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CONTENT AND PROCEDURAL ASPECTS OF THE FUNDAMENTALISATION OF BIOLOGICAL EDUCATION FOR FUTURE TEACHERS BASED ON THE PRINCIPLES OF SUSTAINABLE DEVELOPMENT

Abstract. This article explores contemporary trends in the fundamentalisation of biological education in the context of preparing future biology teachers. Using the case of Oleksandr Dovzhenko Hlukhiv National Pedagogical University, the study demonstrates that fundamentalisation entails a synergistic approach, integrating various essential components. These include the provision of systematic, core, and invariant biological knowledge; the active engagement of academic staff and students in research activities; the development of students' soft skills; proficiency in English for professional communication; competence in modern information and communication technologies and their application in the educational process; the implementation of individualised learning trajectories; and an in-depth understanding of education for sustainable development. The fundamentalisation of biological education enhances the quality of subject-specific instruction within the educational and professional training programme for future biology teachers, forming a crucial element of their general pedagogical competence.

Keywords: fundamentalisation of biological education; professional education; biology teacher; sustainable development; O. Dovzhenko Hlukhiv National Pedagogical University.

Introduction. **Problem statement.** The necessity for modernising higher education, particularly in the natural sciences, arises from the pressing global scientific and political challenges confronting society. These include food security, environmental degradation, energy shortages, economic instability, the information crisis, armed conflicts, and the intensification of ethnic and religious tensions. As these issues stem from human activity, their resolution requires a systematic approach, integrating science, education, and culture. Consequently, the formation of an educated and culturally enriched individual has become a critical priority, with teachers playing a key role in this process by embodying contemporary scientific knowledge and cultural awareness.

Honcharenko (2008; 2009) emphasises the need for a paradigm shift in teaching:

Post-industrial education urgently demands a transition from the "teaching" format to the "learning" format. The goal is not to teach individuals but to enable them to learn independently. It is crucial to move away from an extensive, information-reproductive model towards an intensive, fundamental-creative model, where the holistic development of the learner takes precedence. At the core of this approach lies a methodology rooted in systemic and holistic principles. The quality of

professional education begins with the individual — their intellectual potential, creative capacities, and self-realisation in transformative, innovative activities. Through such activities, a "new quality of personality" emerges, enhancing both the individual and the educational process itself. The fundamentalisation of education is intended to provide the necessary conditions for the step-by-step development of a student's methodological and cultural foundation. This foundation supports creative self-realisation in academic, research, and, subsequently, professional activities, thereby ensuring high-quality learning outcomes .

When considering the fundamentalisation of education and its relationship with teacher training, it is essential to acknowledge that while science generates new knowledge, education humanises it, facilitating individual development and serving as both an indicator of progress and a prerequisite for societal advancement (Kremen, 2003). Teachers, particularly those specialising in biology, human health, and integrated natural sciences, hold a pivotal role in these processes. They must possess a profound understanding of the fundamental laws and principles of the natural sciences, recognise their own role as educators, and appreciate the impact of individuals and social groups in achieving sustainable development. To fulfil this responsibility, educators should develop and implement innovative teaching methods, tools, and approaches that effectively cultivate the knowledge and competencies of students.

Literature Review. An analysis of research and publications on the topic confirms that the principle of fundamentality is increasingly being integrated into education as a didactic concept, as emphasised by Honcharenko (2008, 2009). The Memorandum of the UNESCO International Symposium *Fundamental (Natural and Humanitarian) University Education* (1994) states that the leading characteristics of the new paradigm of 21st-century education should include fundamentality, integrity, and a focus on meeting individual interests. It highlights that fundamental education provides knowledge that enables individuals to navigate any new environment and is universal in nature. According to UNESCO, fundamental education is globally recognised as one of the key factors in national security, sustainable development, and a country's high standing in the international community. The fundamentalisation of higher education aims to achieve a qualitatively new level of competence, which is beneficial not only for solving problems within a specific field but also for the entire professional sphere (Kolot, 2006; Komarova, 2017; Korostiianets, 2013; Lavrentieva, 2015; Pinchuk, 2013; Romanovskyi, 2009).

The analysis of scientific and methodological literature on this issue indicates that the fundamentalisation of natural science education (including biology) involves its orientation toward generalised, systemic, and invariant methodological knowledge. It also emphasises the formation of general human culture, the development of scientific modes of thinking and activity, and alignment with the *Roadmap for Science, Technology, and Innovation* to address the goals of sustainable development. Education is considered fundamental when it constitutes an interaction between an individual and an intellectual environment, wherein the person internalises knowledge to enrich their inner world and, in turn, enhances the intellectual environment itself (e.g., Honcharenko, 2008, 2009; Horshkova et al., 2016; Koreneva, 2019; Rudyshyn et al., 2018; Lutsenko et al., 2020).

The **aim** of this study is to determine the theoretical and methodological foundations of fundamentalising biological education for future biology teachers, driven by contemporary educational trends in sustainable development.

Methods. To formulate a scientific problem, its theoretical study and understanding, the following theoretical methods were used: analysis and synthesis of the results of the developed scientific source base, systematization and generalization of scientific positions on the fundamentalization of natural science education of future teachers in the context of the research topic. The methodological basis of the study is a systemic approach, which allows considering the fundamentalization of biological education of future teachers as a holistic interconnected system, where each element performs a specific function and involves synergy (interaction and mutual enrichment) of many areas, namely: providing education seekers with systemic, core, and invariant

biological knowledge; the active engagement of academic staff and students in research activities; the development of students' soft skills; proficiency in English for professional communication; competence in modern information and communication technologies and their application in the educational process; the implementation of individualised learning trajectories; and an in-depth understanding of education for sustainable development.

Results and Discussion. The professional preparation of future biology teachers should be regarded as a multifunctional, open system — an integrated, systematic, and multidimensional phenomenon that constitutes a comprehensive programme. This training aims to equip students with a structured body of fundamental professional knowledge, aligning with the demands of science and practice, as well as addressing the challenges posed by globalisation, digitalisation, and multiculturalism in contemporary society. Consequently, it focuses on cultivating the worldview of modern teachers, fostering professionalism in educational activities, and shaping their spiritual and moral identity. Collectively, these qualities ensure a teacher's high level of authority, competitiveness, effectiveness, compliance with practical requirements, receptiveness to innovation, and adaptability in future professional endeavours (Lavrentieva, 2015).

An analysis of the training of future biology teachers at Oleksandr Dovzhenko Hlukhiv National Pedagogical University (e.g., Horshkova et al., 2016; Burchak, 2024; Koreneva, 2019; Lutsenko, 2024; Rudyshyn, 2021, 2023, 2024a, 2024b) reveals that the fundamentalisation of biological education within professional training entails the synergy of multiple domains, namely:

1) Providing students with structured, core, and invariant biological knowledge that, through interdisciplinary integration, serves as the foundation for constructing a holistic scientific worldview. This knowledge is crucial for the practical development and substantiation of various biotechnologies and for fostering an awareness of the necessity for nature-aligned human behaviour.

2) Engaging both lecturers and students in scientific research through collaborative participation in applied, exploratory, and fundamental investigations; fostering and expanding scientific schools within higher education institutions; incorporating scientific and creative elements into the study of specialised disciplines and extracurricular activities; and developing students' capacity to formulate independent, well-substantiated scientific judgements and conclusions during seminars, roundtable discussions, conferences, and symposia.

3) Enhancing students' soft skills, including communication proficiency, logical and bioethical reasoning, teamwork, an intrinsic drive for self-improvement, lifelong learning capabilities, emotional intelligence, and a commitment to maintaining competitiveness in the labour market. Additionally, this involves fostering competence in oral and written communication in English or other foreign languages relevant to their field of expertise, alongside mastering modern information and communication technologies and their application in the educational process.

4) Implementing an individualised educational trajectory, which is structured around students' choices regarding the types, modes, and pace of learning, the selection of educational institutions and their offered programmes, academic disciplines, teaching methodologies, and dual education opportunities.

5) Comprehending and applying the principles of education for sustainable development.

Provision of Systematic, Core, and Invariant Biological Knowledge. Fundamental biological knowledge encompasses a systematic understanding of the laws governing the existence of living phenomena and the conceptualisation of biology as a research programme, as proposed by Imre Lakatos' epistemology (Lakatos, 2013). This programme consists of a "hard core" and a "protective belt" of theories and hypotheses. The "hard core" comprises invariant knowledge that remains unchanged across all biological theories within this framework. It is encapsulated in the axiom-formula "DNA-mitosis," which asserts that life is a unique form of matter capable of self-replication and self-organisation based on the matrix principle: DNA originates from DNA (or RNA), chromosomes arise from chromosomes, and cells reproduce from pre-existing cells.

The "protective belt" consists of auxiliary theories and hypotheses that can be modified and adapted to accommodate competing theories while safeguarding the core from falsification through positive or negative heuristics. This belt includes key biological theories, such as the classification of living organisms, modes of nutrition (autotrophic vs heterotrophic), respiration types (aerobic vs anaerobic), cell theory, levels of biological organisation, the synthetic theory of evolution, and genetics of ontogenesis. The "protective belt" facilitates a continuous, consensus-driven discourse with emerging hypotheses, thereby reinforcing the core (e.g., Rudyshyn, 2009, 2013a, 2013b, 2021, 2023, 2024a, 2024b; Rudyshyn, Koreneva, & Samilyk, 2016; Rudyshyn, Melnyk, & Koreneva, 2018; Rudyshyn, Nehretskyi, & Novozhylov, 2020; Rudyshyn, Kmets, Samilyk, & Hulakova, 2021). The evolution of scientific knowledge occurs through modifications and refinements within the "protective belt," whereas the disintegration of the "hard core" — a scientific revolution — implies the abandonment of an existing research programme in favour of a competing one. For instance, prior to the discovery of DNA in 1953, the genome was widely believed to be protein-based.

Thus, students must comprehend that the foundational principles of biology evolve at a considerably slow pace. This stability enables biologists and biology teachers to rely on these principles in their professional practice while continuously acquiring and assimilating new knowledge throughout their careers.

This understanding raises an important question: how can fundamental biological knowledge be effectively "humanized" within the educational system of a pedagogical university? How can the balance between the humanities and natural sciences be optimised within a unified educational system for training future biology teachers? One potential answer lies in the structure of educational programmes at Oleksandr Dovzhenko Hlukhiv National Pedagogical University.

The training of bachelor's degree holders in Biology and Human Health at this institution is conducted through four educational programmes:

1) Secondary Education (Biology and Human Health & Natural Science);
2) Secondary Education (Biology and Human Health & Psychology);
3) Secondary Education (Natural Sciences);
4) Secondary Education (Biology and Human Health & Physical Rehabilitation).

Additionally, the training of master's degree holders in Biology and Human Health, as well as teachers of integrated natural science courses, is carried out within the framework of second-cycle (master's level) higher education programmes (Faculty of Natural Sciences and Mathematics, 2024).

Each of these programmes incorporates educational components that integrate cognitive (scientific knowledge system), methodological, practical, and communicative domains. Biological knowledge is delivered at both theoretical and practical levels, highlighting its societal relevance and enriching students' motivation for public health, environmental conservation, and sustainability initiatives. Furthermore, the curriculum is designed to instil humanitarian, patriotic, ecological, aesthetic, and intellectual motivations among students.

In designing the content of fundamental biology education, emphasis is placed on interdisciplinarity, integrativity, systematicity, and coherence. These principles facilitate the development of comprehensive biological thinking, aligned with the principles of education for sustainable development. The fundamentalisation of biological education is aimed at systematically equipping students with both general and professional competencies, fostering an intrinsic motivation for lifelong learning and continuous self-improvement.

Notably, educational programmes require ongoing updates in both content and methodology to reflect societal transformations and changes in the natural environment.

Engagement of Faculty and Students in Research Activities (RA). Effective research activities in higher education institutions require the fulfillment of several key conditions:

1) Implementation of complex research projects registered with UkrINTEI;
2) Support and development of scientific schools;

3) Incorporation of research and creative tasks into the study of specialized disciplines and extracurricular activities;

4) Conducting research at the interdepartmental research laboratory;

5) Developing students' ability to make independent, well-founded scientific judgments and conclusions through departmental meetings, seminars, round tables, conferences, and symposia.

Between 2016 and 2021, research was conducted on the topic *"**Fundamentalisation of Biological Education at a Pedagogical University in the Context of Sustainable Development**"* (No. 0116U003633, supervised by Prof. S. D. Rudyshyn). The scientific contributions were presented in the form of dissertations, masteres theses, monographs, textbooks, popular science publications, journal articles indexed in scientometric databases, and conference proceedings at various levels.

Notably, the following dissertations were prepared and successfully defended:

1) V. I. Samilyk (2019): *Formation of Future Biology Teachers' Readiness for Environmental Protection Activities in the Process of Professional Training* (PhD dissertation in Pedagogical Sciences, speciality 13.00.04, Hlukhiv, supervised by Prof. S. D. Rudyshyn).

2) I. M. Koreneva (2019): *Theoretical and Methodological Foundations for Preparing Future Biology Teachers for the Implementation of Education for Sustainable Development* (Doctoral dissertation in Pedagogical Sciences, speciality 13.00.04, Hlukhiv, scientific consultant Prof. S. D. Rudyshyn).

The research school led by Prof. S. D. Rudyshyn, Doctor of Pedagogical Sciences, *"Fundamentalisation of Biological Education at a Pedagogical University in the Context of Sustainable Development,"* remains active (http://fpfmo.ho.ua/osobysta-storinka-rudyshyna-sergiya-dmytrovycha/).

Between 2021 and 2025, the topic evolved into *"Ensuring the Quality of Continuing Professional Education for Biology Teachers"* (No. 0121U100500, 2021–2026, supervised by Prof. S. D. Rudyshyn). As part of this research, the following dissertation was defended:

1) M. V. Khrolenko (2022): *Theory and Practice of Forming Future Biology Teachers' Environmental Competence in the Process of Professional Training* (Doctoral dissertation in Pedagogical Sciences, speciality 13.00.04, Hlukhiv, scientific consultant Corr. Member of the NAES of Ukraine A. I. Kuzminskyi).

In 2025, L. V. Burchak is expected to defend the dissertation *Theoretical and Methodological Foundations for Developing Innovative Competence in Future Biology Teachers in the Process of Professional Training* (Doctoral dissertation in Pedagogical Sciences, speciality 13.00.04, Hlukhiv, scientific consultant Corr. Member of the NAES of Ukraine V. P. Kurok). This research aligns with the project "Professional and Personal Development of Future Specialists in Higher Education in the Context of Ukraine's Integration into the European Educational Space" (No. 0117U004243).

Students actively participate in research and development through:

1) Conducting applied and exploratory scientific research;

2) Completing assignments with a research component during the study of specialised disciplines;

3) Engaging in extracurricular scientific work;

4) Conducting research in the biology laboratory and the interdepartmental research laboratory.

Students develop independent, well-founded scientific judgments and conclusions during seminars, roundtables, conferences, and symposiums, which contribute to the formation of fundamental knowledge and mastery of modern methodological concepts of scientific inquiry.

Several students from Oleksandr Dovzhenko Hlukhiv National Pedagogical University have achieved significant success in research competitions:

1) Nataliia Nechai & Maryna Yeremenko (2013) – Winners of the international competition of scientific articles (essays) *"Scientific Debut – 2013. Sustainable Development"* (Poland):

• N. Nechai: *Species Diversity of Insects as an Indicator of Garden Agrocenosis Stability* (supervised by I. M. Koreneva).

• M. Yeremenko: *Biosphere Capacities and Sustainable Development of Society: Problems and Prospects* (supervised by S. D. Rudyshyn).

2) Kateryna Fesenko (2017) – 1st place in the Ukrainian competition of scientific projects *"Change Your Future"* (Zhytomyr Ivan Franko State University). Presented project: *Green Week*, aimed at fostering ecological awareness and sustainable lifestyle habits among students (supervised by V. I. Samylyk).

3) Vitalii Koneko (2019) – Winner of the *Ukrainian Student Research Competition in Natural, Technical, and Humanitarian Sciences* in the *Ecology* category with the research topic *Pollenation Features of Allergenic Plants in Hlukhiv* (Poltava, Poltava National Technical University; supervised by S. D. Rudyshyn). This research provided the first analysis of allergenic plant species and their pollenation characteristics within the urban ecosystem of Hlukhiv. A flowering calendar for anemophilous plants in the region was created according to the *European Aeroallergen Network* (EAN) standards, identifying only one peak pollenation period per aeropalynological category per season.

4) Iryna Pylypenko & Vlada Zaitseva (2023) – Winners of the *International Student Research Competition* (Kremenchuk Mykhailo Ostrohradskyi National University) with the research topic: *Linguistic Ecology – A Marginal Direction of Linguistics: Conceptual and Categorical Apparatus in the Context of Ecology* (supervised by S. D. Rudyshyn). The study highlighted that ecological terms form a part of the scientific terminology system and require precise definitions. It also warned against the potential negative risks of adapting biomorphic metaphors in language policy, as objectification and biologisation of social systems could lead to their perception as natural objects rather than socio-cultural constructs.

The scientific achievements of students are annually published in the *Almanac QN (Questiones Naturals / Natural Science Issues)*, a collection of research papers by students from the Faculty of Natural and Physical-Mathematical Education at Oleksandr Dovzhenko Hlukhiv National Pedagogical University. The almanac covers various scientific disciplines, including physics, computer science, zoology, botany, human anatomy, genetics, ecology, geology, geography, and the methodology of teaching natural and physical-mathematical sciences.

The Interdepartmental Research Laboratory *"Formation of Professional Competencies of Future Biology Teachers for Scientific and Pedagogical Support of Sustainable Development"* focuses on the following areas:

• Studying physiological and biochemical characteristics of plant life;
• Preserving biodiversity in northeastern Ukraine;
• Ensuring the quality of continuous professional education for biology teachers.
• Partnerships have been established with Ukrainian research institutions and individual specialists for project coordination, joint research, and information exchange, including:
• Institute of Pedagogy of the National Academy of Educational Sciences of Ukraine
• Institute of Botany of the National Academy of Sciences of Ukraine
• Institute of Zoology of the National Academy of Sciences of Ukraine
• National Pedagogical Dragomanov University
• Institute of Higher Education of the National Academy of Educational Sciences of Ukraine
• National Ecological and Naturalistic Centre (Kyiv)

Each year, Oleksandr Dovzhenko Hlukhiv National Pedagogical University hosts the *first stage of the Ukrainian Student Olympiad* in biology, ecology, physics, computer science, and mathematics. These competitions provide students with opportunities to demonstrate their knowledge, logical reasoning, and perseverance in solving complex problems. The main goals include identifying and developing talented students, fostering their creative abilities, increasing interest in scientific and professional activities, stimulating the scientific work of faculty, and selecting candidates for participation in international competitions and olympiads.

The development of soft skills among students is implicitly embedded in the content of all educational components across all study programmes. This integration is reflected in the syllabi of academic disciplines through the use of dialogic teaching methods, schematic and symbolic modelling techniques, critical thinking development strategies, and interactive class formats such as round-table discussions, debates, microteaching, and research paper presentations. These methods often involve the creation of presentations and the implementation of academic projects.

Furthermore, the formation of soft skills is supported through extracurricular (educational) activities within the faculty, in accordance with the work plans of academic group supervisors and the faculty's educational initiatives. The expected outcomes of this approach include the development of communication skills, logical reasoning, bioethical thinking, teamwork abilities, intrinsic motivation for self-improvement, lifelong learning competencies, emotional intelligence, and competitiveness in the labour market (Hrytsai, 2016; Korostiianets, 2013; Lutsenko, 2024; Rudyshyn, 2009, 2013a, 2013b, 2021, 2023, 2024a, 2024b; Samilyk, 2019; Khrolenko, 2022). While *hard skills* facilitate employment, *soft skills* are crucial for career advancement (Rudyshyn, Kononenko, Khrolenko, Konenko, & Merdov, 2020).

The ability to communicate effectively in English or other foreign languages within a professional context is essential. The process of fundamentalisation of biological education will acquire systemic characteristics if there is a gradual implementation of foreign-language instruction for certain subjects at both undergraduate and postgraduate levels. This approach should be tailored to the specific professional trajectories of students.

At the Faculty of Natural and Physical-Mathematical Education at Oleksandr Dovzhenko Hlukhiv National Pedagogical University, several disciplines are already taught in English. These include *Current Problems of Biology* (3 ECTS credits, 90 hours) within the master's degree programme *Secondary Education (Biology and Human Health and Natural Science)*, as well as *Botany and Mycology* (8 ECTS credits, 240 hours) within the bachelor's degree programme. Additionally, faculty members from the Departments of Theory and Methods of Teaching Natural Sciences and Biology, as well as Human Health and Teaching Methodology, incorporate English-language instruction into selected classes during the semester. This includes subjects such as *Biochemistry and Molecular Biology and Microbiology with Basics of Virology and Immunology*.

Since 2013, the university has hosted the annual scientific and pedagogical conference *The 21st Century Challenges in Education and Science* for young scholars, master's students, and undergraduates, conducted in foreign languages.

Language acquisition enhances cognitive functions such as memory, attention, logical reasoning, creativity, and critical thinking. It also broadens educational, career, and travel opportunities while fostering intercultural communication.

The implementation of an individualised educational trajectory is based on students' ability to select learning formats, study pace, and educational providers. This includes the choice of educational programmes, disciplines, teaching methods, and instructional tools (Korostiianets, 2013). The aim is not merely to adapt educational content to individual students but to provide flexibility in learning approaches based on their unique characteristics and abilities, thereby making education more accessible and feasible. The acquired competencies should align with labour market demands.

Students have the freedom to select academic disciplines relevant to their degree level, as enshrined in legislation. The curriculum mandates that at least 25% of the total study workload throughout the entire programme must consist of elective courses.

Dual education is gaining popularity among students, as it enables them to combine academic learning with professional employment. Those working as biology teachers, human health educators, or instructors of integrated natural science courses can complete 25% to 60% of their study programme requirements at their workplace.

Education for sustainable development aims to equip individuals with the knowledge and skills necessary for fostering new worldviews, values, and attitudes that contribute to socially desirable, economically viable, and ecologically balanced societal development. This approach is integral to the professional training of future teachers in achieving sustainable development goals, including poverty and hunger eradication, agricultural advancement, good health and well-being, quality education, clean water and sanitation, affordable and clean energy, climate change mitigation, marine resource conservation, ecosystem protection and restoration, peace, justice, and partnerships for sustainable development.

Sustainable development education is guided by the principles: *"Think globally, act locally"* and *"Preserve biotic and landscape diversity, and it will preserve us in return."* This approach enhances the understanding of the necessity to align socio-economic activities with ecosystems' self-regeneration capacities, ensuring that future generations can meet their own needs (Koreneva, 2019; Rudyshyn, 2009, 2013a, 2013b, 2021, 2023, 2024a, 2024b; Rudyshyn, Koreneva, & Samilyk, 2016; Samilyk, 2019; Koreneva, 2019; Rudyshyn, Melnyk, & Koreneva, 2018; Rudyshyn, Nehretskyi, & Novozhylov, 2020; Rudyshyn, Kmets, Samilyk, & Hulakova, 2021).

Within this framework, research has been conducted under the project *"Fundamentalisation of Biological Education in a Pedagogical University in the Context of Sustainable Development"* (No. 0116U003633, 2016–2021). The research continues under the title *"Ensuring the Quality of Continuous Professional Education of Biology Teachers"* (No. 0121U100500, 2021–2026).

As part of this effort, a specialised educational module was developed within the international grant project *"Implementation of the Environmental Security Strategy: Integration of European Experience"* (562284-EPP-1-2015-1-UA-EPPJMO-MODULE) under the Erasmus+ Jean Monnet Programme of the European Union. The project, led by Olena Melnyk with contributors Iryna Dynylchenko, Inna Koreneva, and Liudmyla Zahorodnia, was implemented at Oleksandr Dovzhenko Hlukhiv National Pedagogical University between 2015 and 2018.

The project's primary objective was to cultivate environmental awareness among students by integrating European experience and values into environmental security education. This goal was achieved through various initiatives, including the development of e-courses on *"Implementation of the Environmental Security Strategy: Integration of European Experience"* and the organisation of academic and methodological events such as debates, conferences, and round tables involving university students, the public, government officials, and other stakeholders. Special emphasis was placed on fostering European-style environmental competence among future educators. The implementation of the developed materials contributed to enhancing environmental competence and ecological awareness among citizens. As a result, the project's outcomes have been integrated into the educational process of six Ukrainian higher education institutions.

Oleksandr Dovzhenko Hlukhiv National Pedagogical University has initiated and institutionalised the All-Ukrainian Scientific and Practical Conference *"Natural Science Education and Science for the Sustainable Development of Ukraine: Problems and Prospects,"* which has become a recurring event for Ukrainian educators in the natural sciences: 2014 (I), 2017 (II), 2019 (III), and 2023 (IV).

Other scientific and practical conferences also take place, including the International Online Conference of Young Scientists and Students *"Hlukhiv Scientific Readings – 2021"* and the conference *"Current State, Issues, and Prospects for the Development of Natural and Mathematical Sciences and Their Teaching Methods"* (October 2022).

Conclusions and Prospects for Futher Research. Biological knowledge is an integral component of natural sciences. However, biological processes differ from chemical and physical ones in that life represents a unique form of matter that is self-replicating and self-organising, counteracting entropy through a matrix principle: matrix (nucleic acid/gene) → protein → trait. This cognitive foundation — often referred to as the "dogma" of biology — guides biologists, biology

teachers, and educators in integrated natural science courses when explaining scientific worldviews, including the origins of life, evolutionary mechanisms, and DNA-based systematics.

The application of fundamental biological knowledge underpins various biotechnological advancements, such as reproductive medicine, antiviral therapies, and the development and safety assessment of genetically modified organisms (GMOs). The fundamentalisation of biological education entails the synergy of multiple domains, including:

- Providing students with systematic, core, and invariant biological knowledge
- Engaging faculty and students in research activities
- Developing students' soft skills
- Understanding and implementing the concept of sustainable development in professional activities

This approach fosters an awareness of the necessity of human-nature coevolution, enabling individuals to acquire and apply new knowledge throughout their lives.

We see prospects for further research in the development of specific methods and technologies for implementing interdisciplinary integration (STEM approach), as well as in the implementation of educational components of courses at the intersection of sciences: biophysics, biogeochemistry, bioinformatics, etc. A future teacher should be prepared to teach not only classical biology, but also integrated courses "Natural Sciences", which are currently being actively implemented in schools. We consider the combination of the provisions of bioethics and the principles of sustainable development in biological education to be a promising foundation for preparing teachers to foster the environmental responsibility in a new generation.

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Сергій Рудишин, *доктор педагогічних наук, кандидат біологічних наук, професор кафедри теорії і методики викладання природничих дисциплін Глухівського національного педагогічного університету імені Олександра Довженка, м. Глухів, Україна.*
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ЗМІСТОВІ ТА ПРОЦЕДУРНІ АСПЕКТИ ФУНДАМЕНТАЛІЗАЦІЇ БІОЛОГІЧНОЇ ОСВІТИ МАЙБУТНІХ УЧИТЕЛІВ НА ЗАСАДАХ СТАЛОГО РОЗВИТКУ

Анотація. У статті досліджено сучасні тенденції фундаменталізації біологічної освіти у контексті підготовки майбутніх учителів біології. На прикладі Глухівського національного педагогічного університету імені Олександра Довженка продемонстровано, що фундаменталізація передбачає синергетичний підхід, який інтегрує різні сутнісні компоненти. До них належать: забезпечення системних, базових та інваріантних біологічних знань; активне залучення науково-педагогічних працівників і студентів до дослідницької діяльності; розвиток м'яких навичок здобувачів освіти; володіння англійською мовою для професійного спілкування; сформованість компетентностей у сфері сучасних інформаційно-комунікаційних технологій та їх застосування в освітньому процесі; упровадження індивідуалізованих освітніх траєкторій; а також глибоке розуміння освіти для сталого розвитку. Фундаменталізація біологічної освіти підвищує якість предметної підготовки в межах освітньо-професійної програми підготовки майбутніх учителів біології, формуючи важливий складник їхньої загальної педагогічної компетентності.

Ключові слова: фундаменталізація біологічної освіти; професійна освіта; учитель біології; сталий розвиток; Глухівський національний педагогічний університет імені О. Довженка.