradation products.*

Practical work 8. Assessment of biological safety of medical devices.

Basic methods of assessing the biological safety of medical devices.

Practical work 9. Study of biocompatibility of components of medical devices (materials).

Basic methods of studying the biocompatibility of medical materials.

Practical work 10. Biomaterials for cardiac surgery.

Materials for artificial heart valves. Main types of biomaterials for artificial heart valves and their biocompatibility.

Practical work 11. Basic methods of assessing the hemocompatibility of polymeric materials that involve contact with blood.

General medical and technical requirements for materials that come into contact with the biological environment. Obtaining antithrombogenic polymeric materials. Classification of antithrombogenic materials.

Practical work 12. Biocompatibility of dialysis membranes.
Requirements for biomaterials used for the manufacture of membranes. Hemodialysis membranes.
Practical work 13. Biomaterials for cell and tissue engineering.
Biocompatible properties of materials for cell and tissue engineering. Properties of matrices
Practical work 14. Modular test work

6. CIndependent work student

The total amount of independent work within the discipline is 66 hours, including:
• preparation for practical classes – 35 hours;
• preparation for modular test (MCT) – 4 hours;
• independent study of topics – 15 hours.
• preparation of abstract work – 6 hours
• preparation for the test 6 hours

An individual assignment in the form of an essay is planned for the discipline "Biomaterials and Biocompatibility". The main goal of the essay is to deepen and expand students' theoretical knowledge on individual topics of the academic discipline, to gain experience in independent work with educational and scientific literature. The essay is completed in accordance with the requirements, within the time specified by the teacher. Approximate topics of essays - Appendix 1

Policy and control

7. Policy educational disciplines (educational component)

Violation of task deadlines and incentive points
Applicants may be awarded incentive points. The total amount of incentive points cannot exceed 5 points.
Incentive points are awarded for the following activities:

- participation in international or all-Ukrainian scientific conferences, congresses, etc. (on the subject of the academic discipline) (subject to publication of abstracts) (5 points;

Attending classes

No penalty points are awarded for absence from classes. However, applicants are encouraged to attend classes, as they teach theoretical material and develop practical skills necessary for the thorough formation of relevant competencies.

The assessment system is focused on receiving points for student activity, as well as completing tasks that can develop practical skills and abilities.

Missed assessment controls

Assessment tests scheduled to be administered during class are conducted on a pre-determined day, which is announced to students during the first week of the educational process. Conducting such assessment tests on another day is permitted in cases of serious and/or force majeure circumstances.

A practical assignment submitted for verification after the deadline, but before the deadline for issuing the current certification (or test/exam), is evaluated with penalty points.

Missing express control (tests) are not processed.

The result of the module test for an applicant who did not appear for the test is zero. In this case, the applicant has the opportunity to complete the module test at another time in agreement with the teacher.

Ensuring objectivity in assessing applicants

The objectivity of assessing applicants at all stages of mastering the discipline is ensured through the following mechanisms. First, the use of test forms for assessing knowledge. Second, detailed recommendations on the rating system for assessing learning outcomes (Section 8 of the Syllabus). Third, the use by applicants and teachers of all possible communication tools that ensure the preservation of communication history (e-mail, social networks, messengers, etc.). Fourthly, in case of disagreement with the assessment results, another teacher with appropriate professional competence and appointed by the department for the current academic year may be involved in checking the written works of applicants. In the absence of a coordinated opinion of the teachers regarding the assessment of the applicant's work, the issue is brought to a meeting of the department, and the issue is resolved in accordance with the "Regulations on Appeals at Igor Sikorsky Kyiv Polytechnic Institute" http://osvita.kpi.ua/node/182.

Procedure for appealing the results of assessment control measures

After receiving comments from the teacher with arguments regarding the assessment, the applicant has the right to individually ask all questions of interest regarding the results of the assessment control measures. If the applicant disagrees with the assessment, he must also provide arguments for his position and contact the dean of the faculty for further resolution of the issue (for details, see "Regulations on Appeals at Igor Sikorsky Kyiv Polytechnic Institute" http://osvita.kpi.ua/node/182).

Academic integrity

When using copyrighted content, analytical research results, and/or other information, applicants must cite the source. The policy and principles of academic integrity are defined in Section 3 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" (https://kpi.ua/code). In the event of a need to check academic texts prepared for applicants for the presence of text borrowings, the applicant may contact the teacher or the responsible person of the department for checking academic texts.

Norms of ethical behavior

The norms of ethical behavior of applicants and employees are defined in Section 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" (https://kpi.ua/code).

Distance learning

Distance learning takes place through the Sikorsky Distance Learning Platform.

Online courses are provided in case of force majeure circumstances (in particular, quarantine measures) and for inclusive education of applicants with special needs.

Inclusive learning

The academic discipline is designed for students with special educational needs, but it should be taken into account that it places a heavy load on the visual apparatus. Depending on the special needs of students, distance learning may be used.

8. Types control and rating system evaluation results teaching (ERT)

Current control

Work in practical classes involves:

• express control in the form of completing a test task containing 10 questions with 0.5 points for each correct answer, equal to 5 points. There are 4 tests x 5 points = 20 points

- practical task weighted score – 4. The maximum number of points for 13 practical classes is 4 points x 13 practical = 52 points

The modular test (MCT) is conducted in the form of a test, which is evaluated at 20 points.
The abstract work is evaluated at 8 points.

Essay evaluation criteria

«Excellent", all work requirements met	7-8 points
«Good", all work requirements are met, or there are minor errors	4-6 points
«Satisfactory", there are shortcomings in fulfilling the work requirements and certain errors.	3-1 points
«Unsatisfactory", the work was not submitted or does not meet the requirements for "Satisfactory"	0 points

Calendar control: is carried out twice a semester as a monitoring of the current status of implementation of the syllabus requirements. The first calendar control involves the completion of practical work No. 1-4, test No. 1, the second calendar control involves the completion of practical work No. 5-11, test tasks No. 2-3, and abstract work

Maximum semester rating of the applicant: 100 points

The sum of the weighted points of the control measures during the semester is:

$$R_C = 52+20+20+8= 100 \text{ points}$$

Semester control: credit.

The conditions for admission to the credit are the acceptance of the abstract work; the defense of all practical works, writing an MCR of at least 15 points, as well as a starting rating (rC) of at least 40% of the RC, i.e. 40 points.

In the case of a semester rating of 60 points and above, the applicant can receive a credit automatically. In case of disagreement or a rating of less than 60 points, students perform a credit test.

A credit is a type of semester control in which a student's mastery of the educational material is assessed based on the results of the current control. To receive a credit automatically, you must have a rating of at least 60 points.

Students who have a rating of less than 60 points at the end of the semester, as well as those who wish to increase their rating score, take a semester test in the form of a credit test at the last scheduled lesson.

After completing the credit test, if the score for the credit test is higher than the rating, the applicant receives a score based on the results of the credit test.

If the score for the credit test is lower than the rating, a “hard” RSO is applied – the applicant’s previous rating is canceled and he receives a score taking into account the results of the credit test. This option forms a responsible attitude of the applicant to making a decision

about taking the credit test, forces him to critically assess the level of his preparation and carefully prepare for the test.

The final test is conducted in the form of a test, is evaluated at 100 points and consists of 50 test questions, 2 points for each correct answer, for a total of 100 points.

Table of correspondence of rating scores to university scale grades:

Number of points	Rating
100-95	*Perfect*
94-85	*Very good*
84-75	*Good*
74-65	*Satisfactorily*
64-60	*Enough*
<60	*Unsatisfactorily*
Admission conditions are not met	*Not allowed*

9. Additional information with disciplines (educational component)

- The approximate topics of the abstracts are given in **Appendix 1.**
- A list of questions for preparing for the module test, as well as for preparing for the exam, is provided in **Appendix 2**.

  The questions submitted for semester control correspond to the topics of lectures and practical classes. Recognition of learning outcomes acquired in non-formal/informal education is carried out in accordance with the "Temporary Regulation on the Procedure for Recognition of Learning Outcomes Acquired by Students of Igor Sikorsky Kyiv Polytechnic Institute in Non-formal/Informal Education" (https://osvita.kpi.ua/node/119).
- Program learning outcomes (extended form) for the discipline " Biomaterials and Biocompatibility" are given in **Appendix 3**.

Working program educational disciplines (syllabus):

Compiled Candidate of Biological Sciences, Bespalova O. Ya.

Approved by the Department of Translational Medical Bioengineering (protocol No. 14 from 06.06.2024)

Approved by methodical by the commission faculty BME (protocol No. 9 from 26.06.2024)

Appendix 1 to the syllabus discipline
«Biomaterials and Biocompatibility»

Approximate topic of the essay:

1.Materials for tissue engineering.
2. Materials for medical equipment.
3. Materials for medical instruments, basic requirements for them.
4. Stainless steel, its purpose in medicine.
5. Use of bioceramics in medicine.
6. Bioinertness and biocompatibility of ceramic materials with the human body.
7. Bioceramic materials for restoring lost functions of individual organs.
8. Materials for implantation in orthopedics.
9. Use of composite biomaterials for tissue engineering.
10. Creation of artificial composites.
11. Medical polymers.
12. General methods of polymer modification to improve compatibility with the body and increase their functionality.
13. Copolymerization, graft copolymerization, immobilization. Physical methods of modification.
14. Polymers of auxiliary pharmacological purpose.
15. Polymer coatings, ways of their production. Disintegration of polymer material inside a living organism.
16. System of prolonged drug administration. Microencapsulation.
17. Artificial organs and materials for their construction.
18. Use of bioplastic materials for reconstruction of soft and bone tissue defects.
19. Main groups of polymers of pharmacological importance.

Appendix 2 to the syllabus discipline
«Biomaterials and Biocompatibility»

List of questions submitted for semester control.
Question I from section 1 "Fundamentals and applied aspects of biomaterials science

Topic 1.1. Basic information about medical materials.
1. Define the concept of biomaterials. Explain the subject and tasks of biomaterials science.
2. Determine the main directions of using biomaterials in medicine.

3. State the requirements for biomaterials in terms of their effect on a living organism.
4. Analyze the biological compatibility of medical materials.
5. Characterize the biological reaction of the organism to the medical material implanted in it.
6. Explain the biodegradation changes of medical material in a living organism.
7. Outline the general medical and technical requirements for materials that come into contact with the biological environment.
8. Describe materials for biomedical equipment and instruments
9. Describe metallic materials. Determine the physical and mechanical properties of metals and their alloys.
10. Describe stainless steel and its purpose in medicine.
11. Describe alloys and explain their use in dentistry and orthopedics.
12. Describe the corrosion of metals under the influence of the biological environment. Protection of metals from biodamage.
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Question II from Section 1 "Fundamentals and Applied Aspects of Biomaterials Science"

Topic 1.2. Use of Biomaterials in Medicine.

1. Analyze the bioinertness and biocompatibility of ceramic materials with the human body and reduce their effect on the immune system.
2. Give a classification of bioactive ceramic materials.
3. Identify the types of ceramics most common in medicine and their areas of application.
4. Explain how bioceramic materials are used to restore lost functions of individual organs.
5. Characterize ceramics based on aluminum and zirconium oxides.
6. Describe materials for implantation in orthopedics and dentistry.
7. Describe dental products based on metals.
8. Describe ceramic dental materials
9. List the types of composite materials.
10. Analyze the mechanical structure of composite materials.
11. Explain the use of composite biomaterials for tissue engineering.
12. Describe the creation of artificial composite materials.
13. Describe bioceramics based on calcium orthophosphate, its properties and uses.

Appendix 3 to the syllabus discipline
«Biomaterials and Biocompatibility»

Program learning outcomes (extended form)

As a result of studying the academic discipline " Biomaterials and Biocompatibility ", students will be able to

Learning outcomes		Relevance of learning outcomes to competencies in the educational and professional program [1]	
		General Competence (soft skills)	**Special competence (professional)**
PLO 09	Understand theoretical and practical approaches to the creation and application of artificial biological and biotechnical objects and materials for medical purposes	GC 02 - Knowledge and understanding of the subject area and understanding of professional activities	PC 04- Ability to ensure the technical and functional characteristics of systems and tools used in medicine and biology (for prevention, diagnosis, treatment, and rehabilitation)
PLO 11	Conduct quality control and operational monitoring of medical equipment and materials for medical purposes, artificial organs, and prostheses	GC 06- Ability to search, process, and analyze information from various sources	PC 08- Ability to conduct research and observation on the interaction of biological, natural, and artificial systems (prostheses, artificial organs, etc.)
PLO 15	Select and recommend appropriate medical equipment and biomaterials for equipping medical institutions and ensuring the main stages of the technological process of diagnosis, prevention, and treatment	GC 06- Ability to search, process, and analyze information from various sources	PC 04- Ability to ensure the technical and functional characteristics of systems and tools used in medicine and biology (for prevention, diagnosis, treatment, and rehabilitation)
PLO 17	Application of knowledge in chemistry and bioengineering to create, synthesize, and apply artificial biotechnical and biological objects	GC 02 - Knowledge and understanding of the subject area and understanding of professional activities	PC 08- Ability to conduct research and observation on the interaction of biological, natural, and artificial systems (prostheses, artificial organs, etc.)
PLO 21	Understanding and use of scientific and technical principles, methods, and research tools for the development, planning, and design of experimental and new researches in the field of biomedical engineering using medical, biological, biomedical devices and biotechnical systems, medical biomaterials, as well as for quantitative assessment of the functioning of physiological systems	GC 06- Ability to search, process, and analyze information from various sources	PC 09- Ability to identify, formulate, and solve engineering problems related to the interaction between living and non-living systems

[1] Order of the Ministry of Education and Science of Ukraine No. 1204 dated November 19, 2018 “On approval of the standard of higher education in the specialty 163 Biomedical Engineering” for the first bachelor's level of higher education».