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INTERNATIONAL LEGAL REGULATION OF SCIENTIFIC ACTIVITY: CURRENT CHALLENGES AND RESEARCH APPROACHES

The article examines contemporary approaches to the international legal regulation of scientific activity in the context of globalisation, digital transformation, and technological development. It is established that scientific research has become an important factor influencing international relations, economic development, human rights protection, and global security, which requires effective international legal mechanisms for regulating cooperation between states, scientific institutions, and international organisations. International legal regulation performs not only a coordinating role but also ensures the protection of academic freedom, ethical standards, and the balance between scientific progress and public interests.

The study demonstrates that the regulation of scientific activity is based on a combination of treaty norms, soft law instruments, ethical principles, and institutional recommendations developed by organisations such as UNESCO, the United Nations, the Council of Europe, and the European Union. Yet the absence of unified international standards leads to inconsistencies in the implementation of legal norms at the national level.

Special attention is given to challenges affecting academic freedom, including political pressure, armed conflicts, information manipulation, and restrictions on international scientific cooperation. The article also analyses the influence of artificial intelligence, biotechnology, and digital technologies on the transformation of international legal approaches to scientific regulation. It is emphasised that technological progress calls for the development of updated legal standards on liability, data protection, transparency, and ethical governance in scientific research.

The research concludes that strengthening scientific integrity, harmonising international legal standards, and improving institutional cooperation are essential for building an effective and adaptive international framework capable of responding to contemporary global challenges in the field of scientific activity.

Keywords: *international legal approaches to the regulation of scientific activity, adaptation in the field of scientific research, European regulatory frameworks for scientific activity, case law of the European Court of Human Rights concerning freedom of scientific activity, practice of the Court of Justice of the European Union, international legal instruments in the field of scientific activity, international scientific cooperation.*

Карвацька Світлана. Міжнародно-правове регулювання наукової діяльності: сучасні виклики та наукові підходи.

У статті розглядаються сучасні підходи до міжнародно-правового регулювання наукової діяльності в контексті глобалізації, цифрової трансформації та технологічного розвитку. Встановлено, що наукові дослідження стали важливим чинником, який впливає на міжнародні відносини, економічний розвиток, захист

прав людини та глобальну безпеку, що вимагає ефективних міжнародно-правових механізмів регулювання співпраці між державами, науковими установами та міжнародними організаціями. Міжнародно-правове регулювання виконує не лише координаційну роль, а й забезпечує захист академічної свободи, дотримання етичних стандартів та баланс між науковим прогресом і суспільними інтересами.

Дослідження демонструє, що регулювання наукової діяльності ґрунтується на поєднанні договірних норм, інструментів м'якого права, етичних принципів та інституційних рекомендацій, розроблених такими організаціями, як ЮНЕСКО, Організація Об'єднаних Націй, Рада Європи та Європейський Союз. Водночас відсутність єдиних міжнародних стандартів створює суперечності у застосуванні правових норм на національному рівні.

Особлива увага приділяється проблемам, що впливають на академічну свободу, зокрема політичному тиску, збройним конфліктам, маніпулюванню інформацією та обмеженням міжнародного наукового співробітництва. У статті також аналізується вплив штучного інтелекту, біотехнологій та цифрових технологій на трансформацію міжнародно-правових підходів до регулювання наукової діяльності. Підкреслюється, що технологічний прогрес вимагає розробки оновлених правових стандартів щодо відповідальності, захисту даних, прозорості та етичного управління в наукових дослідженнях.

У дослідженні зроблено висновок, що зміцнення наукової доброчесності, гармонізація міжнародно-правових стандартів та покращення інституційної співпраці є необхідними для формування ефективної та адаптивної міжнародної системи, здатної реагувати на сучасні глобальні виклики у сфері наукової діяльності.

Ключові слова: *міжнародно-правові підходи до регулювання наукової діяльності, адаптація у сфері наукових досліджень, європейські рамки регулювання наукової діяльності, практика Європейського суду з прав людини у сфері свободи наукової діяльності, практика Суду Європейського Союзу, міжнародно-правові акти у сфері наукової діяльності, міжнародне наукове співробітництво.*

Introduction. The contemporary development of science is characterised by rapid internationalisation, digitalisation, and interdisciplinarity, which significantly increases the role of international legal regulation of scientific activity. Scientific research increasingly transcends national jurisdictions through global research networks, joint projects, and cross-border data exchange, creating the need for coherent international legal standards that can balance scientific freedom, human rights protection, and state interests. However, the existing system of international legal regulation of science remains fragmented and uneven, encompassing universal international treaties, soft law instruments, regional regulatory frameworks, and judicial practice, particularly that of the European Court of Human Rights. The absence of a comprehensive and unified regulatory approach complicates the effective governance of academic freedom, research ethics, access to scientific results, and liability for violations of established standards.

A number of significant aspects of international legal cooperation at both the universal and regional levels — particularly the definition of science and the understanding of scientific activity, research, and inquiry — remain unresolved and still lack a modern, systematic framework capable of fully reflecting the phenomenon of science within contemporary international law. However, any study of the substance and specific features of the international legal regulation of research and scientific cooperation is impossible without first defining the concept of science itself, along with the related notions of scientific collaboration and cooperation. Moreover, there is still a lack of comprehensive studies in

legal theory and international law that would systematically map out this doctrinal field and develop a generally accepted glossary applicable to practical legal research and regulation [3].

Additional challenges arise from the rapid development of emerging technologies, particularly artificial intelligence, biotechnology, and big data processing, which generate new legal risks and regulatory conflicts. This reinforces the need to rethink approaches to international legal scientific research in light of the principles of open science, digital security, and ethical responsibility. In this context, it is essential to identify effective research approaches that can provide a systematic analysis of existing legal norms and put forward proposals for their improvement in response to contemporary global challenges.

The aim of the article is to provide a comprehensive examination of the international legal framework governing scientific activity within the context of contemporary global and technological transformations, and to explore the substance and specific features of the international legal instruments that establish standards for academic freedom, scientific creativity, international research cooperation, and research ethics. The article focuses specifically on the current challenges arising from the digitalisation of science, the rapid development of artificial intelligence, the protection of intellectual property rights, the safeguarding of academic integrity, and the need to protect human rights and security interests in scientific research, especially in contexts shaped by armed conflict and global instability. The article also seeks to systematise modern international legal and doctrinal approaches aimed at addressing these challenges, to assess the effectiveness of existing mechanisms of international scientific cooperation, and to identify possible directions for improving the international legal regulation of scientific and research activities in light of emerging trends in international law and the evolving global scientific landscape.

Given the subject matter under consideration, achieving the objectives of this study required a combination of research methods. In particular, the research draws on formal-legal, systemic, and structural methods, together with programmatic, hermeneutic, comparative, and prognostic approaches. These methods made it possible to examine the international legal regulation of scientific research comprehensively, identify contemporary challenges in this area, assess existing doctrinal and normative approaches, and outline possible directions for the further development of international legal standards governing scientific and research cooperation.

Literature Review. Issues relating to the international legal regulation of research have attracted considerable attention from both Ukrainian and foreign scholars; however, a comprehensive assessment of current challenges in this field is still insufficiently developed. Certain aspects of academic freedom, international scientific cooperation, research ethics, academic integrity, and the protection of intellectual property rights have been examined in legal scholarship devoted to international law, human rights law, and educational law, as well as in documents adopted by UNESCO, the Council of Europe, the European Union, and other international institutions. Meanwhile, the rapid advancement of digital technologies, the growing use of artificial intelligence in research processes, increasing security concerns associated with armed conflicts, and the transformation of the global scientific environment create the need for a reassessment of existing international legal approaches and the development of new regulatory mechanisms. Despite the substantial body of academic literature devoted to related issues, the question of ensuring an effective and coherent international legal framework for research under contemporary conditions remains open to further scholarly discussion and in-depth analysis.

In Ukrainian legal scholarship, the works of K. V. Bortniak, S. B. Karvatska, and Ya. O.

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Tytska address various dimensions of the international legal regulation of research. Their studies address issues related to academic freedom, the protection of human rights within education and research, the expansion of international scientific cooperation, and the influence of digital transformation on contemporary legal frameworks. These scholars also explore issues of academic integrity, international standards governing access to scientific knowledge, and the legal implications of applying digital technologies and artificial intelligence in research activities. Particular emphasis is placed on the protection of scientific independence in the context of global change and armed conflicts, as well as on the contribution of international organisations and judicial institutions to the development of modern legal standards in the fields of science and education.

In foreign scholarship, work on this issue has focused primarily on the protection of freedom of scientific research as a fundamental right, particularly in the writings of Kriszta Kovács. Considerable academic attention has also been paid to maintaining a balance between scientific and technological innovation and precautionary regulatory mechanisms within the European Union, as reflected in the studies of Kathleen Garnett, G. Van Calster, and Leonie Reins. In addition, an important contribution to the analysis of how EU legislation responds to and regulates transformative scientific and technological developments has been made by Aurélie Mahalatchimy, Pin Lean Lau, Phoebe Li, and M. L. Flear, whose research explores the legal dimensions of emerging scientific innovations and the challenges they pose for contemporary international and European legal systems.

Results and Discussion. Freedom of scientific research is recognised in international law as an essential element of democratic governance, closely linked to freedom of expression and the right to participate in cultural and intellectual life. One of the principal legal foundations is the International Covenant on Economic, Social and Cultural Rights (1966) [18], which guarantees access to the benefits of scientific progress and protects the autonomy necessary for research activities. At the regional level, the European Convention on Human Rights (1950) [12] does not expressly regulate academic freedom; however, the European Court of Human Rights has interpreted Article 10 on freedom of expression as encompassing scientific communication and academic debate. In addition, international regulation in this field is significantly influenced by soft-law instruments, particularly the UNESCO Recommendation on Science and Scientific Researchers (2017) [27], which sets out principles concerning research ethics, academic independence, and the obligations of states to foster favourable conditions for scientific development. Consequently, the international legal framework governing science combines binding treaty norms with non-binding standards that collectively shape the contemporary system of protection for scientific freedom.

The challenges facing the international legal regulation of scientific activity are becoming increasingly complex as a result of rapid technological transformation, the expansion of artificial intelligence, and the global exchange of research data. Digitalised research opens up new opportunities for innovation and open access to knowledge; however, it also raises concerns about personal data protection, intellectual property rights, cybersecurity, and the misuse of dual-use technologies for military or destructive purposes. Nevertheless, political interference in academic processes and restrictions on research freedom continue to threaten the independence of scientific institutions and researchers in various parts of the world.

The system of international legal regulation aimed at preventing discrimination in the field of education is based on a set of universal and regional instruments. Among the key acts in this area are the Universal Declaration of Human Rights [28], the Convention against

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Discrimination in Education [11], the Islamic Declaration of Human Rights [29], the Convention on the Rights of the Child (1989) [14], the International Convention on the Elimination of All Forms of Racial Discrimination [17], the Convention on Technical and Vocational Education (1990) [13], the Dakar Framework for Action adopted at the World Education Forum (2000) [24], as well as the Sustainable Development Goals 2030 [25].

Yet despite the existence of an extensive international normative framework, significant challenges and unresolved issues continue to hinder effective efforts to eliminate discrimination in scientific and educational activities. These obstacles include the uneven implementation of international standards, limited access to education and research opportunities for vulnerable groups, and insufficient legal mechanisms for monitoring and enforcement at both national and international levels.

International legal regulation of scientific activity is rapidly evolving under the influence of globalisation, digital transformation, and emerging security threats. First, contemporary legal discourse focuses on the ethical and bioethical challenges raised by advances in artificial intelligence, genetic engineering, and biotechnology, which may affect fundamental human rights and human dignity. Second, scholars emphasise the need to balance intellectual property protection with equitable access to scientific knowledge and research outcomes for the public benefit. Third, growing attention is being paid to the tensions between international scientific cooperation and national security interests, particularly with regard to dual-use technologies in fields such as AI, nuclear research, and defence innovation. Fourth, legal regulation of scientific activities in international spaces, including marine research and the exploitation of ocean genetic resources, remains insufficiently developed. Fifth, contemporary studies underline the growing significance of "soft law" instruments, including UNESCO recommendations, ethical principles, and international guidelines, which increasingly shape global standards despite their non-binding nature. Overall, recent research trends combine public international law, human rights law, and technology governance in order to modernise legal mechanisms and ensure that scientific progress contributes to sustainable development, human rights protection, and global security.

Contemporary legal scholarship proposes several approaches aimed at modernising international regulation in this field. These include the harmonisation of global standards governing scientific activity, fuller integration of soft-law instruments into national legal systems, the development of accountability mechanisms for breaches of academic integrity, and the incorporation of digital governance principles into international legal norms. Growing importance is also attached to interdisciplinary strategies that combine legal, ethical, and technological perspectives in order to safeguard both scientific freedom and global security.

Scientific discrimination remains a serious obstacle to global scientific and technological development, limiting equal access to education, research opportunities, and academic cooperation. Although international organisations and legal instruments have been created to promote equality in science and the sharing of knowledge, their effectiveness is often constrained by vague legal definitions, weak enforcement procedures, outdated regulatory approaches, political influence within international institutions, and the absence of clear legal liability for discriminatory practices in academia.

In recent years, the international legal regulation of scientific research has undergone significant transformation as a result of digitalisation, the rapid expansion of artificial intelligence, and the growing influence of open science initiatives. An important role in this process is played by the UNESCO Recommendation on Open Science (2021) [26], which

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promotes open access to research findings, transparency, and equal participation in scientific cooperation. Equally significant is the UNESCO Recommendation on the Ethics of Artificial Intelligence (2021) [22], which establishes principles of human rights protection, non-discrimination, algorithmic transparency, and accountability in the use of AI in research activities.

At the European level, the EU Artificial Intelligence Act (2024) [23] introduces a risk-based regulatory framework for AI technologies, including their application in scientific research, while the OECD Recommendation on Access to Research Data from Public Funding (2021) [21] strengthens standards on the accessibility, interoperability, and reuse of scientific data. Taken together, these instruments demonstrate a shift from the traditional notion of scientific freedom towards a broader legal model that integrates ethical, technological, and security dimensions. Contemporary international practice therefore reflects growing attention to digital governance, academic accountability, data protection, and the balance between scientific autonomy and public safety.

This approach aligns with the position of European scholars who emphasise that the EU seeks to create a regulatory environment that supports innovation while safeguarding public interests. The innovation principle requires that the potential impact on innovation be taken into account when legal acts are drafted and revised, with the aim of fostering a dynamic and competitive research landscape [2, p. 528–531].

The EU also actively regulates emerging scientific fields in order to ensure ethical development and public trust. For example, the Artificial Intelligence Act classifies AI applications according to risk levels, imposing stricter requirements on high-risk AI systems to ensure their compliance with standards of safety, transparency, and accountability [20].

The EU has introduced legislation aimed at balancing data accessibility with privacy protection. The General Data Protection Regulation (GDPR) shapes how researchers handle personal data, ensuring respect for the right to privacy. Meanwhile, initiatives such as the European Open Science Cloud seek to promote open access to scientific data and to encourage collaboration while ensuring compliance with legal and ethical standards [20].

In the recent CJEU case concerning Hungary's restrictive "Lex CEU" law, EU law was relied on to strike down restrictions imposed on a foreign university, marking an important milestone in the protection of academic freedom. K. Kovács argues that European courts have adopted a "liberal science scenario", offering strong protection for academic freedom, albeit with different emphases. The European Court of Human Rights focuses on the individual rights of scholars, particularly freedom of expression in academia, while the Court of Justice of the European Union emphasises the institutional autonomy of universities. Taken together, these legal standards help to shield scientific research and innovation from undue political interference across Europe [19].

Notably, the EU legal system does not recognise "science law" as a separate branch of law. Instead, research is regulated through a range of legal fields that cover research-related matters. These include intellectual property law, which governs scientific discoveries, patents, and copyrights related to research outcomes; administrative law, which addresses science policy, research funding, and university autonomy; European research law, regulating scientific grants, Horizon Europe projects, selection procedures, and ethical standards; information law, which governs open access to scientific data (Open Science) and the protection of personal data in research under the GDPR; bioethics law, including rules on human experimentation and on the use of animals in research under Directive 2010/63/EU; and health law, which deals with clinical trials and the regulation of medical innovations. Accordingly, "science law" in the EU does not exist as an autonomous branch

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of law but rather as an interdisciplinary set of legal norms governing various aspects of research.

An important question concerning the balance between innovation and precaution arises within the EU legal system. Kathleen Garnett, Geert Van Calster, and Leonie Reins examine how the EU seeks to promote innovation while managing risk. They analyse the emerging "innovation principle", introduced by industry groups to encourage regulators to consider the impact of legislation on innovation. Unlike the well-established precautionary principle, the innovation principle is not formally enshrined in EU treaties or legislation and remains somewhat ambiguous. The authors conclude that a "qualified innovation principle", which permits reasonable and responsible risk-taking, could complement the EU's precautionary approach by supporting scientific progress without undermining safety [16].

The European Union seeks to create a regulatory environment that both fosters innovation and ensures the adequate protection of the public interest. In this context, the innovation principle plays an important role: it requires that the potential impact of legal and regulatory acts on innovation be taken into account during their drafting, assessment, and revision. The aim of this approach is to create favourable conditions for the development of a dynamic, competitive, and efficient research environment [20].

This position is consistent with the well-founded view of K. V. Bortniak, who argues that the development of science within a state should remain free, while its principal directions are objectively shaped by the market and socio-economic needs of both the state and the private sector. These needs are directed at identifying innovative means of securing competitive advantages for the national economy vis-à-vis other states, since the results of scientific activity inevitably have a practical dimension and are mainly manifested in their innovative character, which extends beyond purely economic value and also generates potential for future research and broader socio-economic development [1, p. 123].

First, international law still lacks a precise and unified definition of discrimination in the scientific and educational sphere; existing provisions describe discrimination only in broad terms and rarely address specific forms of academic inequality. Second, enforcement mechanisms remain weak because international organisations mainly issue recommendations rather than binding measures, stressing that restrictions on scientific publications should be based exclusively on academic criteria rather than on political sanctions or state policies. Third, many international legal instruments governing scientific cooperation were adopted decades ago and no longer fully correspond to the realities of digitalised and globalised science, in which knowledge may also become a tool of political influence and exclusion. Fourth, the work of international institutions may be affected by the political influence of powerful states, which can indirectly foster discriminatory practices in academic publishing and research cooperation. Finally, international legal frameworks still do not adequately criminalise discrimination in academia, focusing instead on related issues such as plagiarism, fraud, and the falsification of research results [4]. Against the backdrop of rapid technological progress and the growing strategic value of science, these shortcomings have contributed to new forms of scientific inequality and exclusion. Contemporary international law therefore needs stronger and more effective mechanisms capable of securing compliance with anti-discrimination standards and providing equal conditions for scientific activity worldwide.

The case law of the European Court of Human Rights plays a significant role in shaping international standards on academic freedom and the independence of scientific research. In Sorguç v. Turkey [10], the Court emphasised the importance of open academic

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debate and warned against excessive state interference in scholarly criticism. In *Mustafa Erdoğan and Others v. Turkey* [9], the ECtHR confirmed that academic freedom protects the expression of critical or unpopular opinions without the threat of sanctions. In Lombardi Vallauri v. Italy [8], the Court found a violation of the applicant's rights following his removal from a university post without sufficient justification, thereby underlining the importance of institutional autonomy in higher education.

More recent ECtHR case law demonstrates the continuing development of legal safeguards for academic expression, particularly in the context of digitalisation and politically sensitive issues. In *Kula v. Turkey* [7], the Court held that disciplinary measures imposed on a lecturer for statements made in an academic setting could violate Article 10 of the European Convention on Human Rights where such restrictions were disproportionate or unnecessary in a democratic society. In *Çölgeçen and Others v. Turkey* [6], the Court addressed the dismissal of university employees during a state of emergency and reaffirmed the importance of the rule of law and academic independence even in exceptional circumstances. The evolution of judicial approaches to digital rights is also evident in *Big Brother Watch and Others v. the United Kingdom* [5], in which the Grand Chamber developed standards on mass surveillance and personal data protection that are relevant for research involving large-scale data processing.

In addition to the ECtHR, the practice of the Court of Justice of the European Union is also important in this field. In Data Protection Commissioner v. Facebook Ireland and Maximillian Schrems (Schrems II) [15], the Court underlined the need to ensure effective protection of personal data in cross-border transfers, an issue that directly affects international scientific cooperation and contemporary research activities.

Conclusions. The current stage of global development confirms that scientific research has become one of the key factors shaping international relations, economic stability, technological competitiveness, and the protection of human rights. Scientific research today extends far beyond national borders, which calls for effective international legal mechanisms capable of regulating cooperation between states, research institutions, universities, international organisations, and private actors. In these circumstances, international legal regulation performs not only a coordinating function but also serves as an important instrument for safeguarding academic freedom, upholding ethical standards, and maintaining a balance between scientific innovation and the public interest.

The analysis carried out above demonstrates that the international regulation of scientific activity is formed through a complex combination of treaty norms, institutional recommendations, soft-law instruments, ethical principles, and regional legal frameworks. International organisations — in particular UNESCO, the United Nations, the Council of Europe, and the European Union — play an increasingly significant role in shaping common approaches to scientific cooperation, access to research outcomes, intellectual property protection, and academic mobility. Despite the existence of numerous international initiatives, however, the legal regulation of scientific activity remains insufficiently unified, which creates disparities in the implementation of international standards within national legal systems.

The protection of freedom of scientific research is an essential component of democratic development and the realisation of cultural and intellectual rights. Contemporary international practice shows that academic freedom is increasingly exposed to various forms of pressure, including political influence, restrictions linked to armed conflict, the manipulation of information, and limitations on access to international scientific cooperation. These trends adversely affect not only individual researchers but also the

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broader development of global scientific dialogue. Strengthening international guarantees for independent scientific work should therefore become one of the priority directions of further legal development.

Another important issue concerns the impact of technological progress on the transformation of international legal approaches to the regulation of research. The rapid expansion of artificial intelligence technologies, digital platforms, biotechnology, and transnational data exchange is significantly changing traditional approaches to liability, ethics, confidentiality, and intellectual property in scientific research. Existing international legal mechanisms often fail to respond adequately to these developments, which makes it necessary to develop updated legal standards capable of regulating new forms of scientific and technological interaction. In this context, particular attention should be paid to ensuring transparency in scientific processes, protecting digital research data, and preventing the misuse of technological achievements in ways contrary to international legal principles.

The study also confirms that maintaining scientific integrity remains a fundamental condition for the credibility and effectiveness of international scientific cooperation. Intensifying competition in the scientific sphere, the commercialisation of research activities, and growing dependence on external sources of funding create additional risks of plagiarism, falsification of results, conflicts of interest, and unequal access to scientific resources. Improving international ethical standards and developing effective mechanisms for monitoring compliance with the principles of academic integrity are therefore becoming increasingly necessary.

Overall, the evolution of the international legal regulation of research reflects broader global transformations linked to digitalisation, globalisation, and the growing interdependence of states and scientific communities. Under present conditions, effective regulation calls for an interdisciplinary approach combining international law, human rights protection, ethical governance, and the regulation of technology. Further development of international cooperation, harmonisation of legal standards, and strengthening of institutional guarantees for academic freedom and responsible scientific conduct will contribute to building a more stable and adaptive international framework for research capable of meeting contemporary global challenges.

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