DOI 10.11603/m.2414-5998.2024.2.14821
УДК 378.147:378.016:576:61

**A. I. Dovgalyuk**
ORCID https://orcid.org/0000-0003-3976-0245
**Z. M. Nebesna**
ORCID https://orcid.org/0000-0002-6869-0859
**O. S. Redko**
ORCID https://orcid.org/0000-0002-9860-9003

*I. Horbachevsky Ternopil National Medical University*

# EDUCATING FUTURE HEALTHCARE PROFESSIONALS: TEACHING THE ELECTIVE COURSE "CELL TECHNOLOGIES IN MEDICINE"

**А. І. Довгалюк, З. М. Небесна, О. С. Редько**

*Тернопільський національний медичний університет імені І. Я. Горбачевського МОЗ України*

# НАВЧАННЯ МАЙБУТНІХ ПРОФЕСІОНАЛІВ ОХОРОНИ ЗДОРОВ'Я: ВИКЛАДАННЯ ВИБІРКОВОГО КУРСУ «КЛІТИННІ ТЕХНОЛОГІЇ В МЕДИЦИНІ»

**Abstract.** Significant progress in biomedical science over the past decades has led to the rapid development of regenerative medicine. Skillful use of the therapeutic potential of stem cells creates opportunities for treating a range of previously untreatable diseases. Today, the number of regenerative medicine centers is constantly increasing worldwide. Regenerative medicine is rightfully considered the medicine of the future. To provide students with the opportunity to master advanced scientific knowledge in this field, the elective course "Cell Technologies in Medicine" was developed at I. Horbachevsky Ternopil National Medical University. This article is dedicated to analyzing the content of this course and the experience of teaching it to the students of Training Program "General Medicine", specialty 222 "Medicine". The aforementioned elective course includes 20 hours of training sessions and 70 hours of independent student work. It consists of 10 comprehensive topics covering various aspects of cell technologies, gene therapy, transplantation, bioengineering, and their applications in medicine. Based on a retrospective analysis of elective course data, it is evident that this subject has experienced a significant rise in popularity among students, as indicated by the steady annual increase in the number of students choosing to study "Cell Technologies in Medicine". This trend underscores the growing recognition of the course relevance and attractiveness, highlighting its effectiveness in imparting valuable scientific knowledge and practical skills to future medical professionals. The course curriculum is built on a competency-based approach to education and aims to engage students in innovative activities and develop their critical thinking skills through a combination of training sessions and the use of online resources. Feedback from students has been predominantly positive, attesting to the elective course ability to provide comprehensive insights into advanced cell technologies and their application in modern clinical practice. In the future, our research efforts will focus on exploring opportunities for collaboration and knowledge exchange with other universities, both national and international, to further enhance medical education in the field of regenerative medicine. The current possibility for students to create their individual educational trajectories through the elective component paves the way for forming a new generation of qualified and highly knowledgeable medical professionals.

**Key words:** cell technologies; medicine education; elective course; teaching.

**Анотація.** Значний прогрес біомедичної науки за останні десятиліття зумовив стрімкий розвиток регенеративної медицини. Вміле використання терапевтичного потенціалу стовбурових клітин створює можливості для лікування низки невиліковних раніше захворювань. Нині у світі постійно зростає кількість центрів регенеративної медицини, яка по праву вважається медициною майбутнього. Щоб надати здобувачам вищої медичної освіти шанс оволодіти передовими науковими знаннями в даній галузі, у Тернопільському національному медичному університеті імені І. Я. Горбачевського МОЗ України розроблено вибіркову дисципліну «Клітинні технології в медицині». Дану статтю присвячено аналізу змісту цієї дисципліни та досвіду викладання предмета для студентів, що навчаються за освітньою програмою «Лікувальна справа» спеціальності 222 «Медицина». Вищезгадана вибіркова навчальна дисципліна містить 20 год аудиторних практичних занять та 70 год самостійної роботи студентів і складається з 10 комплексних тем, які охоплюють різні аспекти клітинних технологій, генотерапії, трансплантології, біоінженерії та їхнього застосування в медицині. На основі ретроспективного аналізу даних про вибіркові дисципліни очевидно, що даний предмет пережив помітний підйом популярності серед здобувачів вищої освіти, про що свідчить стабільне щорічне зростання кількості бажаючих вивчати «Клітинні технології в медицині». Ця тенденція підкреслює зростаюче визнання актуальності та привабливості дисципліни, які є показниками його ефективності у передачі цінних наукових знань та практичних навичок майбутнім медичним фахівцям. Програма дисципліни побудована на компетентнісному підході до навчання і спрямована на залучення студентів до інноваційної діяльності та розвитку у них критичного мислення за допомогою поєднання практичних

занять і використання онлайн-ресурсів. Зворотний зв'язок від здобувачів вищої освіти був переважно позитивним і слугував свідченням здатності вибіркового предмета надавати ґрунтовні уявлення про передові клітинні технології та їхнє застосування в сучасній клінічній практиці. У майбутньому наші дослідницькі зусилля будуть спрямовані на пошук можливостей для співпраці та обміну знаннями з іншими університетами, як національними, так і міжнародними, для подальшого вдосконалення медичної освіти в галузі регенеративної медицини. Нинішня можливість здобувачів вищої медичної освіти створювати собі індивідуальну освітню траєкторію за рахунок інваріантної складової відкриває шлях до формування нового покоління кваліфікованих та високообізнаних медичних фахівців.

**Ключові слова:** клітинні технології; медична освіта; вибіркова дисципліна; викладання.

**Introduction.** In the rapidly evolving landscape of modern medicine, the integration of cutting-edge technologies has become paramount in addressing complex healthcare challenges. Among these advancements, cell technologies stand out as a pivotal field with immense potential to revolutionize diagnostics, therapeutics, and regenerative medicine [1, 3]. With its ability to harness the power of cells for disease modeling, drug discovery, and tissue engineering, cell technologies offer promising avenues for improving patient outcomes and advancing medical practice [2, 4, 5].

Recognizing the significance of staying abreast of such innovations, educational institutions worldwide are redefining their curricula to equip aspiring healthcare professionals with the requisite knowledge and skills. In Ukraine, our education system has embraced this paradigm shift by affording students the opportunity to tailor their learning experience through elective disciplines. This approach empowers students to delve deeper into areas of interest, thereby fostering a more personalized and enriching educational journey.

In response to the growing demand for specialized training in emerging biomedical fields, our university has introduced an elective discipline titled "Cell Technologies in Medicine". Specifically designed for third-year students, this course aims to provide comprehensive insights into the principles, methodologies, and applications of cell technologies within a medical context. By offering this elective, we aim to cater to the diverse interests and career aspirations of our students while ensuring they acquire essential competencies aligned with the evolving healthcare landscape.

**The aim.** In this article, we delve into the rationale behind the establishment of the elective discipline "Cell Technologies in Medicine", highlighting its importance in modern healthcare education and the role it plays in empowering students to shape their academic journey according to their interests and professional goals. Through this exploration, we aim to underscore the significance of incorporating innovative disciplines into medical education and showcase the value of providing students with opportunities for specialized learning in emerging biomedical fields.

**Theoretical framework.** The syllabus of the course "Cell Technologies in Medicine" is drawn up for Ukrainian students studying at I. Horbachevsky Ternopil National Medical University, Training Program "General Medicine", the second (Master's) degree of higher education, branch of knowledge 22 "Health care", specialty 222 "Medicine". The objective of studying the discipline is to formulate comprehensive knowledge and understanding of the conceptual foundations of regenerative medicine, gain insight into modern biotechnological developments, comprehend the legislative regulations governing the application of cell technologies in medicine.

The course "Cell Technologies in Medicine" ensures the acquisition of the following competences and program learning outcomes by students:

1. General competences: ability for abstract thinking, analysis and synthesis, ability to learn and acquire modern knowledge, ability to search, process and analyze information from various sources.

2. Professional competences: ability to determine the required list of laboratory and instrumental studies and evaluate their results, ability to assess the impact of the environment, socio-economic and biological factors on the health of an individual, family, population.

3. Program learning outcomes: to understand and know the basic biomedical and clinical sciences at the level sufficient to solve professional problems in the field of health care, to possess specialized conceptual knowledge, which is the basis for research, implementation of innovative methods of diagnosis and treatment in the field of health care; to critically comprehend problems in the field of medicine and related interdisciplinary problems.

The course "Cell Technologies in Medicine" is based on basic knowledge of disciplines such as "Histology, cytology and embryology", "Medical Biology", "Biological and Bioorganic Chemistry", "Molecular Biology with medical genetics", "Physiology with Bioethics", and "Microbiology, Virology and Immunology". It provides relevant knowledge, competences and program learning outcomes for further mastering such specialized clinical disciplines as obstetrics and gynaecology, surgery and immunology.

As a result of studying the course "Cell Technologies in Medicine" the student must know types and mechanisms of body structure regeneration, identification and classification of stem cells, sources and methods of obtaining and storing stem cells, methods of cell phenotyping, equipment and principles of cell laboratory operation, principles of biological sample cryopreservation, methods of cell genetic modification, basics of cell transplantation, principles of cell and tissue engineering. The student must be able to classify the body's stem cells, adhere to the principles of sterility in the cell culture laboratory, use a laminar box, $CO_2$ incubator, autoclave and inverted microscope, use a haemocytometer to count the number of cells in the suspension, determine the cell type by molecular markers (CD molecules), choose correct methods for cell phenotyping, apply the acquired knowledge to analyse the cause-and-effect reactions of the organism during cell transplantation, independently conduct selection and analysis of modern medical and biological scientific information.

The course "Cell Technologies in Medicine" includes 10 topics. The course consists of 20 hours of training sessions and 70 hours of independent student work. The course teacher utilizes problem-based questions on specific topics, illustrations, photographs of equipment, excerpts from educational videos, and online tours of university cell culture and PCR laboratories. Table 1 presents the structure of the elective educational discipline.

To prepare for classes, students use the Moodle platform, where educational materials are available in electronic format. The course syllabus and academic programs, materials for training sessions, as well as methodical guidelines and a list of recommended literature, are freely accessible to students.

The knowledge of the learned material is assessed not only through oral questioning during classes but also through online testing using the Moodle Learning Management System. Grades for training sessions are recorded in the electronic grade book of the TNMU automation management system. Consultations for students and retakes of the missed classes are conducted within the allotted time slots, according to the schedule of faculty rotations. Upon successful completion of the course, students receive credit.

The elective course "Cell Technologies in Medicine" was first introduced during the academic year 2020–2021. In its inaugural year, 20 students opted for the course, constituting 6.2 % of the total student population for that academic year. The subsequent academic years witnessed a steady increase in student enrollment. In the academic year 2021–2022, the number of students choosing the course rose to 26, representing 8.2 % of the student body. By the academic year 2022–2023, 18 students enrolled in the course, comprising 9.0 % of the total student cohort. Remarkably, during the academic year 2023–2024, student enrollment experienced a significant surge, with 47 students selecting the course, accounting for 19.6 % of the student population. Projections for the upcoming academic year 2024–2025 indicate a substantial rise in enrollment, with 91 students having

**Table 1.** Structure of the course "Cell Technologies in Medicine"

| Topics | Training sessions | Students' independent work |
|---|---|---|
| 1. Introduction to regenerative medicine. The concept of regeneration. Types and methods of regeneration | 2.0 | 9.0 |
| 2. Phases of regeneration. Regulation of regeneration | 2.0 | 5.0 |
| 3. Stem cells. Stem cells classification | 2.0 | 8.0 |
| 4. Histo- and organogenesis. Mechanisms of histogenesis. Stem cell differentiation. Apoptosis | 2.0 | 5.0 |
| 5. Cell laboratory | 2.0 | 8.0 |
| 6. Cultivation of cells. Cryopreservation of biological samples | 2.0 | 10.0 |
| 7. Cellular and nuclear reprogramming. Methods of genetic modification of cells | 2.0 | 8.0 |
| 8. Molecular genetic laboratory. Methods of cell phenotyping | 2.0 | 5.0 |
| 9. Cell transplantation. Molecular bases of humoral and cellular immunity. Molecules of the major histocompatibility complex (MHC). Rejection | 2.0 | 4.0 |
| 10. Therapeutic cloning. Artificial organs. Cellular and tissue engineering | 2.0 | 8.0 |
| TOTAL | 20 | 70 |

opted for the course, constituting 25.6 % of the total student body (table 2).

The consistent upward trend in student enrollment over the years reflects a growing interest and popularity of the elective course "Cell Technologies in Medicine" among students. This increasing trend suggests that the course is perceived as valuable and engaging by the student community. Such a trend underscores the relevance and significance of the course content in meeting the educational needs and interests of the students. Furthermore, the expanding enrollment highlights the effectiveness of the course curriculum in providing relevant knowledge and skills in the field of cell technologies, indicating their growing importance in contemporary medical education.

Since its inception in 2020, the elective course "Cell Technologies in Medicine" has garnered considerable acclaim from students, who have consistently provided positive feedback regarding its engaging and informative content. Participants have expressed appreciation for the course's comprehensive coverage of cuttingedge scientific concepts and its relevance to contemporary medical practice. Many students have highlighted the course's ability to provide valuable insights into the latest advancements in cell technologies and their applications in practical medicine. Moreover, numerous testimonials underscore the course's capacity to foster a deeper understanding of complex biological processes and equip students with essential skills for future research endeavors. The overwhelmingly positive reception from students underscores the course's effectiveness in delivering enriching educational experiences and underscores its significance in shaping the next generation of medical professionals.

**Conclusions and Prospects for Research.** The elective course "Cell Technologies in Medicine" has emerged as a pivotal component of our educational curriculum, offering students a dynamic platform to explore the intersection of cell biology and medical practice. The course's growing popularity, as evidenced by the increasing enrollment rates over the years, underscores its relevance and appeal among students seeking to deepen their understanding of advanced medical concepts.

**Table 2.** Enrollment Trends in the Elective Course "Cell Technologies in Medicine" Over Academic Years

| Academic Year | Number of Students Enrolled | Percentage of Total Students, % |
|---|---|---|
| 2020–2021 | 20 | 6.2 |
| 2021–2022 | 26 | 8.2 |
| 2022–2023 | 18 | 9.0 |
| 2023–2024 | 47 | 19.6 |
| 2024-2025* | 91 (projected) | 25.6 (projected) |

Note. * – projected data for 2024–2025 academic year.

Moving forward, there are several promising avenues for future research and development in this field. One key area of focus involves conducting comparative analyses to evaluate the efficacy of teaching "Cell Technologies in Medicine" across different academic institutions, both within Ukraine and internationally. By examining pedagogical approaches, curriculum structures, and student outcomes, such research endeavors aim to identify best practices and enhance the quality of education in this rapidly evolving discipline.

In conclusion, the ongoing evolution and refinement of the elective course "Cell Technologies in Medicine" reflect our commitment to delivering high-quality education and fostering a culture of scientific inquiry and innovation. As we look ahead, we remain dedicated to advancing the frontiers of knowledge in this field and empowering future generations of medical professionals.

**List of literature**

1. Ntege E. H. Advances in regenerative therapy: A review of the literature and future directions / E. H. Ntege, H. Sunami, Y. Shimizu // Regenerative Therapy. – 2020. – Vol. 14. – P. 136–153. DOI 10.1016/j.reth.2020.01.004.

2. Regenerative medicine applications: An overview of clinical trials / A. Petrosyan, P. N. Martins, K. Solez [et al.] // Frontiers in Bioengineering and Biotechnology. – 2022. – Vol. 10. DOI 10.3389/fbioe.2022.942750.

3. Regenerative medicine, organ bioengineering and transplantation / L. Edgar, T. Pu, B. Porter [et al.] // British Journal of Surgery. – 2020. – Vol. 107, no. 7. – P. 793–800. DOI 10.1002/bjs.11686.

4. Role of Human Mesenchymal Stem Cells in Regenerative Therapy / J. Vasanthan, N. Gurusamy, S. Rajasingh [et al.] // Cells. – 2020. – Vol. 10, no. 1. – P. 54. DOI 10.3390/cells10010054.

5. The Future of Regenerative Medicine: Cell Therapy Using Pluripotent Stem Cells and Acellular Therapies Based on Extracellular Vesicles / M. Jarrige, E. Frank, E. Herardot [et al.] // Cells. – 2021. – Vol. 10, no. 2. – P. 240. DOI 10.3390/cells10020240.

**References**

1. Ntege, E.H., Sunami, H., & Shimizu, Y. (2020). Advances in regenerative therapy: A review of the literature and future directions. *Regenerative Therapy*, 14, 136-153. DOI: 10.1016/j.reth.2020.01.004.

2. Petrosyan, A., Martins, P.N., Solez, K., Uygun, B.E., Gorantla, V.S., & Orlando, G. (2022). Regenerative medicine applications: An overview of clinical trials. *Frontiers in Bioengineering and Biotechnology*, 10. DOI 10.3389/fbioe.2022.942750.

3. Edgar, L., Pu, T., Porter, B., Aziz, J.M., La Pointe, C., Asthana, A., & Orlando, G. (2020). Regenerative medicine, organ bioengineering and transplantation. *The British Journal of Surgery*, 107(7), 793-800. DOI 10.1002/bjs.11686.

4. Vasanthan, J., Gurusamy, N., Rajasingh, S., Sigamani, V., Kirankumar, S., Thomas, E.L., & Rajasingh, J. (2020). Role of human mesenchymal stem cells in regenerative therapy. *Cells*, 10(1), 54. DOI 10.3390/cells10010054.

5. Jarrige, M., Frank, E., Herardot, E., Martineau, S., Darle, A., Benabides, M., … Ben M'Barek, K. (2021). The future of regenerative medicine: cell therapy using pluripotent stem cells and acellular therapies based on extracellular vesicles. *Cells*, 10(2). DOI 10.3390/cells10020240.

Received 21.05.2024.
Recommended 30.05.2024.

E-mail address for correspondence: dovgalyuk@tdmu.edu.ua